Collusive Price Leadership in Retail Pharmacies in Chile.

4 January 2018, 11:15-12:30, bld. 72, room 465

Jorge Ale Chilet (**U. Penn**.)

Collusive Price Leadership in Retail Pharmacies in Chile

Jorge Alé Chilet*
University of Pennsylvania
PRELIMINARY

December 27, 2017

Abstract

I analyze price leadership among retail pharmacy chains in Chile during a price war and a subsequent case of collusion on hundreds of drugs. The pharmacies reached higher prices using staggered price increases that were mostly led by the smallest chain. I find that the largest chain's degree of dominance in each product-market explains both the order of move and the time it took the follower firms to raise prices after the leader's increase. I explain the empirical findings with a price leadership game under asymmetric information, where the leader can reveal its type truthfully thanks to the costs involved.

1 Introduction

Price leadership and its implications for antitrust legislation have long been the focus of academic and policy interest. While a price leader arises naturally in many settings of oligopolistic competition, firms may also use leadership as a mechanism to achieve collusive outcomes. Consequently, economists have long put effort to understand the determinants of 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 informed firm, is followed by its competitors because of the inherent competitive dynamics of the industry. The second type,

*E-mail: jalech@upenn.edu. Contact Information: The Wharton School. Steinberg-Dietrich Hall, 3620 Locust Walk, Philadelphia, PA 19104. This paper is based on Chapter 3 of my doctoral dissertation at The Hebrew University of Jerusalem. I am particularly grateful to my advisor, David Genesove, for his encouragement and guidance. I owe special thanks for helpful suggestions to Alon Eizenberg, Arthur Fishman, Joe Harrington, JF Houde, Massimo Motta, and Saul Lach.

collusive leadership, describes leadership that takes place "in lieu of an overt agreement," and 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 evidence on how firms put collusive leadership into practice is still scarce.

This paper studies price leadership during a price war and a subsequent case of collusion among the main three retail pharmacy chains in Chile. The transition from the price war to the collusive equilibrium featured large coordinated price increases in hundreds of medicines. Furthermore, although the industry leader during most of the period under study was the largest chain, the coordinated price increases were initiated by the smallest chain. This entailed very distinct leadership patterns for coordinated increases. Hence, the nature of price leadership during the transition to collusion changed drastically, and also temporarily, since it returned to its previous state after the pharmacies ceased coordination.

The main contribution of this work is providing the first detailed analysis of price leadership during explicit collusion. My hope is that this study should help us to better understand the function of price leadership as a collusive device. Moreover, the different competitive states in the same industry over time allow me to compare leadership during collusion to leadership during competition. Importantly, I provide empirical evidence of these leadership regimes, which match the competitive and collusive leadership described in the theoretical literature. The changes between these regimes signal a break in conduct and could possibly be used as a way to detect and punish collusive behavior.

The three pharmacy chains, Cruz Verde, Fasa, and Salcobrand (ranked by their number of stores), were engaged in a months-long price war in blockbuster brands starting in December 2006. The price war was a consequence of increasing reliance on loss-leading pricing by which leading brands would be sold at a discounted price with the aim of attracting more consumers to the stores. Prices of loss leaders plummeted further when Cruz Verde launched an advertising campaign of price comparisons. The campaign publicly compared the prices of a subset of the products in Cruz Verde itself with those of its main competitor, Fasa, and was accompanied by further price cuts that resulted in negative profit margins of the loss leader products across all the pharmacies. A judicial court halted the advertising campaign in November 2007 after Fasa filed a complaint of unfair competition. A few weeks later, the three firms started increasing prices of the drugs involved in the price war coordinately. The firms raised the price of each product by means of staggered, rapid price increases, led by the smallest chain, Salcobrand. The

pharmacies coordinated the price increases beforehand and accompanied them with increased monitoring of the other firms's prices. The scope of price fixing grew gradually to include more brands over a *coordination period* that spanned five months. The coordinated price increases lasted until the pharmacies realized that they were being investigated by the competition authority in May 2008. By then, the firms had raised the prices of more than two hundred medicines, largely chronic, prescription-only drugs, as well as the best-selling brands in their class. Prices rose 50 percent on average during the collusive period. Panel (a) of Figure 1 shows an example of a coordinated price increase for *Lady Ten x 21 coated tablets*, a drug indicated for hormonal treatment therapy, and Panel (b) of Figure 1 summarizes the order followed by the pharmacies during all coordinate price increases.

I explain price leadership during the coordination period arguing that the leader, Salcobrand, had the greatest motivation to collude. Three facts support this: First, Salcobrand changed ownership in the middle of the price war. The new owners wanted to end the price war in loss-leader products, and hence they were willing to incur the costs of being the leader during the coordinated increases. In addition, Salcobrand's competitors were in a better position to fight the price war, as the other pharmacies had other sources of revenues besides the retail business: Cruz Verde was vertically integrated with a distributor, and Fasa had stores abroad. Finally, in many retail industries, economies of scale and of density cause marginal costs to decrease as the number of stores increase, and thus the two largest chains presumably had lower marginal costs.

Salcobrand's motivation to collude and the other firms' uncertainty with respect to it are the basis of my theoretical framework, in which the leader's patience level, that is, its discount factor, is its own private information. The leader raises price first as a way to show that it is able to collude on a better price. A price difference between the firms entails a temporary decrease in the leader's market share that is directly determined by the time it takes the follower to follow the price increase. Hence, the follower can screen out impatient leader types that mimic patient ones by choosing a following time such that impatient types are not willing to undertake leadership. Hence, leadership is akin to a menu of contracts offered by the follower that allows truthful revelation on the leader's part.

The empirical part of the paper begins by examining price leadership over time with the aim of documenting changes over the periods of more or less competition. My strategy consists of estimating brand fixed effect regressions of price changes in each pharmacy on weekly lagged price changes in all the pharmacies. The estimates provide a mea-

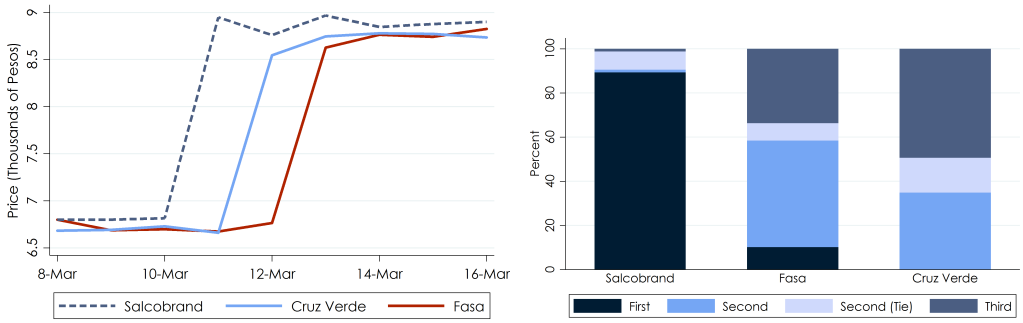
sure of how closely a given pharmacy follows its own and its competitors' price changes. The findings show that Salcobrand closely followed Cruz Verde's prices both before and after the coordinated increases, but that there was a halt in its followership during the coordination period. Similarly, the findings indicate that both Cruz Verde's and Fasa's current prices did not respond to Salcobrand's lagged prices except during the coordination period. These results reveal two distinct leadership regimes over time: While the price leader throughout the period was Cruz Verde, Salcobrand emerges as the price leader during the transition to collusion.

Next, I focus on price leadership during collusion, which is the main contribution of the paper. I study three of its outcomes, namely, the time it took the follower pharmacies to follow the leader, the order in which the firms moved, and the costs of leadership. Regarding the first outcome, I find that Cruz Verde's dominance is a strong predictor of the time it takes the three firms to raise prices in each product. In particular, if Cruz Verde is larger in a market, both Cruz Verde and Fasa increase prices after the leader, Salcobrand, faster. In light of my model this finding is consistent with the fact that the leader has to pay a higher screening cost in markets in which it is more costly to reveal its willingness to collude truthfully.

The second outcome I study is the order of move. Besides Salcobrand's clear leadership position, it would seem that the two other chains took turns to follow the leader in a random order. Yet, I find that a strong predictor of the order they follow is Cruz Verde's size, as well. In markets where Cruz Verde has a higher market share, Cruz Verde is more likely to be the last firm to increase price during coordination. This result shows that each firm's size is correlated with the order of move of the three firms. Further, this correlation is consistent with leadership models where weaker, high-cost firms move first in collusion.

Finally, I study the costs of leadership. I find that the market share of the last pharmacy to raise prices during a coordinated price increase was higher by 5 percent on average for a month after the increase happened. This finding, intuitive as it may be, means that leading the price increases was costly for the leader because of the loss in sales this entailed. The costs associated to leadership may provide an explanation for why the pharmacies gave price leadership such relevance in the coordination mechanism, as seen in its intricate empirical regularities. 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 is persis-

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.

tence in demand.

Related Literature

The literature on price leadership has a long history in economics, beginning with 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 established the canonical types of leadership: competitive price leadership, in which the dominant firm is the leader, and collusive price leadership, which serves as a mechanism to collude.[3]

[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

More recent articles provide theoretical support for each type of leadership and seek to identify who the leader should be under the different cases. I draw from these papers to give a theoretical background for the use of price leadership. Furthermore, I document the presence of the types of leadership these articles discuss in my empirical context in the same industry over different periods of time, and offer asymmetric information among the firms as an alternative explanation to the leader's identity. First, previous 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 articles find that better positioned firms (larger or more efficient) should act as the competitive price leaders. Second, models of collusive price leadership seek to identify the leader and understand how price leadership may facilitate collusion. Ishibashi (2008) argues that a collusive leader moves first to "demonstrate its commitment not to deviate." Mouraviev and Rey (2011) argue that collusion is sustainable provided that the follower can be rewarded with a high enough market share. The authors show that under cost asymmetry the firms can achieve greater collusive profits if the less efficient firm is the leader.[4] Especially related to my model, Harrington and Zhao (2012) study how cooperation between firms may arise in a game of two sided asymmetric information. When firms are asymmetric, they find that the player that benefits the less from collusion is the one most likely to lead.[5]

Despite the large number of theoretical contributions, and although price leadership is common in antitrust cases, empirical work on collusive leadership is almost nonexistent.[6] There are two notable exceptions. A first contribution is Clark and Houde (2013)

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]The reason for this is that leadership relaxes the incentive compatibility constrains, and the less efficient firm is the one for which this constraint is more likely to be binding.

[5]Other theoretical models of collusion, while abstracting from leadership considerations, introduce firm heterogeneity as cost-asymmetries (Bae, 1987; Harrington, 1991; and Miklós-Thal, 2011), or as variation in the firms' discount factors (Harrington, 1989; and Obara and Zincenko, 2017).

[6]Harrington (2006), in a review of 20 European antitrust cases, refers to five instances in which the cartel resorted to staggered price increases and explicitly decided the firms' order of move. Harrington claims that the staggered price increases were chosen in order to avoid detection. In addition, in the cartels discussed, the leadership position was either rotated among the firms or was undertaken by the dominant firm. Whereas leadership rotation makes sense to share the costs of leading, dominant firm leadership could have been due to the cartel wanting to hide their coordination activities or to the dominant firm being also the most aggressive one. Along this line, Davies and De (2013) mention nine European cartels with a ringleader that was also a price leader aggressively pushing for higher prices, and other 10 cartels with a

who study a cartel of Canadian gasoline retailers and find that the high-cost gasoline retailers moved first during coordinated price increases. Given that leadership by the same firms was recurrent, they argue that leadership was a way in which leaders transferred profits to other firms in order to incentivize them to comply with collusive prices.[7] The second contribution is provided by Byrne and De Roos (2016), who 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, in a case where firms did not communicate with each other.[8] There are two main differences between these two contributions and my paper. First, those papers study one type of collusive regime each (explicit collusion and tacit collusion, respectively), while my paper analyzes price leadership in a price war and in collusive periods with and without communication among the firms. Second, those articles analyze pricing dynamics in one or two markets, while this paper studies leadership in hundreds of product-markets. This allows me to explain the heterogeneous outcomes of price leadership based on the market structure in each product.

This work also contributes to the literature on the internal workings of cartels, such as Porter (1983), Levenstein (1997), Genesove and Mullin (2001), and Roller and Steen (2006), and Asker (2010). Scott Morton (1997) studies whether an entrant's strength (as measured by age, capacity, long-term contracts) affects shipping cartels' decision to predate upon the entrant. Marshall, Marx, and Raiff (2008) study price announcements in the vitamins cartel and document that during collusion there was a fundamental change in the leader of the announcements.[9] A companion paper, Alé Chilet (2017), studies the same case of collusion analyzed in the current work. That paper focuses on the development of collusion over products over time, as the cartel moved gradually from a price war to a coordinated equilibrium. The main finding is that pharmacies started increasing prices of differentiated products and of products in which firms' market shares are more asymmetric. This is attributed to trust building over time, which made firms to start cooperating on products in which is was safer to collude. Therefore, while that companion paper examines the changing characteristics of the scope of collusion over time, this paper looks at the *cross section* of price increases, focusing on the heterogeneity among the firms rather than on the behavior of the cartel as a unity.

ringleader that was not a price leader.

[7] I am able to analyze price leadership more precisely than Clark and Houde (2013) due to the high frequency price data in hundreds of markets. Clark and Houde infer leadership from precisely timed phone calls.

[8] Other papers have studied competitive leadership in US gasoline stations (Lewis, 2012) and British supermarkets (Seaton and Waterson, 2013). See also the references in Marshall, Marx, and Raiff (2008).

[9] Price announcements are not costly and, thus, are of a different nature from actual price increases.

2 Price Fixing among Retail Pharmacy Chains in Chile

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.[10] 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 (and their number of stores as of 2008) are Cruz Verde (512), Fasa (also known as Farmacias Ahumada; 347), and Salcobrand (295). Cruz Verde's market share had increased steadily from roughly 32 in 2004 to 41 percent in 2007, 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 product. The heterogeneity in the pharmacies' shares over products will be important in the next sections of the paper.

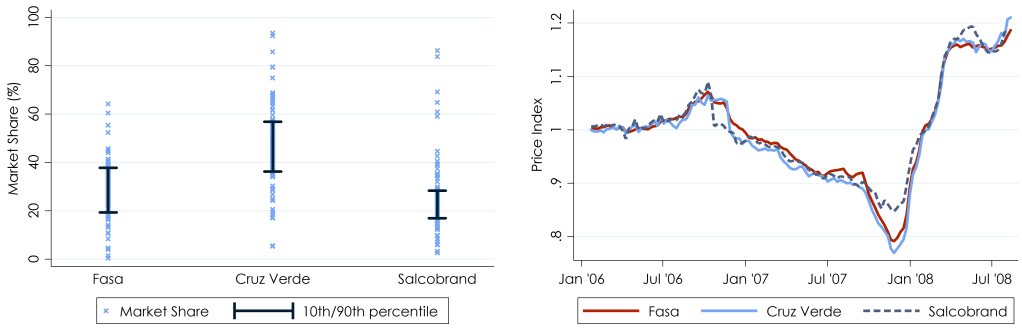
Starting in 2005, the pharmacies started relying heavily on a loss-leading strategy, which consisted of selling hundreds of chronic, branded, and best-selling drugs for prices close to or below their wholesale price. Prices starting dropping further in December 2006 in a period described by Chile's National Economic Prosecutor (NEP) as a price war. Throughout this price war either rapid 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 claimed 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. Some weeks later, the pharmacies started coordinating price increases.

During the coordination period the pharmacies would choose a subset of drugs on which to collude. Then, the chains would raise the price of each product 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 similar.[11] I refer to these as coordinated increases. By the time an antitrust

[10] The industry was reviewed in depth in Alé Chilet (2017).

[11] This mechanism was identified in an expert report commissioned for the trial (Nuñez, Rau and Rivera,

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.

investigation started in May 2008, the coordinated increases had led to an average price increase of almost 50 percent in 222 best-selling brands that constituted 30 percent of the pharmacies' revenues. I refer to the latter as the coordination period. These events can be seen in the pharmacies' price indexes of Panel (b) of Figure 2. The pharmacies were found guilty of colluding by the Competition Tribunal in January 2012.

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.[12] In fact, some depositions 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. For example, Fasa's commercial manager at the time testified that

> [i]n 2007 two relevant events happened[:] in May or June Salcobrand was acquired by the Yarur corporation (...). They started to set their own pricing strategies, so [that Salcobrand] ceased to be price follower. I realized that

2010). Collusion was explained in some depositions as pure price leadership. For example, Sergio Purcell, Fasa's CEO, claimed: "[P]rice increases started to pop up in our regular [price] surveys of Salcobrand (...) [T]hen, we survey[ed] again to double check, and we saw that Cruz Verde had similar prices [to Salcobrand's,] and so we matched that [price] increase." (Observations to the evidence. Cruz Verde, p. 341.)

[12] 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.

> because [I] noticed in the [price] surveys we used to do every week that [Salcobrand] was increasing prices without following the market.[13]

Based on these claims, I will argue here that Salcobrand initiated the price increases because, as the weakest firm in the industry, it had the most to hain from colluding.

The main argument for Salcobrand's position as the leader is its change in ownership in August 2007, in the midst of the price war. 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 to follow 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.[14] The outcomes of this change of strategy are evident in the price indexes in Panel (b) of Figure 2. Notice that in the final months of 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.[15]

In addition, the situation during the price war was better for the two largest chains, Cruz Verde and Fasa, because of their other sources of revenues besides the retail business (Cruz Verde's distributor, and Fasa's stores abroad).[16] Furthermore, in many re-

[13] Ricardo Ewertz. Observations to the evidence. Cruz Verde, p. 346. The narrative of Salcobrand's defense lawyers is also in the same line. They explain that "Salcobrand provided clear signals that it was entirely decided to raise prices, run the risk that the other players would not follow, and maybe lose market share, but someone had to be the first and unambiguously conveyed to the affected manufacturers that it would be the first to raise prices." (75 Observations. Salcobrand, p. 83)

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

[15] Importantly, the other pharmacies realized Salcobrand's new intentions. As a former Fasa board member explained, "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." Deposition of Pablo Lamarca. 75 Observations. Salcobrand, p. 64. Notice the similarity to reputation effects of, for example, Kreps and Wilson (1982). Similarly, as quoted in Alé Chilet (2017), a former Cruz Verde board member noted that "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 (…)" Deposition of Fernándo Suárez Laureda. Observations to the evidence. NEP, p. 224.

[16] These are similar reasons to the ones given by Clark and Houde (2013) to explain price leadership by a group of firms. Salcobrand attributes Fasa's willingness to fight the price war explicitly to Fasa's profits

tail industries, economies of scale and of density cause marginal costs to decrease as the number of stores increase (e.g., Jia 2008, Holmes 2011). Thus, Salcobrand's competitors were in a better position to continue the price war due to their higher cash stock and 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."[17]

3 Theoretical Framework

In this section I suggest a theoretical framework of collusive price leadership based on the institutional settings of the industry at the time. The main difference with most previous explanations of price leadership is that I introduce asymmetric information. In the model there are two firms: an incumbent firm, whose discount factor of 1 is public information; and an entrant, whose discount factor—its type—is its own private information. If type information were public and the discount factor of the entrant is high enough, the two firms would set collusive prices. Yet, asymmetric information precludes immediate collusion.

One way by which the entrant can reveal its discount factor is entering into a price leadership game with the incumbent and raise its prices unilaterally to collusive levels. Although these unilateral increases are costly, if the entrant's discount factor is high enough, the entrant can take leadership upon itself because leadership may allow the entrant to reveal its private information. Then, the incumbent can follow and raise its own prices after a certain number of time periods. If the time the incumbent waits is high enough, only entrant's types whose discount factor is high enough would accept entering into the leadership game. Therefore, leadership is individually rational only for high types.[18]

I claim that the features of the model capture the reasons for Salcobrand's leadership in a better way than alternative explanations. Also, the model points out at a fundamental issue in collusion, namely, the firms' beliefs at the onset of coordination, and highlights how price leadership can be used to signal the leader's willingness to collude. Finally, the model provides an interpretation of the large heterogeneity of the time it takes the

abroad (75 Observations. Salcobrand, p. 64).

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

[18] Previous work has rationalized the market share transfer to the followers 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).

pharmacies to collude in each product. This last point will be discussed in more detail in Section 6.

The Model

Consider two firms denoted by A and B, which play an infinitely repeated price setting game on differentiated products. The firms sell to consumers who buy every period and who have no outside option. Suppose there are only two possible price levels the firms can set: the competitive Nash price p^N, and the collusive price p^C, where $p^N < p^C$. Prices are perfectly observed. The firms are asymmetric in size, such that if firms set the same price, Firm A's market share is α, and Firm B's share is $1-\alpha$. In addition, if there is a difference in the firms' prices the cheapest firm steals $\lambda = \nu\alpha(1-\alpha)$ share of consumers from the more expensive firm, where ν denotes the degree of price sensitivity. This functional form is similar to the prediction of what the change in market shares would be in a logit demand model.[19] In addition, λ is high enough such that if one firm sets the collusive price, a myopic competitor would prefer to set the competitive price.[20] Finally, firms have the same marginal cost, which is normalized to 0.

The model introduces incomplete information on one of the firms' discount factor, which defines its type. Accordingly, firms know the type distribution, but the type realization of one of the firms is its own private information. Firm B is an established player whose discount factor is close to 1, which is public information. On the other hand, Firm A's discount factor δ is distributed between 0 and 1 with probability p, and is 0 with probability $1-p$. Moreover, only if δ is higher than a critical discount factor δ^*, the collusive price can be sustained by the two firms. If $\delta > \delta^*$, then A is a collusive type.

Suppose that until $t = 0$ the two firms have set a price p^N. How can the firms collude? I will focus on cases where the probability $1-p$ that Firm A's discount factor is zero is high enough. This implies that Firm B does not undertake a unilateral price increase hoping that the competitor will follow suit because the expected profits from doing so are negative. Consider, therefore, the following collusive mechanism: At $t = 0$ Firm B offers to raise prices T periods after Firm A price increase. If Firm A accepts the offer, Firm A increases its price to p^C immediately. If the price increase is maintained over time, Firm B matches the price increase at a time T. Otherwise, Firm B never raises price. On

[19] The logit demand implies that λ is highest when Firm A's market share α is in a medium range. I provide empirical support for this assumption in Section 6 and in the Appendix. The fact that $\alpha > \lambda$ implies $\nu(1-\alpha) < 1$.

[20] The assumption implies that $\nu\alpha > (p^C - p^N)/p^N$.

the other hand, if Firm B does not increase its price by time $t = \bar{T}$, Firm A decreases its price back to p^N forever. This setting determines a game in which the strategy of Firm A consists of choosing a maximum waiting time of $\bar{T} \in [0, \infty)$ and the strategy of Firm B consists of a time by which to raise price $T_B \in [0, \infty)$, $T_B \leqslant T$. The credibility of the offer T will be discussed further below.

The following proposition states the individual rationality constraint for which Firm A will accept Firm B's offer.

Proposition 1. *Firm A leads a price increase that is followed by Firm B at $t = T$ iff*

$$\delta^T > 1 - \frac{1}{\nu(1-\alpha)} \frac{p^C - p^N}{p^C} \tag{1}$$

Proof. The condition that Firm A prefers to follow the collusive mechanism than to continue setting price p^N is

$$\sum_{t=0}^{T-1} \delta^t (\alpha - \lambda) p^C + \sum_{t=T}^{\infty} \delta^t \alpha p^C > \sum_{t=0}^{\infty} \delta^t \alpha p^N$$

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

from which the proof follows immediately, after substituting $\lambda = \nu\alpha(1-\alpha)$. □

The inequality in Proposition 1 establishes a negative relationship between Firm A's discount factor δ and the time it is willing to wait.[21] Therefore, an increasingly higher waiting time T will be sustained only by higher types of Firm A. This implies that if T is large enough, Firm A will truthfully convey a lower bound of its discount factor to Firm B. In particular, there exists T such that Firm A can convey that it is a collusive type. However, Firm A prefers a low T. Indeed, if T is too high, Firm A will prefer not to engage in price leadership due to the costs associated with this. Conversely, Firm B has the incentive to choose a high T, because of the profit transfer it receives. These opposing forces are formalized in the following corollary.

[21] I assume that the inequality is informative, that is, the right hand side is positive. This is a necessary condition for the existence of the suggested equilibrium. The RHS is positive when $\nu(1-\alpha) > (p^C - p^N)/p^C$. Note that the RHS is always smaller than 1.

Corollary 1. *Any T such that*

$$T \in \left(\frac{\ln\left(1 - \frac{1}{\nu(1-\alpha)} \frac{p^C - p^N}{p^C}\right)}{\ln \delta^*}, \frac{\ln\left(1 - \frac{1}{\nu(1-\alpha)} \frac{p^C - p^N}{p^C}\right)}{\ln \delta} \right)$$

will result in a partially separating equilibrium where only collusive types of Firm A will lead the increase.

The firms' relative bargaining power and the probability distribution of δ will determine which particular value in the interval is going to be ultimately chosen. For example, if Firm B makes take it or leave offers, Firm B has all the bargaining power and will choose a higher T. Yet, it is stopped short of extracting the full ex-post surplus due to the uncertainty about A's true discount factor.

Moreover, notice that the bounds are increasing in Firm A's market share α as a result of the logit assumption.[22] This implies that Firm B takes more time to follow a if Firm A is larger because the signaling costs of truthful reveleation are increasing with Firm A's size. This would explain the empirical finding I present in Section 6 that the market share of the largest firm, Cruz Verde, is negatively correlated with the time it takes the firms to raise prices.

Finally, collusion among the pharmacies occurred over multiple products and was gradual over products over time. The model can be extended to a setting in which Firm B does not perfectly learn Firm A's type after succeeding to collude in one product. This might be, for example, because Firm B follows Firm A's price increase at a time period lower than T's lower bound, and takes the risk of being undercut provided that this risk is low. Even though I do not find evidence that the time between the price increases decreased over time, learning over time is consistent with findings in Alé Chilet (2017) that the pharmacies' monitoring of the collusive increases declined over time, which suggests fewer cheating concerns as time passed. In addition, the fact that there were multiple products in reality, might serve to make Firm B's proposal credible, as deviation from T may result in collusion impeded in other products.

[22] 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 for the three drugstore chains obtained from the Competition Tribunal of Chile. They include every consumer purchase of the 222 brands that the pharmacies were accused to be colluding on between 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.[23] 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. Finally, I define coordinated price increases as instances in which the three pharmacies raised prices within ten days from each other.[24]

5 Price Leadership Regimes over Time

In this section I study how price leadership varies with the industry's different competitive regimes. I analyze the interaction of the dynamic pricing strategy of the pharmacies with each other, imposing as little structure as possible. The main finding is that the coor-

[23] 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.

[24] Moreover, I consider only large price increases where the list price rose by at least 15 percent, or by more than 1,500 Chilean Pesos, roughly equivalent to $3, during the coordination stage. I do not have explicit evidence that all of these price increases were coordinated by means of explicit messages. However, this term seems the most suitable one.

dinated price increases feature very distinct leadership patterns from other price changes. In particular, while the price leader throughout the period was Cruz Verde, Salcobrand emerges as the price leader during the transition to collusion.

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, which is precisely price leadership, and how these patterns varied over time.[25]

With some abuse of notation, let Δp_{ijt} be the percentage price change of brand i in pharmacy j at time t with respect to the previous time period, and $Y_{it} = \left[\Delta p_{i1t}, \Delta p_{i2t}, \Delta p_{i3t}\right]'$ the vector of price changes at the three pharmacies. 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 λ_i is a fixed effect for brand i, and $f(t)$ is a cubic polynomial of time. The coefficients β_τ capture the price response to the lagged own and competitors' prices. For estimation to be consistent, $E\left[\epsilon_t \epsilon_t'\right] = \Omega$, and $E\left[\epsilon_t \epsilon_\zeta'\right]$=0 for $t \neq \zeta$.[26]

In the estimation I use weekly data to avoid serial correlation issues and I include two lags of prices differences. I present separate regressions results for each pharmacy 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.

Table 1 present the results. There are three main findings that suggest a change in the nature of price leadership during the coordination period. First, during coordination, the price response to competitors' price changes increased. Yet, the coefficient of Salcobrand's price changes on the price equation of the other pharmacies is almost seven times larger during coordination, while that of the other pharmacies increases two or three times. This shows that the pharmacies followed Salcobrand much more closely during

[25] An alternative strategy would consist of looking at time windows around price changes, such as the one presented in Panel (a) of Figure 1. During the coordinated price increases the order in price increases this is straightforward, as in most cases the three pharmacies raised prices within days of each other. However, such clear patterns occurred only during the coordination period, and thus this approach is not feasible for the other periods.

[26] Given that the average number of time periods in each regression is at least 20, the Nickell (1981) bias introduced by the fixed effects λ_i should be small (see Judson and Owen, 1999).

Table 1 – 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

the coordinated price increases. Second, although Salcobrand responds to its competitors' lagged price changes, the coefficient during the coordination period is almost zero, which means that Salcobrand did not follow the other firms' prices during the collusive price increases. Finally, excluding coordinated price changes (Columns 7 to 9) results in almost the same coefficients as those during the price war and post-coordination, so that the findings described above no longer hold. This finding is stronger if all instances of large price increases (>15 percent) are excluded from the estimating sample (the results are not reported). Thus, Salcobrand's leadership occurs almost exclusively during the coordinated increases.[27]

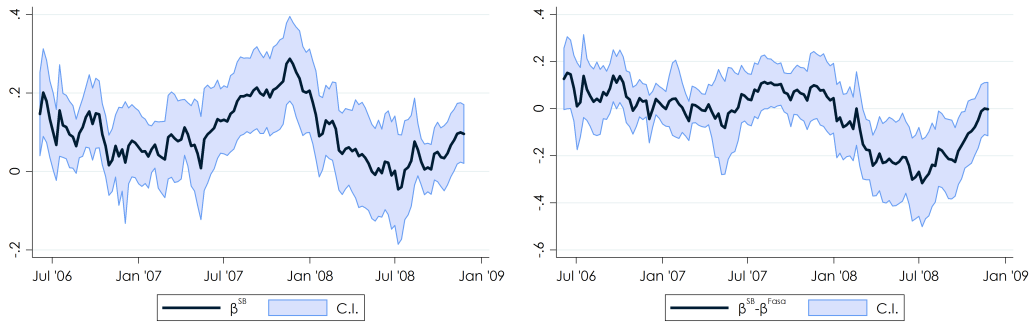
In addition to the analysis for the three periods above, I estimate Equation (2) in 20-week rolling window regressions, the results of which I present in Figure 3.[28] The aim of these regressions is to show the change in Salcobrand's pricing behavior over time. Panel (a) shows Salcobrand's price response to Cruz Verde's lagged price changes, which I calculate as the sum of the coefficients of Cruz Verde's two lagged prices in Salcobrand's price regression. 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's or also in that of Fasa's, Panel (b) compares Salcobrand's and Fasa's price responses to Cruz Verde's price. In particular, the Panel plots the difference between Salcobrand's and Fasa's pricing responses to Cruz Verde's lagged price changes. The difference in the coefficients is not significantly different from zero throughout the price war and the post-collusive period. This shows that Salcobrand followed Cruz Verde in most of the period in a similar way as Fasa did. However, during coordination Salcobrand *stopped* following Cruz Verde's prices. Because Fasa's tendency to follow Cruz Verde did not change during the period of coordinated increases, the difference 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.

To summarize, the analysis shows two types of leadership in the period under study.

[27] It is not clear from Table 1 whether Cruz Verde or Fasa is the price leader. Yet, testimonies gathered in the case suggest that Cruz Verde is more likely the price leader. 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). Fasa's CEO also claimed that Fasa's pricing strategy was one of "price followers of [its] two competitors" (75 Observations, p. 52. Salcobrand.). Similarly, Salcobrand's defense lawyers claimed that in the price war period "the rules were set by Cruz Verde, [Fasa] responded, and Salcobrand wasn't even considered a relevant player." (75 Observations, p. 80. Salcobrand.)

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

Figure 3 – Price Leadership of Cruz Verde over Time



(a) Salcobrand's price response to a price change of Cruz Verde

(b) Difference in Salcobrand's and Fasa's price responses to a price change 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.

In the first one, *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. This mechanism was instrumental in the shift from the loss-leading equilibrium to the coordinated one. The 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 was a follower of Cruz Verde's, the dominant firm, as we would expect from the abundant literature on competitive price leadership. Yet, during coordination, Salcobrand *stopped* responding to the other firms' price changes. Strong price leadership by the small firm, therefore, only occurred in the coordinated transition to the new equilibrium.

6 Outcomes of Collusive Leadership

I have shown 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

price leadership during the coordinated transition to higher prices. In particular, the next subsections delve further into the time it took followers to follow the leader, the order followed by the firms, and the costs of leadership.

Duration of price increases

This subsection studies the time it took the followers to match the leader's prices. Time is an important outcome because, as can be expected and is documented below, price increases that took longer were more costly for the leader.

Panel (*a*) of Figure 4 plots the time it took the two followers to follow the leader's increase against Cruz Verde's market share in each product. The plot shows a strong negative correlation between the following time and Cruz Verde's market share. In other words, the larger Cruz Verde was, the less time it took Cruz Verde itself and Fasa to follow the leader.

The following empirical specifications check whether the result of the effect of market asymmetry is robust to the inclusion of covariates. I look at the effect on two dependent variables: the total delay, that is, the time it took the last firm to raise prices after the leader's increase; and the intermediary delays, which are the time spanned between the first and the second, and between the second and the third firm to raise prices. 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 2 presents the estimates of regressions of the log number of days it takes the firms to match the leader's increases (usually Salcobrand's). Most specifications measure firm dominance using the range of shares between Cruz Verde and Salcobrand, but I also show results when using Cruz Verde's market share. Column (1) shows the correlation between the range of shares and the increase time, which is very significant. Column (2) adds a dummy variable for instances of ties between the second and the third firm to raise prices and shows that when the followers were tied, price increases took considerably less time. Column (3) controls for market size. The effect of market size is positive, which means that collusion took more time when markets are larger. Column (4) includes in the regression Cruz Verde's market share directly. In addition, 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 was the last firm to raise price. They also show that the effect of market size is mostly derived for brands

Table 2 – Time of Coordinated Increases

	Dependent Variable: ln Time of Price Increases [Days]						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Range of Shares	-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. The variable *Range of Shares*corresponds to the difference in market shares between Cruz Verde and Salcobrand. 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

in which Fasa was the last firm to raise price. Column (7) presents 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.

Next, I study the time spanned by the intermediate increases of the first and the second firm, and that of 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 3. These reveal a similar effect of Cruz Verde's dominance, as measured by the range of shares, on intermediate increases. Column (1) shows the time between the first and the third firm to raise prices, mimicking the analysis in Table 2. Columns (2) to (5) estimate the effect of Cruz Verde's dominance on the time spanned between the leader's and the first follower's increase. Column (3) also includes a dummy variable indicating 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. Columns (4) and (5) separate products according to the pharmacy that moved last. Finally, Columns (6) to (8) analyze the time spanned between the first and the second follower, considering ties as cases in which the dependent variable is zero.

The results, both those of the total and the intermediary delays, reveal a strong dominant firm effect, similar to that found in the previous subsection, by which collusive leadership in markets where the dominant firm is larger takes more time. This finding is consistent with the prediction of the leadership model of Section 3 that a less dominant follower delays more its price increase. The reason for this is that in these cases truthful information is more costly for the leader to convey and, thus, require a larger following time.

Determining the Order in Price Followship

Salcobrand was the leader in most coordinated price increases, while the other two chains took turns being the second and third mover. Table 4 shows the number of times in which each firm was the first, second, and third mover, including instances in which two firms raised prices simultaneously. From this preliminary evidence, it would seem

Table 3 – Time of Coordinated Increase – Intermediate Increases

	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	-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
Pseudo LL	-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

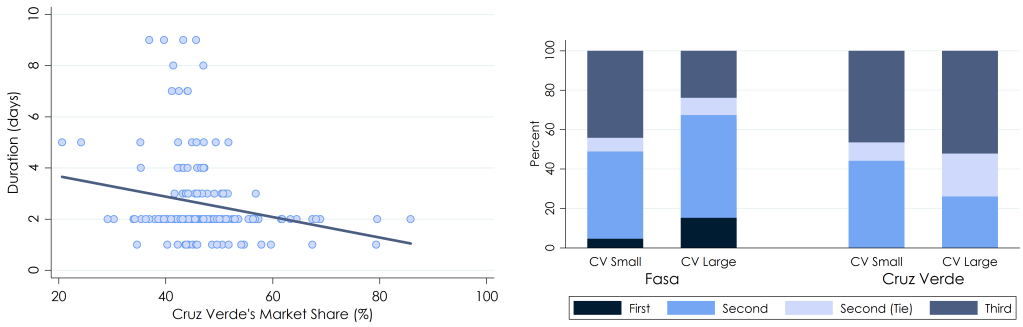
Note: The table present results of Poisson regressions. The dependent variable is measured in days. I exclude a few instances of two firms raising price first simultaneously. The variables *Range of Shares* corresponds to the difference in market shares between Cruz Verde and Salcobrand. All specifications include a quadratic time trend. Standard errors in parentheses are clustered at the brand level. * p<0.1, ** p<0.05, *** p<0.01

Table 4 – 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.

Figure 4 – Order of Move and Duration of Coordinated Price Increases



(a) Duration of Price Increases

(b) Order of Move

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.

that the two followers randomized their position.[29] However, as I will show next, movement among the two followers is highly correlated with Cruz Verde's market share. To see this, Panel (b) of Figure 4 presents the number of times in which Fasa and Cruz Verde were the first, second, tied second, and third firm to increase prices for two different sets of products. 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).[30] The Figure shows quite clearly that when Cruz Verde was relatively larger, Fasa tended to move earlier and Cruz Verde tended to move later.

In order to check whether the effect of Cruz Verde's market dominance on price leadership is statistically significant, I estimate ordered probit models where the dependent variable is the order in which each pharmacy increases price. As Salcobrand was the price leader in the vast majority of coordinated increases, I limit the analysis to the order fol-

[29] 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 to enhance cooperation when the different outcomes do not result in large differences in payoffs (Kaplan and Ruffle, 2012).

[30] 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.

lowed by the other pharmacies, Cruz Verde and Fasa. I measure Cruz Verde's dominance using three different measures of market asymmetry: the range of shares between Cruz Verde and Salcobrand (the difference in their average market shares in the two months before coordination begins); Cruz Verde's own average market share; and the dummy variable *Dominant*, which indicates brands in which Cruz Verde's market share was 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 as to exclude price effects from the market size calculation. I deal with ties, where two firms increased prices in the same day, 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 (which is why the number of observations vary between the two pharmacies).

I show the results in Table 5. Columns (1) to (4) present the results for Fasa, and Columns (5) to (8) present 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 statistically significant. The results for one pharmacy are not the mirror image for the other one because Salcobrand is not always the leader. In addition, using 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 closer substitutes of one another. Thus, when one firm increases price first in more homogenous markets, the market stealing effect is stronger (see Section 6), which suggests that the pharmacies followed the price leadership mechanism more closely in markets in which leadership was more costly.

The previous results 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 larger market share.[31]

[31] 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.

Table 5 – 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	-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)		
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. The variables *Range of Shares* and *Dominant* correspond to the difference in market shares between Cruz Verde and Salcobrand and to a dummy variable indicating whether Cruz Verde had a market share larger than 50 percent, respectively. Standard errors clustered at the brand level in parentheses. * p<0.1, ** p<0.05, *** p<0.01

The Costs of Price Leadership

The price increases during coordination were a result of loss leading pricing and of supply side changes at the industry level. Hence, they were exogenous to demand. This provides a good opportunity to study the costs associated with a firm taking the leadership position.[32] In this subsection I present evidence that leadership was costly for the firms and was, therefore, an outcome the pharmacies were concerned with. Admittedly, the large difference in retail prices across pharmacies lasted only a few days. Thus, given an inelastic demand for the pharmacies, the loss in sales in these days 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 persistent effect in the demand that lasted for more than a month.

The lack of consumer level data precludes a full estimation of the dynamic effects of price increases on the demand (as in Dubé, Hitsch, and Rossi, 2010, for example). Hence, my empirical strategy consists of estimating 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 for all the brands. Let the dummy variables *First*, *Second*, and *Third* indicate if the firm was the first, second, or third firm to increase price in a coordinated manner, respectively, during the previous weeks. The main specifications estimate the following regression:

$$\ln Sales_{ijt} = \beta_0 + \beta_1 \Delta \ln p_{ijt} + \theta_1 First + \theta_2 Second + \theta_3 Third + \lambda_i + \mu_j + \delta_t + \epsilon_{ijt}, \quad (3)$$

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. Given the ties, these variables are not perfectly collinear and, therefore, I can include them all in the regressions. 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 (3) for

[32] Harrington (2006) notes the large profit transfers among the firms in some European cartels that employed price leadership during the time period between the increases.

November 2007 to June 2008. In addition, δ_t controls for aggregated time-specific demand shocks.

The identification of the leadership effects comes from the fact that the coordinated increases used to define the leadership indicators 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 cannot be undone by means of unilateral, uncoordinated price changes because, in those cases, firms may respond endogenously. A possible concern is that the the order of the firms was not random. However, if the firms were minimizing the inter-firm transfers of consumers due to leadership, as could be suggested by Salcobrand's leadership position, the estimates would provide a lower bound of the effect.[33] I exclude the contemporaneous effect by dropping the weeks when the price increase occurs from the estimating sample.

Table 6 shows the results of various specifications of the estimation of Equation (3). All regressions include brand, week, and pharmacy fixed-effects, 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 Columns (2) to (8) it is measured by the pharmacy's market share, either in logs or in levels. Column (2) is the baseline specification. The results suggest that the price follower's market share rose on average 5 percent as a result of a coordinated increase. I also show in the Appendix that when the model shown in Column (2) is estimated for each brand separately, the transfers due to leadership in each brand are increasing with respect to Cruz Verde's market share, but concave. This finding provides support to the logit functional form used in Section 3. In addition, Columns (3) to (7) of Table 6 present estimates for different subsets of the data. They show that the transfer of market shares are higher in price increases that take three days or more (Column 3); for Fasa and Salcobrand (Column 4); in more homogenous products, as measured by the top half distribution of the cross elasticities estimated in Alé Chilet (2017) (Column 5); and for markets in which Cruz Verde is less dominant (Column 6). Column (7) shows that the results are robust when looking only at products in which there was a coordinated price increase. Column (8) measures the dependent variable in levels and shows that the follower gains a 1 percent market share (in absolute values) after a coordinated price increase.

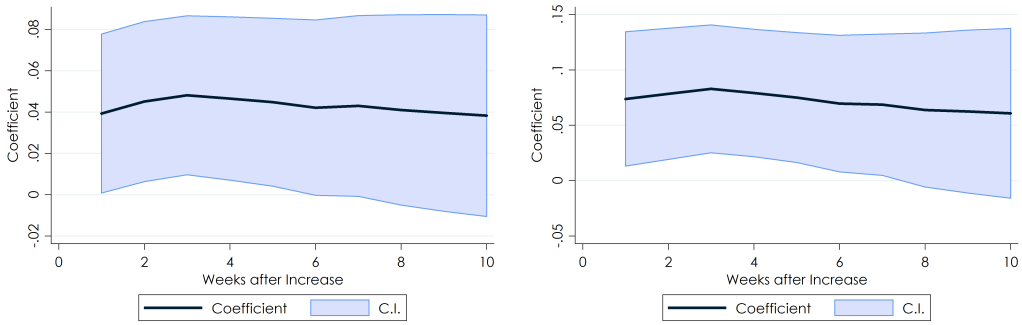
[33] Another possible concern is the lack of data on product advertising, since competitors advertising may counteract own brand loyalty effects (Shum, 2004). Yet, if the leader ramps up advertising after a price increase, my estimates also provide a lower bound of the cost of leadership. However, I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

Table 6 – The Costs of Price Leadership

	Ln Units Sold	Ln Market Share						Share
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
First	-0.030	-0.030	-0.044	-0.087***	-0.068**	0.027	-0.002	-0.011*
	(0.025)	(0.023)	(0.036)	(0.018)	(0.034)	(0.025)	(0.013)	(0.007)
Second	0.006	-0.001	-0.020	0.068***	-0.016	-0.027	-0.013	-0.002
	(0.025)	(0.019)	(0.028)	(0.022)	(0.031)	(0.026)	(0.016)	(0.006)
Third	0.052*	0.047**	0.071**	0.139***	0.079***	0.032	0.030*	0.011*
	(0.026)	(0.020)	(0.031)	(0.020)	(0.029)	(0.028)	(0.016)	(0.006)
Δ ln Price	-1.356***	-1.345***	-1.673***	-1.408***	-1.780***	-1.201***	-0.774***	-0.370***
	(0.238)	(0.238)	(0.315)	(0.164)	(0.407)	(0.310)	(0.157)	(0.068)
Constant	5.304***	-1.429***	-1.417***	-1.340***	-1.436***	-1.574***	-1.449***	0.259***
	(0.031)	(0.029)	(0.046)	(0.008)	(0.045)	(0.028)	(0.016)	(0.009)
Brand, Week, Pharmacy F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample	All	All	Lengthy Increases	Fasa, SB	Homog.	Cruz Verde Dominant	Coordinated Increases	All
N	22575	22575	11322	15050	12372	11244	15810	22575
R-squared	0.350	0.391	0.320	0.138	0.399	0.243	0.550	0.475
No. of Brands	221	221	110	221	121	110	156	221

Note: The table shows the results of the estimation of Equation (3). 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 4 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 markets in which Cruz Verde was more dominant, that is, brands in which it had a market share higher than the median of the distribution. 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

Figure 5 – The Costs of Leadership 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.

In addition to the results above, I also estimate the varying persistence of the leadership effect on market shares over time. For this purpose, in the next specifications the variables *First*, *Second*, and *Third* indicate an increasingly large number of time periods after the coordinated price increase. Consequently, the coefficients of these variables indicate, respectively, what the effect of being the first, second, and third mover today will be in the firm's market share in an increasingly large number of weeks in the future, thus capturing the cumulative effect of leadership over time. I show the estimates of the coefficient of *Third* in Figure 5. Panel (a) shows the results for all the brands and Panel (b) those for more homogeneous markets (similar to the specification of Columns 2 and 7 of Table 6, respectively). 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.

Overall, the findings suggest the presence of store persistence or dynamic linkages across demand in different periods that make consumers choose pharmacy based on their last purchases.[34] These dynamic effects generate larger costs of leadership than

[34] Therefore, such demand linkages make temporary price changes have medium run effects. For example, these effects appear in a model where consumers buy drugs once a month from their preferred drugstore. However, if faced with a price increase, some consumers 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. In addition, the persis-

those that could have been expected from the short price differences among the firms. This fact has important implications for my analysis. This is, first and foremost, because large costs suggest a trade off between the profits from ending the price war and the costs of being the first to raise prices, in a similar way as in a war of attrition. Second, leadership implies a profit transfer among the firms, which relates to market share allocation from the weakest to the strongest firm observed in many antitrust cases. Finally, the costs of leadership have a more general implication for models of collusion. When almost perfect monitoring is available, as in the pharmacies' case, positive gains from undercutting the cartel are very small. This makes cheating unlikely. However, in the presence of persistence in the demand, which is common in consumer markets, deviation might still be worthwhile because the gains will endure long after deviation is detected.[35]

7 Conclusion

This paper is the first empirical study of price leadership during a case of collusion. It documents different leadership regimes in the same industry over time. Moreover, these regimes correspond with the predictions of theoretical models of leadership. I explain the outcomes of leadership patterns, mainly the time it took the followers to match the leader's price increase, using variation in market structure. The main results are that the firms' order of move is explained by each firm's market share, and that in markets where the largest firm was relatively larger, collusion happened faster.

There are three points I would like to note. First, the stark change in price leadership patterns coincide with the transition from a price war to collusion. This is an important fact, because changes in price leadership may suggest a change in firms conduct and could, potentially, be used by antitrust authorities to screen for anticompetitive behavior.

Also, the findings of this paper suggest that the firms used an intricate mechanism to collude and that price leadership played a central role. There is a renewed interest in the ways in which leadership facilitates the emergence of collusion, both with explicit coordination and with tacit understanding. Yet, much much work still needs to be done

tence of brand market shares has been attributed to loyalty by Dubé, Hitsch, and Rossi (2010). Eizenberg and Salvo (2015) highlight the role of entry of new consumers into a market with persistance in the demand. Bronnenberg, Dubé, and Gentzkow (2012) provide evidence on the long-run effects of brand preferences.

[35] Subcompetitive pricing à la Abreu, Pearce, and Stacchetti (1986), which might deter more profitable deviations, do not seem to occur in reality. See Levenstein and Suslow (2006), and also Genesove and Mullin (2001) and Levenstein (1997) for analyses of specific cases.

to understand the mechanisms by which this happens.This suggests that one direction for further study is the relationship between price leadership and the role of communication in collusion. I argue here that leadership helps collusion by conveying information on the firms' willingness to collude. However, the collusive price increases were explicitly coordinated and, hence, price leadership too. Recent empirical work suggests that it is mostly the dominant firm the one that can lead the industry to higher margins when firms do not communicate with each other. Hence, the case of the Chilean pharmacies seems to indicate that price increases led by the smallest firm in a market is either too costly or not credible enough in the absence of communication.

References

[1] Abreu, Dilip, David Pearce, and Ennio Stacchetti. "Optimal cartel equilibria with imperfect monitoring." Journal of Economic Theory 39.1 (1986): 251-269.

[2] Admati, Anat R., and Motty Perry. "Strategic delay in bargaining." The Review of Economic Studies 54.3 (1987): 345-364.

[3] Alé Chilet, Jorge. "Gradually rebuilding a relationship: The emergence of collusion in retail pharmacies in Chile." Working paper (2017).

[4] Asker, John. "A study of the internal organization of a bidding cartel." The American Economic Review 100.3 (2010): 724-762.

[5] Bae, Hyung. "A price-setting supergame between two heterogeneous firms." European Economic Review 31.6 (1987): 1159-1171.

[6] Bronnenberg, Bart J., Jean-Pierre H. Dubé, and Matthew Gentzkow. "The evolution of brand preferences: Evidence from consumer migration." The American Economic Review 102.6 (2012): 2472-2508.

[7] Byrne, David, and Nicolas De Roos. "Learning to coordinate: A study in retail gasoline." Working paper (2016).

[8] Clark, Robert, and Jean-François Houde. "Collusion with asymmetric retailers: Evidence from a gasoline price-fixing case." American Economic Journal: Microeconomics 5.3 (2013): 97-123.

[9] Cooper, David J. "Barometric price leadership." International Journal of Industrial Organization 15.3 (1997): 301-325.

[10] Davies, Stephen, and Oindrila De. "Ringleaders in larger number asymmetric cartels." The Economic Journal 123.572 (2013): F524-F544.

[11] Deneckere, Raymond J., and Dan Kovenock. "Price leadership." The Review of Economic Studies 59.1 (1992): 143-162.

[12] Dubé, Jean-Pierre, Günter J. Hitsch, and Peter E. Rossi. "State dependence and alternative explanations for consumer inertia." The RAND Journal of Economics 41.3 (2010): 417-445.

[13] Eizenberg, Alon, and Alberto Salvo. "The Rise of Fringe Competitors in the Wake of an Emerging Middle Class: An Empirical Analysis." American Economic Journal: Applied Economics, 7.3 (2015): 85-122.

[14] Erdem, Tülin. "A dynamic analysis of market structure based on panel data." Marketing science 15.4 (1996): 359-378.

[15] Genesove, David, and Wallace P. Mullin. "Rules, Communication, and Collusion: Narrative Evidence from the Sugar Institute Case." American Economic Review (2001): 379-398.

[16] Harrington Jr, Joseph E. "Collusion among asymmetric firms: The case of different discount factors." International Journal of Industrial Organization 7.2 (1989): 289-307.

[17] Harrington Jr, Joseph E. "The determination of price and output quotas in a heterogeneous cartel." International Economic Review (1991): 767-792.

[18] Harrington Jr, Joseph E. "How do cartels operate?" Foundations and Trends® in Microeconomics 2.1 (2006): 1-105.

[19] Harrington, Joseph E., and Wei Zhao. "Signaling and tacit collusion in an infinitely repeated Prisoners' Dilemma." Mathematical Social Sciences 64.3 (2012): 277-289.

[20] Harsanyi, John C., and Reinhard Selten. "A general theory of equilibrium selection in games." MIT Press Books (1988).

[21] Holmes, Thomas J. "The Diffusion of Wal-Mart and Economies of Density." Econometrica 79.1 (2011): 253-302.

[22] Ishibashi, Ikuo. "Collusive price leadership with capacity constraints." International Journal of Industrial Organization 26.3 (2008): 704-715.

[23] Jia, Panle. "What happens when Wal-Mart comes to town: An empirical analysis of the discount retailing industry." Econometrica 76.6 (2008): 1263-1316.

[24] Judson, Ruth A., and Ann L. Owen. "Estimating dynamic panel data models: a guide for macroeconomists." Economics letters 65.1 (1999): 9-15.

[25] Kaplan, Todd R., and Bradley J. Ruffle. "Which way to cooperate." The Economic Journal 122.563 (2012): 1042-1068.

[26] Keane, Michael P. "Modeling heterogeneity and state dependence in consumer choice behavior." Journal of Business & Economic Statistics 15.3 (1997): 310-327.

[27] Kreps, David M., and Robert Wilson. "Reputation and imperfect information." Journal of Economic Theory 27.2 (1982): 253-279.

[28] Lewis, Matthew S. "Price leadership and coordination in retail gasoline markets with price cycles." International Journal of Industrial Organization 30.4 (2012): 342-351.

[29] Levenstein, Margaret C. "Price Wars and the Stability of Collusion: A Study of the Pre-World War I Bromine Industry." The Journal of Industrial Economics 45.2 (1997): 117-137.

[30] Markham, Jesse W. "The nature and significance of price leadership." The American Economic Review (1951): 891-905.

[31] Marshall, Robert C., Leslie M. Marx, and Matthew E. Raiff. "Cartel price announcements: The vitamins industry." International Journal of Industrial Organization 26.3 (2008): 762-802.

[32] Marshall, Robert C., and Leslie M. Marx. The economics of collusion: Cartels and bidding rings. MIT Press, 2012.

[33] Miklós-Thal, Jeanine. "Optimal collusion under cost asymmetry." Economic Theory 46.1 (2011): 99-125.

[34] Nichol, Archibald J. "Partial monopoly and price leadership: a study in economic theory." Press of Smith-Edwards Company, 1930.

[35] Nickell, Stephen. "Biases in dynamic models with fixed effects." Econometrica: Journal of the Econometric Society (1981): 1417-1426.

[36] Nuñez, Javier, Tomas Rau, and Jorge Rivera (2010). Expert Report, Chilean National Economic Prosecutor, Case No. 184-2008.

[37] Mouraviev, Igor, and Patrick Rey. "Collusion and leadership." International Journal of Industrial Organization 29.6 (2011): 705-717.

[38] Obara, Ichiro and Zincenko, Federico. "Collusion and heterogeneity of firms." The RAND Journal of Economics, 48 (2017): 230–249.

[39] Porter, Robert H. "A study of cartel stability: The Joint Executive Committee, 1880-1886." The Bell Journal of Economics (1983): 301-314.

[40] Seaton, Jonathan S., and Michael Waterson. "Identifying and characterising price leadership in British supermarkets." International Journal of Industrial Organization 31.5 (2013): 392-403.

[41] Röller, Lars-Hendrik, and Frode Steen. "On the workings of a cartel: Evidence from the Norwegian cement industry." The American economic review (2006): 321-338.

[42] Rotemberg, Julio J., and Garth Saloner. "Collusive price leadership." The Journal of Industrial Economics (1990): 93-111.

[43] Shum, Matthew. "Does advertising overcome brand loyalty? Evidence from the breakfast-cereals market." Journal of Economics & Management Strategy 13.2 (2004): 241-272.

[44] Spence, Michael. "Job market signaling." The Quarterly Journal of Economics 87.3 (1973): 355-374.

[45] Stigler, George J. "The Kinky Oligopoly Demand Curve and Rigid Prices." The Journal of Political Economy (1947): 432-449.

[46] Stiglitz, Joseph E. "Competition and the number of firms in a market: Are duopolies more competitive than atomistic markets?." Journal of Political Economy 95.5 (1987): 1041-1061.

[47] Van Damme, Eric, and Sjaak Hurkens. "Endogenous Stackelberg leadership." Games and Economic Behavior 28.1 (1999): 105-129.

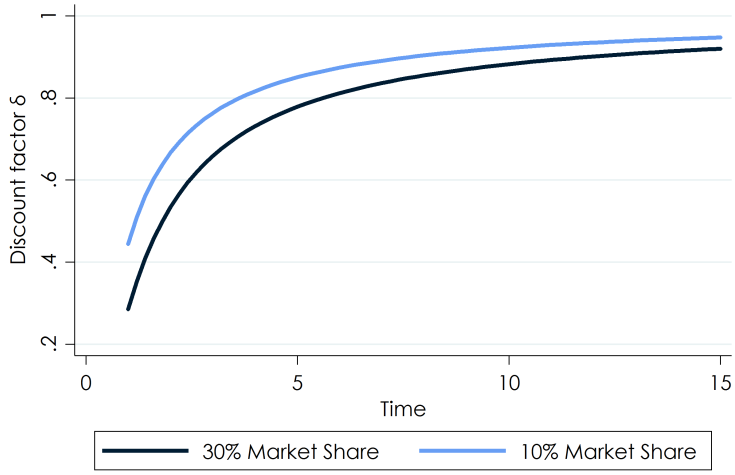
[48] Van Damme, Eric, and Sjaak Hurkens. "Endogenous price leadership." Games and Economic Behavior 47.2 (2004): 404-420.

[49] Weiss, Andrew. "A sorting-cum-learning model of education." Journal of Political Economy 91.3 (1983): 420-442.

Appendix

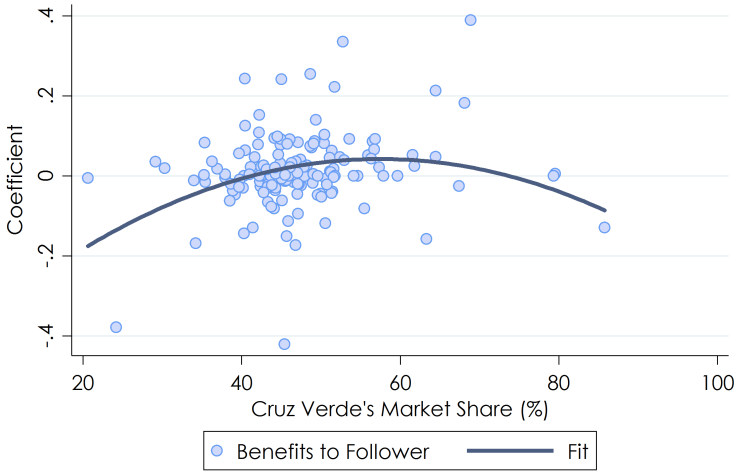
A1 Figures

Figure A1 – Discount Factor Thresholds in the Screening Mechanism



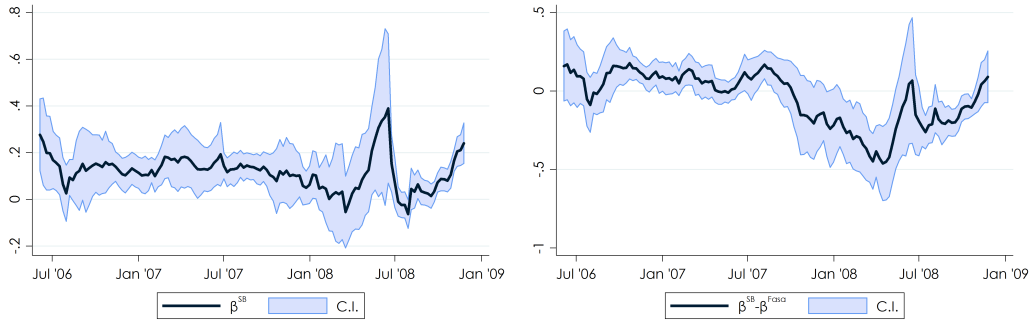
Note: The Figure shows the critical values of the discount factor above which the Leader prefers to lead the price increase $\hat{\delta}$ in the model of Section 3 for two values of the Leader's market shares. $\lambda = \upsilon\alpha(1-\alpha)$, $\upsilon = 1$, and $(p^C - p^N)/p^C = 0.5$.

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 (3) 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. Notice that the fit is positive for market share values between 40 and 60, where most of the distribution mass is. 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.