Segmented Switchers and Retailer Price Promotion Strategies: Theory and Application to Internet Pricing

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Abstract

Empirical studies reveal a surprisingly wide variety of price promotion strategies among retailers, even among Internet sellers of undifferentiated homogenous goods such as books and music CD’s. Several empirical findings remain puzzling, particularly that within the same market some small retailers decide to deeply discount, while other small retailers forgo the price-sensitive switchers and price high to play their niche. We present theoretical and empirical analyses that address these varied pricing strategies. Theoretical models are usually based on asymmetric loyalty between two firms that compete for informed switchers. Our model of three asymmetric firms shows that under multiple switcher segments, where different switchers compare prices at different retailers, firm-specific loyalty is not sufficient to explain the variety of retailer pricing strategies. We demonstrate that a retailer’s pricing is driven by the ratio of the size of switcher segments for which the retailer competes to its loyal segment size. The relative switcher-to-loyal ratios among retailers explain when a firm is more or less inclined to discount deeply or frequently. We thereby identify when a small firm finds it optimal to play the niche and price high, despite having few loyals, or to discount and go for the switchers. Our analysis reveals several interesting findings, such as a small firm that benefits from a greater number of partially informed switchers, even when it cannot sell to them. The empirical results confirm our model’s predictions for varied retailer pricing strategies in a rich set of Internet bookseller price data.

KEYWORDS: Internet Retailing; Price Promotion; Game Theory; Retailer Loyalty; Switcher Segments.
Introduction

Internet retailing offers consumers considerable choice in where to shop and purchase. For example, a search for several products on mySimon.com, a popular price comparison engine, reveals over three dozen retailers for online books, more than 70 retailers offering printers, and over 100 digital camera retailers. Obviously, many of these retailers are “small” relative to the big players in the category. Internet book retailer A1Books, for example, has less than 1% of the reach (number of viewers who visit the site) of Barnes & Noble (B&N) Online. There exist dozens of similarly small Internet booksellers who compete with each other and the considerably larger firms Amazon.com and B&N Online for a wide assortment of books. What characterizes the price promotion strategies among these many retailers, both large and small?

Frequent discounting by small firms is generally consistent with the extant theory (e.g., Narasimhan 1988; Raju, Srinivasan, and Lal 1990). Customers are conceptualized to possess different information for comparison shopping. Customers who know the price of only one retailer are uninformed or loyal customers, while customers who know the prices of all retailers are switchers. Urbany, Dickson, and Kalapurakal (1996) report various reasons why more than half of grocery customers compare prices across retailers, and “cherry-picking” customers tend to benefit going store to store for specials (Fox and Hoch 2005). Since a “small” firm has relatively few loyal customers, it generally has more incentive than a “large” firm to discount and attract the switchers. However, some small retailers decide to price high and sell only to its loyal or niche segment of customers. Although this strategy may be appealing for specialized or highly differentiated goods, it is unclear why a small retailer will price higher than a larger rival for a homogenous good such as a book. Clay, Krishnan, and Wolff (2001) report these types of “puzzling” Internet retailers in their empirical analyses, representing small and undifferentiated firms that, nevertheless, charge relatively high prices. More generally, Internet retailers exhibit considerable price dispersion as firms discount or price high, often in ways inconsistent with theoretical predictions (Pan, Ratchford, and Shankar 2004).
Especially problematic for conventional price promotion theories is why we observe some small retailers with heavy discounting and others with a high-price strategy in the same homogenous goods market. Previewing our empirical study of Internet booksellers, both Worthy and A1Books are “small” retailers with similar Internet reach and site popularity. They sell many of the same books (A1Books carries 90% of the books carried by Worthy in our sample), and also compete with the larger retailers such as Amazon on a wide variety of books. Despite such similarities, A1Books discounts heavily while Worthy has high prices that exceed those of A1Books and Amazon, on average. What explains these fundamental pricing differences among small retailers? How frequently can we expect large retailers to offer shallow or deep discounts? We present theoretical and empirical analyses that examine a variety of observed price promotion strategies, such as in Internet retailing.

We address two fundamental shortcomings of conventional price promotion models: 1) the duopoly structure can be limited in the variety of price promotion strategies that are considered, and 2) switchers are usually assumed homogenous in that they know the prices of all retailers. Retailer price promotion strategies from the standard duopoly approach (“small” vs. “large” retailers) are driven by different loyal segment sizes and homogenous switchers that compare all prices.\(^1\) We present a model of an asymmetric triopoly (three firms) that includes multiple “switcher segments,” where different switchers compare prices at different retailers. Markets involving several asymmetric firms may prove more insightful and reflective of actual market conditions than the conventional duopoly. Furthermore, in the context of multiple retailers, there may exist multiple segments of “partially informed” switchers in addition to the typical switchers who compare prices for all retailers. Even in an Internet setting where retailers proliferate and many shoppers use price comparison engines, not all switchers will be exhaustive price-comparison machines. For example, many online book customers may compare prices among most of the retailers, but other switchers are likely to be unfamiliar with many small

\(^1\) Prior models have been applied to both brand and retailer competition. We model retailers given our focus on homogenous goods, and to be consistent with the context of our empirical setting.
retailers (such as *A1Books*) and compare prices at only the larger firms (like *Amazon* and *B&N*). Recent studies indicate that online shoppers visit only 1.2 to 1.4 booksellers on average (Johnson et al. 2004; Montgomery et al. 2004). Even the use of price-comparison “shopbots” remains relatively low, given the various cognitive costs of evaluating many alternatives (Montgomery et al. 2004). Consumers are more likely to visit Internet retailers they trust based on an assortment of factors (e.g., Bart et al. 2005). If some customers prefer to price compare only among trusted stores, while other customers compare prices from all listed retailers, switcher segments with different types of price-comparison behavior will occur. The realistic assumption, therefore, is that switchers are segmented since they are informed about a subset of retailer prices. By including segmented switchers in an asymmetric triopoly, our model derives a more complete set of promotion strategies that are not predicted under asymmetric duopolies.

Prior theoretical models, based largely on Varian (1980) and Narasimhan (1988), sometimes report varied results for promotional activity. Raju et al (1990) conclude that the average discount offered by the stronger brand (greater loyalty) is larger than the average discount offered by the weaker brand (less loyalty), but Rajiv, Dutta, and Dhar (2002) reach a different conclusion. Findings also differ about price promotion frequency. Narasimhan (1988) and Raju et al (1990) conclude that the promotional frequency of the stronger brand is less than that of the weaker brand.² Rajiv et al (2002) conclude that high-service stores (as an analogue to a strong brand) promote more frequently under promotional advertising. “Small” retailers seem to promote with less intensity, although discount prices may have a higher expected payout to smaller stores (Hoch, Drèze, and Purk 1994; Shankar and Bolton 2004). The “high” versus “low” pricing dichotomy does not often fit the rich promotional strategies observed empirically (e.g., Bolton and Shankar 2003). The need clearly exists for research to address these price promotion variations, particularly for the pricing strategies of “small” retailers.

² Narasimhan (1988) considers several cases where the frequency and depth of discount change, according to switchers’ brand preferences. For homogenous goods we compare to Narasimhan’s (1988) basic results.
By considering a homogenous good market with three firms asymmetric in loyals and switchers, our results clarify the varied price promotion strategies in equilibrium. For example, we show that a firm can adopt a partitioned pricing strategy that combines frequent shallow discounts to compete with one firm with infrequent deep discounts to compete with another firm. Our results also explain when a small firm is better off pricing high with little discounting, despite possessing few loyals. Our analysis reveals several interesting findings, such as a small firm that benefits from a greater number of partially informed switchers, even when it cannot sell to them. In general our model not only encompasses a three-firm extension of prior duopoly models, but also explains previously ambiguous situations, such as when a retailer has both few loyals and few switchers.

Our specific research questions include: How do multiple asymmetric firms compete for multiple switcher and loyal segments? How do firms differ in their price dispersion, including the frequency and depth of their promotions, based on their loyal and switcher customer bases? Why do some small retailers price high, while others offer deep discounts? Our results demonstrate that a retailer’s pricing is driven by the ratio of switchers for which the retailer competes to its loyal segment size. The retailers’ relative switcher-to-loyal ratios explain when a “large” or “small” firm is more or less inclined to discount deeply or frequently, or when a small firm with few loyals is better off pricing high. Our empirical results for Internet bookseller pricing confirm the model’s predictions based on the switcher-to-loyal ratio, adding a new perspective to previous studies of dispersed prices (Baye and Morgan 2001; Burdett and Judd 1983; Raju et al 1990; Salop and Stiglitz 1977).

The remainder of this paper is organized as follows. We first present our model, highlighting the strategic intuition in detail and contrasting our results with prior models. We also formulate several hypotheses from the model’s results. We then describe our empirical results for Internet booksellers. We conclude with managerial implications and future research.
**Model and Analysis**

Our model builds upon Narasimhan (1988) and Varian (1980). Whereas Varian (1980) considers many symmetric firms and Narasimhan (1988) studies two asymmetric firms, we analyze a market with three asymmetric firms and multiple switcher segments. Switcher segments among multiple asymmetric firms are not components of prior models, making our research unique. For conventional retailers, it is easy to imagine that not all customers will be informed of all prices because of the high cost associated with searching prices. In an Internet setting, however, search costs are generally low. We can reasonably assume that at least some customers are highly informed about online prices, even for low-cost items (Carlton and Chevalier 2001; Kocas 2002; Smith and Brynjolfsson 2001). However, this assumption does not preclude multiple segments of partially informed switchers who do not compare prices among every retailer. Even when dealing with price-comparison engines, not all retailers are listed, and not all customers utilize price-comparison sites (Iyer and Pazgal 2003; Montgomery et al 2005). Asymmetric awareness of retailers by price sensitive switchers may lead to different pricing strategies (Pan et al 2004).

The fundamental intuition behind our model is that multiple switcher segments can lessen price competition among firms (see Lal and Sarvary 1999 for a model of price competitiveness in the context of consumer search costs). Firms with greater motivation to discount, because of a smaller loyal segment size and/or a greater number of switchers to potentially serve, will more actively compete for the fully informed switchers. This leaves firms with fewer relevant switchers for a given loyalty size to focus on their loyals and the subset of switchers who consider them in their price-comparison search. In such instances, prices will generally be higher than they would be were the firm to compete for all switchers. Other firms discount less in reaction to these higher prices, and so the severity of price competition becomes less overall. Under some conditions, the firm with the fewest loyals can be the highest-priced firm, a result that asymmetric loyalty by itself cannot implement. Our model predictions reflect a wide variance in retailers’ price dispersions, consistent with empirical observations.
Assume a market for a homogenous good, such as a specific book or music CD, sold by three retailers. On the demand side, each customer purchases a single unit of the good if it is offered at or below the reservation price $r$, which is assumed to be homogenous for all customers and across all retailers.\footnote{A common reservation price is a typical assumption (Iyer and Pazgal 2003; Narasimhan 1988; Raju et al 1990; Varian 1980). Narasimhan (1988) considers a case where consumers have different reservation prices for brands.} We model different segments of loyal customers, who buy from their preferred retailer as long as the price does not exceed $r$, and switchers who comparison shop. The loyal customers are faithful to only one firm, with the number of customers loyal to Firm $i$ given as $n_i$. Without loss of generality, we assume that $n_1 > n_2 > n_3$ (i.e., the retailers can be ranked in terms of their loyal segment sizes). We also assume the existence of two switcher segment sizes, $s_{12}$ and $s_{12}$, whose members are not loyal to any firm but rather buy from the lowest priced retailer among those they compare. Switcher segment $s_{123}$ is fully informed, meaning its members compare prices quoted by all three firms. Switcher segment $s_{12}$ compares prices quoted only by the larger Firms 1 and 2. Although these partially informed switchers are not apprised of all retailer prices, they still compare the prices from the best-recognized retailers, which may have the biggest reach and the most active communication channels. Firms 1 and 2 would be like $B\&N$ and $Amazon$ (the two biggest online booksellers), while Firm 3 would be like $A1Books$. Although some switchers will price compare all three retailers ($s_{123}$), $A1Books$ has less than 1% of $B\&N$’s reach, so there are likely other switchers who are unfamiliar with $A1Books$ and only compare $Amazon$ and $B\&N$ ($s_{12}$). A more general consideration of segmented switchers (adding $s_{23}$ and $s_{13}$ switcher segments) does not change the model’s intuition or conclusions. We also note that generalizing to more than three asymmetric retailers gives results very similar to a triopoly (details available from the authors). Hence, our model focuses on three firms and two switcher segments for relative tractability.

We make several other customary assumptions that do not alter the nature of our results. The market size is normalized to one $n_1 + n_2 + n_3 + s_{12} + s_{123} = 1$, without loss of generality.

While the segment sizes and the reservation price are common knowledge, because of imperfect
addressability and targetability retailers cannot price discriminately (Blattberg and Deighton 1991; Chen, Narasimhan, and Zhang 2001). All firms face constant fixed and marginal costs, which are assumed to be zero, without loss of generality (Iyer and Pazgal 2003; Narasimhan 1988; Raju et al. 1990). Overall, the model and its assumptions are similar to Narasimhan (1988) and other related models, except for analyzing three firms and two switcher segments.

In an effort to capture its switcher segments, firms have an incentive to undercut the price of other firms competing for those switchers, a tendency that results in a downward push in prices. Motivation also exists to price at the reservation price, in case the switchers cannot be served with a lower price. A retailer’s “minimum price” makes the firm indifferent between selling only to its niche of loyal customers at the reservation price and selling to its switcher segments given it is the lowest-priced firm at the minimum price. A firm will never discount below its minimum price since it could then do better by focusing on its loyal customers. A firm’s smaller loyal segment size and/or larger switcher segment size gives more incentive to forgo selling only to the loyals. We define a firm’s ratio of switcher-to-loyal segment sizes, $\phi$, as $\phi_3 = \frac{s_{123}}{n_3}$, $\phi_2 = \frac{(s_{123} + s_{12})}{n_2}$, and $\phi_1 = \frac{(s_{123} + s_{12})}{n_1}$. Under segments $s_{123}$ and $s_{12}$, Firms 1 and 2 compete for the same switchers, so Firm 2 always has a higher switcher-to-loyal ratio (“SLR” or $\phi_i$) than Firm 1 given Firm 2’s smaller loyal segment. However, Firm 3 can only capture switcher segment $s_{123}$, so its SLR may be higher or lower than that of both firms. Thus, Firm 3 may discount deeply to capture the switchers, or play only its niche loyal segment and charge higher prices. Absent multiple switcher segments, the relative order of $\phi_i$ for these firms would strictly be a function of the loyal segment sizes, as seen in prior models. Our addition of segmented switchers thus changes the nature of a retailer’s incentive to discount.

Equilibrium Price Promotion Strategies

The tension of selling to switchers and loyals results in a lack of pure strategies typical of such models. Therefore, we solve for a mixed strategy equilibrium that depends upon the relative sizes of the loyal and switcher segments. A mixed strategy can be interpreted as arising from a retailer’s uncertainty about the pricing decisions of competing retailers (Gibbons 1992).
Equilibrium prices are defined by a probability density function indicating the range of prices a retailer may charge (the retailer’s price support). We find that the retailers’ equilibrium price promotion strategies fundamentally depend on the firms’ relative switcher-to-loyal ratios. In Proposition 1, we present the mixed strategy equilibrium for the case that is more typical of prior models, where the “large” Firm 1 has the lowest $\phi_i$.

**Proposition 1:** When $\phi_3 > \phi_1$, Firms 1 and 3 have mutually exclusive price ranges that, when combined, form Firm 2’s price range. Firm 2 competes with Firm 3 in the lower part of its price range and with Firm 1 in the upper part of its price range.

**Proof:** See Appendix.

The probability and cumulative distribution functions for the equilibrium prices are shown in Figure 1. Firm 2 has more motivation to compete for $s_{123}$ than Firm 1, and because Firm 3 can only capture $s_{123}$, the competition between Firms 2 and 3 is fairly intense. The low prices Firm 2 quotes while trying to capture $s_{123}$ make it easier for Firm 2 to also sell to $s_{12}$. Thus, there is no guarantee that Firm 1 will capture any switchers, even at its minimum price, since the other two firms already compete for $s_{123}$ at lower prices. Firm 1 is, therefore, less inclined to discount. The more intense competition between Firms 2 and 3 makes the lower bound of Firm 1’s price range move up, to the point in equilibrium where Firm 1 no longer directly competes for $s_{123}$. Thus, Firms 1 and 3’s equilibrium price ranges do not overlap. Moreover, note that when Firm 2 prices below Firm 1 and competes with Firm 3 to capture segment $s_{123}$, it also always serves segment $s_{12}$. That is, in the price region where only Firms 2 and 3 compete, $s_{12}$ effectively becomes a component of Firm 2’s loyal segment. Because an effectively larger loyal segment means that Firm 2 now has more to lose from price cuts, the lowest price that Firm 2 can profitably quote increases, which lessens the severity of the price competition with Firm 3. The lowest price support for Firms 2 and 3 thus rises above the minimum prices of both firms.

----- Insert Figure 1 here -----
These results emerge mainly because of asymmetry in both the switcher and loyal segment sizes. The lowest prices are higher in our model than in Varian (1980), Narasimhan (1988), and other models which lack multiple switcher segments. The existence of $s_{12}$ as a switcher segment that omits Firm 3 leads to higher average prices for Firms 2 and 3, while their competition for segment $s_{123}$ leads to higher average prices for Firm 1. At the extreme of $s_{12} = 0$ (where $\phi_3 > \phi_2$), the results represent a three-firm extension to Narasimhan (1988).

We find that the equilibrium of Prop. 1 does not change regardless of whether or not Firm 3’s switcher-to-loyal ratio (SLR) exceeds that of Firm 2. The intuition is straightforward, noting that the lower price support for Firms 2 and 3 rises above their respective minimum prices. Therefore, the equilibrium is unaffected by whether the minimum prices of Firms 2 and 3 switch order, since neither is part of the equilibrium price ranges for those two firms. Furthermore, even though Firm 2 may have the highest SLR, it still sets its lower price support partially in response to Firm 1’s higher support as Firm 1 forgoes competition for $s_{123}$. Firm 1’s main issue is that both Firms 2 and 3 have higher SLRs, immaterial of whose is greater.

Proposition 1 contrasts remarkably with the case where Firm 3 has the (weakly) lowest SLR, or $\phi_3 \leq \phi_1$ (recall $\phi_2 > \phi_1$). In this situation, Firm 3 lacks sufficient discount motivation to capture its switcher segment, and so becomes a high-priced niche retailer focusing on its loyal segment. Since Firm 1’s SLR is not the lowest, it finds it worthwhile to play for $s_{123}$. Segments $s_{12}$ and $s_{123}$ implicitly combine into a single switcher segment that is served only by Firms 1 and 2. The resulting equilibrium is defined in Proposition 2:

**Proposition 2**: When $\phi_3 \leq \phi_1$, only Firms 1 and 2 discount while Firm 3’s price is set at the reservation price $r$.

**Proof**: See Appendix.

The density and cumulative probability functions for the equilibrium prices are presented in Figure 2. The lower price support is defined by Firm 1’s minimum price, since Firm 2 never needs to discount below this to compete for the switchers. Firm 3 is content to be a niche player, pricing high to serve only its relatively small loyal segment. Given that $n_1 > n_3$, the Proposition
condition that $\phi_3 \leq \phi_1$ essentially represents the case where $s_{123}$ is small in comparison to $s_{12}$ ($s_{123} = 0$ will always meet the condition of Proposition 2). Firm 3 recognizes that most of the switchers compare prices only between Firms 1 and 2, so Firm 3 becomes a high-priced retailer for its small loyal niche.

----- Insert Figure 2 here -----  

**Model Discussion**

Before turning to the empirical validation of our model, we describe the firms’ profits and prices in more detail, focusing on key aspects of segmented switchers. A summary of the firms’ profits and lowest prices is given in Table 1. The inclusion of a partially informed segment of switchers reduces the competitive pressure on the firms. The firms’ lowest price supports are higher than their respective minimum prices ($p_i^\text{min}$). With the partially informed switcher segment $s_{12}$ included, average prices and profits are generally higher, since the price supports increase as Firm 1 “abandons” $s_{123}$ under Proposition 1. Multiple switcher segments thus tend to reduce competition, since not all firms are able to capture all switchers.

The relative sizes of the fully and partially informed segments shape the nature of competition between the firms. Under Proposition 1, as Figure 3a depicts, Firm 1’s discount deepens as $s_{12}$ exceeds $s_{123}$ (holding the total number of switchers constant). However, when the size of the fully informed segment increases, so does the severity of competition between Firms 2 and 3. As shown in Figure 3b, this increased competition for segment $s_{123}$ pushes Firms 2 and 3’s discounts deeper. At the same time, it forces Firm 1 to offer shallower discounts, since Firm 2 already serves more of segment $s_{12}$ (in expectation) with its deeper discounts. The composition of switchers thus fundamentally affects when retailers should offer frequent or infrequent, deep or shallow discounts.

----- Insert Table 1 and Figure 3 here -----  

When we compare firms’ profits as the composition of switcher segments varies, we first observe that Firm 1 is indifferent, since it always receives the guaranteed profit ($n/r$). Firm 2’s profits increase when $s_{12}$ increases at the expense of $s_{123}$, given that segment $s_{12}$ acts as a
second-degree loyal segment to Firm 2. Firm 2 achieves more than its guaranteed profit at $s_{12} = 0$, but it can gain even more profit if at least some switchers disregard Firm 3.

A more interesting result pertains to the profits of Firm 3 under Proposition 1. Firm 3 can benefit from a positive $s_{12}$ customer base as long as the higher price support more than compensates for the loss of some $s_{123}$ customers as $s_{12}$ increases. Firm 3’s profits generally do not reach a maximum when all switchers belong to $s_{123}$. Firm 3 may thus prefer to lose some of its $s_{123}$ customers, the only switchers to whom it can sell, and “convert” them into $s_{12}$ to make Firm 2 focus more on its competition with Firm 1. That is, Firm 3 benefits from a more balanced distribution of switchers, a condition that places Firm 2 in a more balanced consideration for both switcher segments. Our model thus complements the results of Iyer and Pazgal (2003) and Baye and Morgan (2001) that pertain to retailers belonging or not to Internet agents that allow price comparisons among multiple firms. By considering various-sized switcher segments, our model points to a small retailer potentially benefiting from some degree of price comparison strictly between the larger or better-known firms. This result further highlights the competitive nature of the asymmetric triopoly. Firm 3’s prices and profits depend critically upon how Firms 1 and 2 compete with each other for its switcher segment.

When the relative size of the fully informed switcher segment is significantly small, Firm 3 may prefer to ignore the switchers completely and offer no discounts at all (Prop. 2). This result represents an important distinction between our segmented-switcher model and other models of asymmetric loyalty. When multiple switcher segments exist, loyal segment sizes are not sufficient to describe the nature of competition among the various firms. The relative sizes of the switcher segments must also be considered as they affect the switcher-to-loyal ratios $\phi_i$ among the firms. A small firm may thus discount or price high to play the niche, depending on its relative SLR.

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4 Firm 3’s profits for at least some positive region of $s_{12}$ are higher than its profits at $s_{12}=0$. More specifically, as long as the total number of switchers remains above a modest threshold, Firm 3’s profit has a positive slope at $s_{12}=0^+$, such that there is at least some positive $s_{12}$ where Firm 3 is better off.
Comparison with Prior Models

The finer competitive details provided by our model help explain some of the variety in prior findings for promotion frequency and depth. In terms of promotion frequency, our Prop. 1 results generally follow Narasimhan (1988) and Raju et al (1990) in that they predict that the “strong” retailer (one with greater loyalty) promotes less frequently. However, our model also predicts that a “strong” retailer can promote more frequently if it has relatively more interest in the switchers than the weaker retailers do (e.g., Firm 1 promotes more often than Firm 3 under Prop. 2). This conclusion is consistent with Rajiv et al (2002), where a high-service (i.e., strong) store offers advertised sales more frequently, albeit due to traffic building. Our model conditions for Proposition 2 concur with the predictions of Rajiv et al (2002), even in the absence of traffic considerations, suggesting that a relatively larger size of switchers targeted by high-service stores can explain a higher frequency of advertised sales.

In the case of promotion depth, recall that Narasimhan (1988), Raju et al (1990), and Rajiv et al (2002) all deal with asymmetric duopolies. Under their respective models, Narasimhan (1988) suggests that the two stores offer the same depth of discounts (for indifferent switchers), Raju et al (1990) predict that the stronger (or larger) store should offer deeper discounts, and Rajiv et al (2002) predict that the stronger store should offer shallower discounts. Our model of segmented switchers predicts the conditions under which a store may offer deeper or shallower discounts. More specifically, a strong store may indeed offer shallower discounts if it has the least motivation to promote, as characterized by its smaller switcher-to-loyal ratio (Prop. 1). A strong store may also offer the same discount depth as a smaller store if no other weak firms compete for switchers (Prop. 2, Firms 1 and 2). A strong store may even offer deeper discounts than a weak store if its share of switchers is relatively larger than that of the weak store (Prop. 2, Firms 1 and 2 compared to Firm 3). Our three-firm model with segmented switchers thus encompasses the various cases of prior duopoly models.

Iyer and Pazgal (2003) present a model of many firms (as in Varian 1980) with switchers and asymmetric loyalty, but they include at most two types of firms. Iyer and Pazgal (2003) also
consider “partial loyals” who behave as loyals with a lower reservation price. In contrast, we model three asymmetric firms with multiple switcher segments. Some of our results, therefore, differ from Iyer and Pazgal (2003) and other models that lack segmented switchers. In particular, we predict the existence of a high-priced niche strategy for a “small” retailer, which we empirically observe. Other models do not make such predictions for homogenous goods.

Our model also offers some unique insights into price strategies when a retailer competes on multiple fronts. The novel discounting behavior of Firm 2 in Prop. 1 completely draws from the three-firm asymmetry with segmented switchers. Firm 2 offers two types of discounts: deep discounts to compete with Firm 3 and shallow discounts to compete with Firm 1. Furthermore, as Figure 3 depicts, depending on the relative sizes of the switcher segments, the frequency of deep and shallow discounts varies. Competing with different firms for different switcher segments allows a retailer to develop a partitioned pricing strategy, where the depth and frequency of discounts vary on each competitive front. This type of price-promotion strategy is unique to our model of asymmetry in an oligopoly.

**Model Predictions**

To demonstrate that our model can explain pricing behavior in a rich empirical context, we present testable model predictions and examine them with pricing data from Internet book retailers. Our model yields price distributions as equilibrium strategies that depend upon the relative switcher-to-loyal ratios of the firms. While summary statistics that describe the promotion strategies can be used to generally test the fit of pricing data, a more robust method is to compare the empirical and theoretical price distributions themselves. We present hypotheses based on summary statistics in H1. Hypotheses H2 and H3 are based on the price distributions.

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5 Mixed strategies in pricing are usually assumed to be observable through temporal price dispersion (Narasimhan 1988; Varian 1980) that is pooled across multiple products and retailers (e.g., Iyer and Pazgal 2003; Raju et al 1990). Data for multiple products (books, in our case) represent repeated observations of a mixed pricing strategy over time. Our analysis is consistent with this view in that we define “discount” in terms of temporal price changes, and we consider a retailer’s average discounting behavior across books. The hypotheses, therefore, reflect what should be observed for a retailer on average, according to both model propositions taken in tandem. In its most general form, a mixed strategy is a probability distribution over pure strategies such that price dispersion may be reflected across books as well as time. See Gibbons (1992) for a discussion of mixed strategy interpretations.
The equilibrium price supports and distributions make immediate the following:

**H1:** Retailers with a higher switcher-to-loyal ratio will, on average, have: a) lower average prices, b) higher standard deviations in prices, c) more frequent discounts, d) a higher maximum discount frequency, e) greater discount depth, and f) a higher maximum discount depth.

Under the model’s propositions, firms with a higher SLR will have lower average prices (H1a) and a higher standard deviation in prices (H1b) in relation to price deviation from the reservation (regular) price. The frequency of price discounts relates to the likelihood that a retailer will price below the maximum retail price. Under Prop. 1, Firms 2 and 3 will discount more frequently than Firm 1, and under Prop. 2, a firm with a higher SLR will promote more frequently than a firm with a lower SLR. Overall, a firm with a higher SLR will discount at least as often as a firm with a lower SLR, and will therefore discount more frequently (H1c) and have a higher maximum discount frequency (H1d), on average.

The discount depth relates to the price supports and cumulative distribution functions (CDF). From our model, a firm with a lower price support will tend to have a greater depth of discount. Under Prop. 1, for example, Firm 2 has a greater probability of discounting at a lower price than Firm 1, as evidenced in the CDF plot of Figure 1b. From the model’s propositions, in most cases, a firm with a higher SLR will be more likely to discount with greater depth. Across all possible conditions, we expect to observe that retailers with higher SLRs will, on average, have greater discount depth (H1e) and higher maximum discount depth (H1f).

The pricing relationships predicted by H1 move beyond the typical loyalty perspective to a broader view that includes segmented switchers. For example, a firm with a high SLR will discount more frequently (H1c) due to having relatively few loyals (as in typical models) and/or having fewer switchers who consider its prices. By combining loyalty and switcher asymmetries, we can predict pricing behavior under previously ambiguous situations, such as when a firm has both few loyals and few switchers.
While summary statistics of retailers’ prices can indicate whether the switcher-to-loyal ratio explains price promotions, a more rigorous test would consider the entire price dispersion curve. Theoretically, we have very clear predictions about how equilibrium price distributions should appear (Figures 1 and 2). We test whether the empirical price distributions vary as predicted by analyzing stochastic dominance. For any two CDF functions, $F_j(x)$ first-order stochastically dominates $F_i(x)$ iff $F_j(x) \leq F_i(x), \forall x$. Put differently, if Firm $j$’s price CDF lies nowhere above and somewhere below Firm $i$’s distribution, then Firm $j$ first-order dominates. In Figure 1b, for example, Firm 1 first-order stochastically dominates Firms 2 and 3, while Firm 2 dominates Firm 3. First-order dominance is a fairly strict standard when considering empirical price distributions that may include shocks or random error. Second-order stochastic dominance is similar except it considers the deficit functions, or the integral of the CDF. Second-order stochastic dominance holds under first-order dominance, but not vice-versa. Our model predicts that a firm with a lower SLR should stochastically dominate a firm with a higher SLR (the sole exception being Firms 2 and 3 when $\phi_2 > \phi_3$ under Prop. 1). On average, we should observe:

H2: The price distributions of retailers with a lower switcher-to-loyal ratio will first- and second-order stochastically dominate firms with a higher switcher-to-loyal ratio.

The model’s propositions also make very specific predictions concerning different pricing strategies for “small” firms with a small loyal segment size (Firm 3). For a higher SLR, the small firm will be stochastically dominated by the large firm, while the reverse is true if the small firm has a lower SLR.

H3a: The price distributions of small retailers with a high switcher-to-loyal ratio will be first- and second-order stochastically dominated by large firms with a lower switcher-to-loyal ratio.

H3b: The price distributions of small retailers with a low switcher-to-loyal ratio will first- and second-order stochastically dominate large firms with a higher switcher-to-loyal ratio.
Empirical Evidence

We test the predictions of our modeling effort by using pricing data we collected from online book retailers. A book is a homogenous product that is uniquely identified by an ISBN number, a classification that is widely used and recognized by customers as well as sellers. To ensure that the online retailers in our data set share at least a common switcher segment, we collected daily data on book prices from all the retailers listed on the price comparison site mySimon.com. In the period during which our data were collected, mySimon was the leading price-comparison engine, with 80% of the price-comparison site visit market share (Mediametrix and Nielsen Netratings; see also Allen and Wu 2002, Kocas 2002). Our consideration of booksellers listed on mySimon establishes the existence of a “fully informed” switcher segment (\(s_{123}\) in our model), without precluding the existence of other switcher segments. Prices reported from mySimon are taken directly from each retailer’s web site, reflecting the book’s offered price to all shoppers at that point in time, net of shipping and handling costs.

Data Collection Methodology

We compiled a sample of 2,207 books from various sources.\(^6\) From June 2001 to August 2002, we collected daily price data on these books from all the bookstores returned by a search on mySimon. We prefer that price changes in the data reflect the mixed strategy discounting of retailers rather than systematic changes from price shocks (e.g., net price changes due to a switchover to free shipping) or reservation price changes. Price data collected over longer periods of time have more risk of being contaminated by systematic price adjustments. To alleviate this problem, we use only data on non-bestseller books collected during a relatively short window of time. Bestsellers have more price dispersion than non-bestsellers and are more likely to have reservation price adjustments and be traffic generators compared to non-bestsellers (Clay et al 2001). Eliminating bestsellers, duplicates, and books not carried by any of the

\(^6\) These sources consisted of four booklists that were publicly available on the Internet: 1) 140 books from Publisher's Weekly bestsellers list on 6/4/01; 2) 730 books from “One Book List: Collaborative Books to Read,” a list compiled by the Usenet newsgroup rec.arts.books; 3) 60 books from Latest Acquisitions by Government Environmental Library 2001; and 4) 1,277 books bought by Sidney Sussex University Library in 2001.
mySimon bookstores left a total of 1,640 books. For our empirical analysis, we used the daily pricing data on these 1,640 books for a period of 26 days in June 2002. This month represents the most recent time period for which we have complete data from all the retailers and no systematic price adjustments. This 26-day window also spans a relatively short period of time in an effort to minimize reservation price adjustments.7

In our June 2002 sample period, 28 unique mySimon retailers carried at least one of the 1,640 books. All books in the sample were offered by multiple retailers. To compare retailers that carry a similar assortment of books, we ranked the booksellers with respect to the percentage of books they carried from the total list of 1,640. We observed a gap between the top 14 retailers, who carried at least 40% of the books, and the bottom 14 retailers who carried at most only 9% of the 1,640 books. Based on this observation, we limited our analysis to the 14 retailers that carried at least 40% of the books. The final sample had 392,245 total observations, or nearly 28,000 per retailer on average.

**Loyal and Switcher Measures as Predictor Variables**

Our objective is to observe how the relative switcher-to-loyal ratios of these 14 retailers affect their pricing strategies. In order to form an empirical proxy of the switcher-to-loyal ratio, we need indicators of loyal and switcher segment sizes for these 14 firms. With this objective in mind, we collected data on several measures for each retailer in our sample.

**Reach and Link Popularity.** Reach measures the number of users who visit a given site and therefore represents the sum of both loyal and switcher customer visits. Reach data are obtained from Alexa, an Amazon.com company that collects data on the browsing behavior of several million customers who use Alexa’s toolbar. Link popularity refers to the total number of links that a site has across the Internet. Book-link popularity is determined as the number of sites that link to a book retailer and which contain the word “book” on the same page where the link

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7 Empirical studies strive to use a “large enough” number of periods to capture temporal realizations of the mixed strategy. Our number of time periods is similar to others (e.g., Clay et al 2001; Raju et al 1990), although we use daily instead of weekly data to minimize systematic price adjustments. We did examine three- and six-month versions of the data set (87 and 184 days, respectively), and the overall results and conclusions are the same.
appears. Book-link popularity and link popularity may indicate the sum of switcher and loyal customers, although the resulting conclusions may correlate more with loyalty (retailers with a large number of loyals may be linked more often). We determine link popularity as the sum of all links found by the search engines Alltheweb, AltaVista, Google/AOL, HotBot/Inktomi, and MSN. Book-link popularity is determined using AltaVista.

Page Views per User. Page views per user, also obtained from Alexa, are the average number of unique pages viewed per user by site visitors each day. The page views per user can be used as an indicator of loyalty, because loyal customers tend to spend significantly more time on a single site when compared to switchers. Page views per user have been a preferred measure of online loyalty in recent studies (Demers and Lev 2001; Goldfarb 2002). Research has examined the drivers of trust and loyalty in online shopping, and website navigation issues arise as important factors (e.g., Bart et al. 2005; Shankar, Smith, and Rangaswamy 2003; Srinivasan, Anderson, and Ponnavolu 2002). Navigating website information for in-depth content increases satisfaction and loyalty (Shankar et al. 2003). Demers and Lev (2002) find page views per user to be highly correlated to the number of visits and average time spent at the website. Greater Internet loyalty is also associated with greater willingness to pay (Srinivasan et al. 2002). The page views per user metric thus represent a good proxy for loyalty given its association with in-depth navigation and loyalty behaviors generally absent from price-sensitive switchers.

Search Share. Search share is an indicator of the relative switcher generation potential of the retailers. A bookstore desiring to attract more switchers may become listed more often in a price-comparison query. For a particular set of price-comparison sites, we formulate a retailer’s search share as the proportion of price comparison sites that return prices for that retailer. We use the nine top-ranked book price-comparison sites as well as mySimon to formulate a list of price-comparison sites for books.\(^8\) Greater search share means the retailer is listed on more book

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\(^8\) These book price-comparison sites are the top nine sites that identify the booksellers from which they quote prices, as ranked by google.com. These sites are bookfinder.com, addall.com, bestbookdeal.com, allbookstores.com, textbookland.com, aaabooksearch.com, campusbooks.com, compareshopbooks.com and anybooksforless.com. Other general price-comparison sites beyond mySimon were not included, since mySimon represents over 80% of all price-comparison activity conducted on the Internet.
price-comparison sites, and may thus attract more switchers from various segments. Although search share does not differentiate switcher segment sizes, it does give a firm-specific indication of relevant switcher intensity. The switcher-to-loyal ratio of our model, in general form, represents the *sum* of its switcher segment sizes relative to loyal segment size. Hence, it is sufficient to form a proxy of a retailer’s relative firm-specific switcher size, without needing to know precisely the size of each particular switcher segment.

We note that there are several reasons why a firm might be listed in a price-comparison engine. Sometimes a retailer’s prices are used by the price-comparison site without specific action on the part of the retailer. In addition, relatively high-cost retailers are not necessarily absent from price-comparison sites. A firm with comparably higher prices may want greater access to all potential buyers and, therefore, may share its pricing data with the search engine (Iyer and Pazgal 2003). Whether high-priced or low-priced, retailers listed within price-comparison sites have access to a higher number of switchers. Therefore, the degree of participation in price-comparison engines serves as an indicator of the retailer’s access to switchers who become informed of its prices.

**Switcher-to-Loyal Ratio.** Given the above measures, we notice that while reach and popularity could provide measures of the sum of switcher and loyal segment sizes, we can use page views per user (normalized across retailers) as a proxy for relative loyal segment sizes, and search share as a proxy for the relative switcher segment size. Since $\phi_i$ is defined as the ratio of the firm’s switcher-to-loyal segment sizes, we form a proxy measure of $\phi_i$ as the ratio of search share (the relative expected number of switcher customers) to the normalized page views per user (the relative expected number of loyal customers).

Descriptive statistics for the 14 retailers are presented in Table 2. The retailers are ordered by decreasing switcher-to-loyal ratio (SLR). In terms of link popularity and reach, Amazon, B&N, and BooksAMillion are the top three firms. Given the overwhelming sizes of Amazon and B&N, popularity measures are too skewed to be of much use in determining the retailers’ pricing strategies. Both of the top two retailers likely have very large loyal segments,
but they also likely appeal to many switchers. It is hard to ascertain from popularity measures alone whether Amazon and B&N will price more according to their loyals or switchers.

However, SLR allows us to assess the relative discounting behavior of firms that loyalty or switcher sizes alone cannot accomplish. For the smaller firms, the SLR clearly separates those with a high SLR (e.g., eCampus) from those with low SLR (e.g., Varsity). For example, despite eCampus and Varsity having nearly the same popularity and page views per user, the SLR is clearly higher for eCampus than Varsity. We now show empirically that the relative SLRs explain the discounting behavior of the retailers consistent with our model predictions.

----- Insert Table 2 here -----

**Price Promotion Measures**

For each retailer, we calculate various measures of price-discounting activity. We do so with the view toward price discounts reflecting price changes over time. During June 2002, each book had a sequence of daily retailer prices. Average price for any retailer is the average of all normalized prices for that retailer, where normalized prices are calculated by dividing any given book price by the highest price quoted for that book by any one of the 14 retailers in the sample period. The standard deviation of the normalized prices in each sequence, averaged over all the books carried by the retailer, gives the average standard deviation. For each retailer we also count the number of price changes in our daily data. We then average that figure across all the books sold by the retailer to calculate the average number of price changes (discount frequency). The maximum is found by taking the highest number of price changes for the retailer across books. We calculate the retailer’s absolute changes in normalized prices, averaged across all books, to obtain the average and maximum depth of discounts across books for that retailer.

**Analysis of Pricing Strategies**

The summary statistics for retailer prices are given in Table 3, where the retailers are ordered by their switcher-to-loyal ratio. To test the expected price relationships under H1, we use the firms’ SLRs along with the pricing data from Table 3. In regression analyses for the 14 retailers studied, we use a price statistic as the dependent variable and SLR as the independent
variable. The resulting standardized coefficient of the SLR and its significance are, by definition, identical to the Pearson correlation coefficient and its significance. We report these correlations in Table 4. We observe that the SLR is significantly correlated with the firms’ price discounting. The results support H1, demonstrating that retailers with a higher SLR have lower prices (H1a) and a higher standard deviation (H1b) on average. They also discount more often (H1c and H1d) with greater depth (H1e and H1f). We conclude that a firm’s switcher-to-loyal ratio is a significant predictor of its promotional activity.

Further investigation of Table 4 reveals that only search share and SLR have any significant correlation with the price-discount statistics. Note that the proxy loyalty measure (page views per user) does not correlate well with the pricing statistics. This result echoes our model’s implication that asymmetry in loyalty alone is not adequate to assess pricing strategies. Empirically, we should demonstrate that the switcher-to-loyal ratio is a better explanatory variable than other retailer variables. The correlations of Table 4 suggest search share as a possible alternative. Comparing SLR to search share as an independent variable, we generate F-statistics from regressions using both SLR and search share and compare them to restricted regressions with either variable alone. The results show that search share never significantly adds to the regression fit beyond SLR for any price variable. Conversely, SLR does significantly add beyond search share alone for all but the standard deviation and maximum frequency analyses. Our SLR proxy is, therefore, able to capture the average discounting behavior of the retailers studied. Furthermore, it does so better than the other retailer descriptive variables.

Tests of Retailer Price Distributions

Hypotheses 2 and 3 relate our model predictions to measures of stochastic dominance. Figure 4 presents the empirical cumulative distribution functions (CDF) of normalized prices for

9 We also analyzed the correlations of the pricing statistics with reach and link popularity after omitting Amazon and B&N due to their high values. The correlations remain insignificant, except for a positive correlation of 0.59 \((p<0.05)\) between reach and maximum discount frequency. The page view measures for Amazon.com and Sam Goody may reflect more than book searches by consumers. Deleting these two retailers does not change the insignificance of the page view correlations in Table 4, while the SLR correlations remain highly significant.
the 14 retailers. The numbers in parentheses next to each retailer in the figure refer to that retailer’s rank according to decreasing SLR (the same ordering as in Tables 2 and 3). The figure makes clear that at the lower price levels, most firms have a small percentage of observed prices. This observation makes a strict test of stochastic dominance problematic, since a retailer who may have highly discounted a few books on a few days (out of 28,000 prices quoted by the average retailer) distorts the fact that the same retailer may have relatively high prices for all other books across all days. Furthermore, the retailers’ CDF functions may cross in closely-spaced price regions, meaning neither firm stochastically dominates the other. For a given pair of retailers, our model predicts that the retailer with a lower SLR should stochastically dominate the other. However, we cannot make general statements about multiple firms of the same type (e.g., a Firm 1 should dominate a Firm 2, but multiple Firm 2’s may not exhibit any dominance pattern among themselves). Therefore, we eliminate the 5% lowest prices quoted by each retailer and examine stochastic dominance by considering retailer pairs in which stochastic dominance is evident.

11 With 14 retailers, there are a total of 91 combinations of two that we can examine for stochastic dominance. Out of the 91 pairs, there are 23 combinations (25%) whose CDF’s intersect at least once, such that neither retailer can first-order stochastically dominate the other. Of the remaining 68 combinations, 42 (62%) are classified correctly when we use SLR as the predictor. The chi-square statistic of 3.77 shows that the classification guided by the SLR measure produces significantly better results ($p = 0.05$) than by chance alone.

----- Insert Figure 4 here -----

We use the deficit functions (the integral of the CDF) to test for second-order stochastic dominance. Of the 91 pairs of deficit functions, 15 pairs (16%) have functions that intersect at least once. Of the remaining 76 pairs, 53 (70%) are classified correctly according to SLR. The

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10 The figure shows normalized prices for all books across all days. From our model, a retailer that stochastically dominates another retailer for one book should do so for all books (only the reservation price varies across books). We thus examine price distributions across both books and time to test for stochastic dominance.

11 The lowest 5% of a retailer’s prices represent prices that are at least eight standard deviations (in inter-temporal terms) below the average price for each retailer. This procedure reflects the concept of “almost” stochastic dominance (see Leshno and Levy 2002).
chi-square statistic of 11.84 is significant at the 0.001 level, showing that SLR can classify the second-order stochastic dominance of firms significantly better than chance. Overall, H2 is supported. For retailers exhibiting stochastic dominance over others, the switcher-to-loyal ratio significantly predicts the relative price dispersions.

To test H3, we examine the price dispersion of “small” retailers in more detail. First, we identify the “large” firms to form a basis of comparison. Amazon, B&N, and BooksAMillion possess the highest popularity (Table 2). These three retailers also have the highest page views per user (the loyalty proxy), aside from Sam Goody (a music retailer with very low book-link popularity and, hence, not a “large” firm in the book category). These three largest retailers have very similar SLR values, with B&N possessing the smallest SLR (B&N’s prices stochastically dominate those of Amazon and BooksAMillion, as H2 predicts). To test H3, we seek to identify “small” firms whose SLRs clearly fall above or below those of the large firms. The SLRs of the large firms range from 1.00 to 1.17. Using the spread of 0.17 as a guideline, IBookstreet and PageOne appear to have SLRs that are relatively close to those of the three large firms, such that it is empirically difficult to classify either firm as having a clearly higher or lower switcher-to-loyal ratio relative to the large firms. This observation reveals four Internet booksellers (DoubleDiscount, TextatCost, eCampus, and A1Books) as being small retailers with high SLRs, where we expect Proposition 1 to hold. The 12 pairings of large and small retailers should give evidence of the small firms’ price distributions being stochastically dominated by the large firms (H3a). We also have five small retailers (BookVariety, WordsWorth, Varsity, Worthy, and Sam Goody) with lower SLRs than the large firms, where we expect Proposition 2 to hold. The 15 pairings of large and small firms should indicate that the small firm prices stochastically dominate those of the large firms (H3b). In comparing small and large retailers,

\[12\] Given Sam Goody’s music emphasis, its switcher-to-loyal ratio for books alone may be higher than 0.10. However, omitting Sam Goody as a retailer only strengthens the significance of the relevant stochastic dominance tests (note it has relatively low book prices), so including Sam Goody makes our analysis more conservative.
we view distribution functions that cross as evidence that is contrary to stochastic dominance, although we still eliminate the lowest 5% of prices as before.

For the small firms with high SLRs, price distributions are first-order (second-order) stochastically dominated by the large firms for 8 out of 12 (10 out of 12) pairs of retailers. The chi-squared statistic is 1.33 (not significant) for first-order dominance and 5.33 \((p = 0.02)\) for second-order dominance. In every case where stochastic dominance is expected but not found, the distribution functions for the pair of retailers cross. Therefore, we see no evidence that any small firm’s price distribution dominates a large firm. Overall the results support H3a.

For small firms with low SLRs, price distributions first- and second-order stochastically dominate the three large firms for 12 out of 15 pairs of retailers. The chi-squared statistic is 5.40 \((p = 0.02)\), supporting H3b. Combining the small firms with high and low SLRs into a single test, first-order (second-order) stochastic dominance is correctly predicted for 20 out of 27 pairs (22 out of 27), with a significant chi-square of 5.26, \(p = 0.02\) (10.71, \(p < 0.01\)). This finding is consistent with H2 when small firms are considered relative to large ones. Overall, the switcher-to-loyal ratio is able to significantly explain whether “small” firms are high-priced or low-priced, relative to the “large” firms.

**Empirical Analysis Summary**

We have presented evidence that supports the hypotheses, indicating that a retailer’s switcher-to-loyal ratio explains its pricing behavior consistent with the model’s predictions. The SLR is particularly adept at explaining whether “small” firms take a high-priced or low-priced approach. We can explain why, for example, *Worthy* prices high and *A1Books* prices low, despite both firms being “small” in the same homogenous goods market. Even with the empirical complexities of nearly 400,000 price observations from multiple retailers, the evidence is convincingly supportive of the model. As the first study conducted using an SLR measure, our empirical proxy significantly describes retailer price promotions that are consistent with the model’s predictions. We also test pricing strategies according to the entire price dispersion curve by using tests of stochastic dominance. The empirical literature has no clear consensus on
suitable price dispersion constructs (Pan et al 2004). The stochastic dominance tests correspond to the predicted theoretical relationships and represent a more complete perspective on retailer price dispersion.

As a summary, consider the microcosm of the three retailers all dealing in college textbooks: TextatCost, eCampus, and Varsity. From the retailer information given in Table 2, Varsity is the smallest retailer of the three in terms of reach and popularity. While it experiences similar page views, it receives a lower search share and reach when compared to the other two firms. Standard models and predictions would likely suggest that Varsity take the high discount approach as the “small” firm, but the opposite is true. Varsity is the premium-priced retailer among the three. This scenario is possible in our model if Varsity has the lowest SLR, which it does. Furthermore, Varsity carries 89% of the books from our sample that Amazon carries (compared to only 57% for eCampus and 48% for TextatCost) and charges higher prices than Amazon (see Figure 4). Varsity apparently leverages its low switcher-to-loyalty ratio into greater assortment while still charging high prices. The empirical analysis supports our contention that loyalty by itself is not sufficient to understand retailer pricing strategies for homogenous goods.

**Discussion, Implications, and Future Research**

Price competition among retailers, large and small, involves fundamental decisions about whether and how often to discount prices. Most theoretical models, based on asymmetric duopolies, suggest that small retailers discount to capture the lucrative switcher market. However, observed price promotion strategies reflect a wide variety of approaches, with some small retailers pricing high and others deeply discounting. Our model examines competitive promotional strategies in an asymmetric oligopoly with segmented switchers. Reflecting the realistic assumption that price-sensitive switchers do not necessarily compare prices at all retailers, switcher segments add an important strategic dimension beyond asymmetric retailer loyalty. Whereas firms may be classified as large, medium, or small with respect to their loyal segment sizes, this ranking may have little to do with the price-discounting behavior of the firm.
We find that the firm’s ratio of the relative size of switchers (who consider its prices) to the relative size of its loyal customers is a better indicator of that firm’s price-discounting strategy than loyalty alone. Our model is the first to consider multiple switcher segments, allowing us to categorize a small or large firm as a heavy or light promoter under different loyal and switcher segment compositions. We provide empirical support for our model’s key predictions by analyzing data from the online booksellers market. The segmented switcher perspective identifies whether a small firm will discount, as usually predicted, or instead price high and play the niche. Overall, our model captures a wide variety of price promotion activity consistent with empirically observed price dispersions. Our key findings can be summarized as follows:

- Asymmetry, in terms of different loyal segment sizes and the existence of switcher segments, leads to a multiplicity of discounting strategies.

- The relative switcher-to-loyal ratio (SLR) of the firm is a significant determinant of its promotional strategy. Using the relative SLR, it is possible to categorize when firms will be frequent or deep discounters.

- A small firm may find it profitable to price high and play the niche if the other firms are already intensely competing for the switcher segment(s) the small firm could serve.

- A large firm may find it more profitable to offer deeper (shallower) discounts than a smaller firm if the relative share of switchers for which it competes is large (small).

- A partitioned discounting strategy for midsize firms, one that combines frequent shallow and infrequent deep (or infrequent shallow and frequent deep) discounts, is possible as a result of competition on multiple fronts.

- Small firms may also benefit from having at least some partially informed switchers in the market, even though they cannot sell to them. These partially informed customers may reduce the market’s overall competitive price intensity.

More generally, the existence of multiple, partially informed switcher segments tends to reduce price competition among the retailers. Interestingly, mySimon considerably reduced the number of firms from which it quoted prices after late June 2002, simultaneously increasing the
strength of strategic alliances it had with its participant stores. By reducing the number of firms
mySimon returns as the comparison set, mySimon helps these participant stores enjoy higher
profits, as our model predicts, while generating higher commissions and referral fees for itself.

Using data from the online book market, we empirically validate our model’s key
implications. An empirical SLR measure significantly explains price dispersion among retailers,
consistent with our model’s predictions. The high number of retailers and books examined in
our study results in a rich data set, thereby demonstrating that the switcher-to-loyal ratio can
explain a wide range of retailer strategies. Our tests of stochastic dominance relate to the entire
price dispersion curve, which is more comprehensive than testing summary price statistics alone.

Our results have numerous managerial implications. Small retailers (even of
homogenous goods) with relatively few loyal customers should not take a deep discount strategy
without carefully assessing its access to price-sensitive switchers. If awareness is low or
switchers are difficult to reach, then a high-priced niche strategy may be optimal. If instead a
wide switcher market is accessible, the retailer may discount, although the depth of discounts
depends upon how the larger firms compete. A small firm that discounts may choose to limit its
reach among switchers to some degree in order to reduce overall price competition. Pursuing
fewer switchers will be advantageous if more shallow discounts can be used to capture the
switchers that remain.

Larger firms often face a dilemma due to having both a large loyal following and access
to a large number of switchers. The frequency and depth of discounts depends critically on the
mix of switcher segments in the overall competitive context. When a vast majority of switchers
are well informed, the large firm should offer few shallow discounts since other firms will more
aggressively discount. In the case where many small retailers may be unknown to the bulk of the
switchers, a large firm may find itself more deeply discounting to compete with it nearest rival.
For example, Amazon and B&N exhibit moderate levels of discounting (Figure 4). A midsized
firm has considerable flexibility in its discounting strategy, such as offering frequent but shallow
discounts to compete with the larger retailer, but infrequent and deep discounts to compete with
smaller firms. The midsized retailer should discount often enough to convince its larger rival to concede some of the switchers, who then behave like loyals to the midsize firm.

Our model distinguishes between different pricing strategies, such as high-promoter and low-promoter firms, without relying on traffic-building or product differentiation considerations. A segmented switcher perspective enables us to resolve some varied results found in past models. We consider this paper a unifying extension to stylized game theoretic models of price comparison and related empirical research. However, we also recognize several limitations. By omitting traffic-building from our model and by excluding high-traffic items from our data set, we are unable to see how segmented switchers alter retailers’ traffic-related strategies. To that end, we hope to include traffic issues in future research. Empirically, our measure for the switcher-to-loyal ratio is a proxy. Recent research in trust and loyalty for Internet retailers (e.g., Bart et al. 2005; Shankar et al. 2003) may suggest other metrics for the loyalty component of SLR. More direct measures on the size of partially and fully informed switcher segments could further scrutinize the drivers of price promotion strategies in greater detail.

Future research could also extend recent analyses of Internet shopping agents and firms’ strategies regarding the degree of price comparison. Iyer and Pazgal (2003) would be an excellent starting point, and our results complement some of their key findings. The existence of segmented switchers, and the varied strategies that result, gives a richer context in which firms can contemplate not only whether or not to participate in shopping agents but also when to participate in different sites that reach different switcher segments. Our results show that some firms may benefit from more switchers in certain segments, even if that firm would never sell to those types of switchers. The implication is that retailers should think not only about how to best invest in loyalty building, but also of how they can invest in limiting or expanding switcher segments in relation to other firms in their market. We hope our theoretical and empirical results motivate future research that more precisely captures not only the retailers’ multiple switcher segments but also the pricing strategies that result.
Table 1
SUMMARY OF EQUILIBRIUM RESULTS IN PROPOSITIONS 1 AND 2

<table>
<thead>
<tr>
<th>Proposition 1 ($\phi_3 &gt; \phi_1$)</th>
<th>Proposition 2 ($\phi_3 \leq \phi_1$)</th>
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<tr>
<td><strong>Profits</strong></td>
<td><strong>Profits</strong></td>
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<td>$Firm 1$</td>
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Table 2
SUMMARY MEASURES FOR THE RETAILERS

<table>
<thead>
<tr>
<th>Retailer</th>
<th>Reach/M per day</th>
<th>Link popularity</th>
<th>Book-link popularity</th>
<th>Page views per user</th>
<th>Search share</th>
<th>Normalized page views</th>
<th>Switcher-to-loyal ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoubleDiscount</td>
<td>16.5</td>
<td>16,371</td>
<td>100</td>
<td>2.6</td>
<td>1.0</td>
<td>0.377</td>
<td>2.65</td>
</tr>
<tr>
<td>TextatCost</td>
<td>24.5</td>
<td>61,585</td>
<td>2,897</td>
<td>3.3</td>
<td>1.0</td>
<td>0.478</td>
<td>2.09</td>
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<tr>
<td>eCampus</td>
<td>75.5</td>
<td>37,418</td>
<td>1,998</td>
<td>3.4</td>
<td>1.0</td>
<td>0.493</td>
<td>2.03</td>
</tr>
<tr>
<td>A1Books</td>
<td>6.3</td>
<td>25,693</td>
<td>4,173</td>
<td>3.5</td>
<td>0.7</td>
<td>0.507</td>
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<tr>
<td>BooksAMillion</td>
<td>81.0</td>
<td>164,506</td>
<td>56,890</td>
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<td>0.768</td>
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<tr>
<td>1Bookstreet</td>
<td>6.65</td>
<td>34,239</td>
<td>6,722</td>
<td>2.7</td>
<td>0.4</td>
<td>0.391</td>
<td>1.02</td>
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<tr>
<td>Amazon</td>
<td>23,600.0</td>
<td>57,347,588</td>
<td>3,676,495</td>
<td>6.8</td>
<td>1.0</td>
<td>0.986</td>
<td>1.01</td>
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<tr>
<td>B&amp;N</td>
<td>1,775.0</td>
<td>839,878</td>
<td>46,155</td>
<td>6.2</td>
<td>0.9</td>
<td>0.899</td>
<td>1.00</td>
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<td>PageOne</td>
<td>1.5</td>
<td>9,925</td>
<td>274</td>
<td>2.4</td>
<td>0.3</td>
<td>0.348</td>
<td>0.86</td>
</tr>
<tr>
<td>BookVariety</td>
<td>1.0</td>
<td>184</td>
<td>24</td>
<td>1.0</td>
<td>0.1</td>
<td>0.145</td>
<td>0.69</td>
</tr>
<tr>
<td>WordsWorth</td>
<td>2.85</td>
<td>20,409</td>
<td>1,309</td>
<td>2.6</td>
<td>0.2</td>
<td>0.377</td>
<td>0.53</td>
</tr>
<tr>
<td>Varsity</td>
<td>8.85</td>
<td>31,589</td>
<td>1,923</td>
<td>3.9</td>
<td>0.3</td>
<td>0.565</td>
<td>0.53</td>
</tr>
<tr>
<td>Worthy</td>
<td>4.4</td>
<td>19,999</td>
<td>206</td>
<td>1.8</td>
<td>0.1</td>
<td>0.261</td>
<td>0.38</td>
</tr>
<tr>
<td>Sam Goody</td>
<td>63.0</td>
<td>38,012</td>
<td>271</td>
<td>6.9</td>
<td>0.1</td>
<td>1.000</td>
<td>0.10</td>
</tr>
</tbody>
</table>

| Retailer Average | n.m. | n.m. | n.m. | 3.7 | 0.57 | 0.54 | 1.23 |

n.m. = not meaningful, given extraordinary values for Amazon and B&N.
Table 3
SUMMARY STATISTICS FOR THE RETAILER PRICES

<table>
<thead>
<tr>
<th>Retailer</th>
<th>Average</th>
<th>Std. dev.</th>
<th>Avg. freq.</th>
<th>Max. freq.</th>
<th>Avg. depth</th>
<th>Max. depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoubleDiscount</td>
<td>0.674</td>
<td>0.0096</td>
<td>2.128</td>
<td>5</td>
<td>0.093</td>
<td>0.530</td>
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<td>TextatCost</td>
<td>0.750</td>
<td>0.0020</td>
<td>0.057</td>
<td>3</td>
<td>0.003</td>
<td>0.223</td>
</tr>
<tr>
<td>eCampus</td>
<td>0.742</td>
<td>0.0120</td>
<td>0.729</td>
<td>17</td>
<td>0.039</td>
<td>0.718</td>
</tr>
<tr>
<td>A1Books</td>
<td>0.754</td>
<td>0.0009</td>
<td>0.017</td>
<td>1</td>
<td>0.001</td>
<td>0.060</td>
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<tr>
<td>BooksAMillion</td>
<td>0.837</td>
<td>0.0015</td>
<td>0.052</td>
<td>3</td>
<td>0.002</td>
<td>0.126</td>
</tr>
<tr>
<td>1Bookstreet</td>
<td>0.945</td>
<td>0.0028</td>
<td>0.050</td>
<td>2</td>
<td>0.002</td>
<td>0.100</td>
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<tr>
<td>Amazon</td>
<td>0.837</td>
<td>0.0038</td>
<td>0.071</td>
<td>3</td>
<td>0.004</td>
<td>0.240</td>
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<tr>
<td>B&amp;N</td>
<td>0.871</td>
<td>0.0044</td>
<td>0.118</td>
<td>4</td>
<td>0.006</td>
<td>0.209</td>
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<td>PageOne</td>
<td>0.752</td>
<td>0.0000</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>BookVariety</td>
<td>0.872</td>
<td>0.0000</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>WordsWorth</td>
<td>0.876</td>
<td>0.0047</td>
<td>0.145</td>
<td>2</td>
<td>0.007</td>
<td>0.109</td>
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<tr>
<td>Varsity</td>
<td>0.916</td>
<td>0.0013</td>
<td>0.036</td>
<td>1</td>
<td>0.002</td>
<td>0.058</td>
</tr>
<tr>
<td>Worthy</td>
<td>0.886</td>
<td>0.0000</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Sam Goody</td>
<td>0.766</td>
<td>0.0007</td>
<td>0.022</td>
<td>1</td>
<td>0.001</td>
<td>0.066</td>
</tr>
<tr>
<td>Retailer Average</td>
<td>0.820</td>
<td>0.003</td>
<td>0.245</td>
<td>3</td>
<td>0.011</td>
<td>0.174</td>
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</table>

Table 4
CORRELATIONS OF PREDICTOR VARIABLES AND RETAILER PRICES

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Observed Price Promotion Statistics</th>
<th>Average</th>
<th>Std. dev.</th>
<th>Avg. freq.</th>
<th>Max. freq.</th>
<th>Avg. depth</th>
<th>Max. depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach/M per day</td>
<td></td>
<td>0.073</td>
<td>0.065</td>
<td>-0.092</td>
<td>0.008</td>
<td>-0.091</td>
<td>0.096</td>
</tr>
<tr>
<td>Link popularity</td>
<td></td>
<td>0.063</td>
<td>0.057</td>
<td>-0.089</td>
<td>0.001</td>
<td>-0.088</td>
<td>0.091</td>
</tr>
<tr>
<td>Book-link popularity</td>
<td></td>
<td>0.065</td>
<td>0.055</td>
<td>-0.090</td>
<td>0.001</td>
<td>-0.089</td>
<td>0.090</td>
</tr>
<tr>
<td>Page views per user</td>
<td></td>
<td>-0.044</td>
<td>0.034</td>
<td>-0.164</td>
<td>0.091</td>
<td>-0.159</td>
<td>0.092</td>
</tr>
<tr>
<td>Search share</td>
<td></td>
<td>-0.463</td>
<td>0.594**</td>
<td>0.435</td>
<td>0.580**</td>
<td>0.455</td>
<td>0.707***</td>
</tr>
<tr>
<td>Switcher-to-loyal ratio</td>
<td></td>
<td>-0.655**</td>
<td>0.677****</td>
<td>0.724**</td>
<td>0.577**</td>
<td>0.739***</td>
<td>0.772****</td>
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</tbody>
</table>

Hypothesis

<table>
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<tr>
<th>Hypothesis</th>
<th>H1a</th>
<th>H1b</th>
<th>H1c</th>
<th>H1d</th>
<th>H1e</th>
<th>H1f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Relationship with Switcher-to-Loyal Ratio</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*p < 0.10, **p < 0.05, ***p < 0.01
Figure 1a
DENSITY FUNCTIONS OF EQUILIBRIUM PRICES IN PROP. 1, ILLUSTRATED FOR \( s_{123} = s_{12} \)

Figure 1b
CUMULATIVE DENSITY FUNCTIONS OF EQUILIBRIUM PRICES IN PROP. 1, ILLUSTRATED FOR \( s_{123} = s_{12} \)
Figure 2a
DENSITY FUNCTIONS OF EQUILIBRIUM PRICES IN PROP. 2

Figure 2b
CUMULATIVE DENSITY FUNCTIONS OF EQUILIBRIUM PRICES IN PROP. 2
Figure 3a
DEPTH AND FREQUENCY OF PROMOTIONS WHEN THE SIZE OF THE FULLY INFORMED SWITCHER SEGMENT IS SMALLER THAN THE SIZE OF THE PARTIALLY INFORMED SWITCHER SEGMENT ($s_{123} < s_{12}$, PROP. 1)

![Graph showing depth and frequency of promotions for Firm 1, Firm 2, and Firm 3](image)

Figure 3b
DEPTH AND FREQUENCY OF PROMOTIONS WHEN THE SIZE OF THE FULLY INFORMED SWITCHER SEGMENT IS LARGER THAN THE SIZE OF THE PARTIALLY INFORMED SWITCHER SEGMENT ($s_{123} > s_{12}$, PROP. 1)

![Graph showing depth and frequency of promotions for Firm 1, Firm 2, and Firm 3](image)
Figure 4
RETAILER CUMULATIVE DISTRIBUTION FUNCTIONS FOR ALL BOOKS

Cumulative Probability

- (6) 1Bookstreet
- (4) A1Books
- (7) Amazon
- (8) Barnes&Noble
- (5) BooksAMillion
- (10) BookVariety
- (1) DoubleDiscount
- (3) eCampus
- (9) PageOne
- (14) Sam Goodys
- (2) TextatCost
- (12) Varsity
- (11) WordsWorth
- (13) Worthy

Price
References


Appendix

Under the model assumptions, the profit functions of the firms are given by the following equation:

\[
\pi_i(p_i, p_{-i}) = p_i(n_i + \delta_{i2}s_{i2} + \delta_{i23}s_{i23})
\]

where \( p_i \) represents the price quoted by Firm \( i \), \( p_{-i} \) represents the vector of prices quoted by other firms, and \( \delta \) takes values from the set \([0,1]\) based on lowest quoted price(s). \( \delta_{i2} \) applies to Firms 1 and 2 and equals 1 for the lower-priced firm, \( \frac{1}{2} \) in the event of a tie in prices, and 0 for the higher-priced firm. \( \delta_{i23} \) applies similarly to all three firms, except if two firms quote the lowest price, \( \delta_{i23} \) equals \( \frac{1}{2} \) for those firms and 0 for the other firm. For a three-way tie in prices, \( \delta_{i23} \) equals \( \frac{1}{3} \) for all three firms. We begin with three lemmas that give some basic properties of the equilibrium solution.

**Lemma 1:** There is no Nash equilibrium in pure strategies.

**Proof of Lemma 1.**

Assume that \((p_1^*, p_2^*, p_3^*)\) is a pure strategy equilibrium. In each of the cases below, we show that there exists at least one \( p_i , i = \{1,2,3\} \) so that \( \pi_i(p_i, p_{-i}^*) > \pi_i(p_i^*, p_{-i}^*) \). Then, by definition, \((p_1^*, p_2^*, p_3^*)\) cannot be a Nash equilibrium strategy. The reasoning is identical to Narasimhan (1988), the only difference being the need to check more cases which arise from the existence of three asymmetric firms. We check all possible orderings of the price triplets \((p_1^*, p_2^*, p_3^*)\) and a candidate price deviation \( p_i \) for each. We then show that \( \pi_i(p_i, p_{-i}^*) > \pi_i(p_i^*, p_{-i}^*) \), \( \varepsilon > 0 \).

i) \( p_1^* = p_2^* = p_3^* \) \( p_2 = p_2^* - \varepsilon \)

ii) \( p_1^* = p_2^* > p_3^* \) \( p_2 = p_2^* - \varepsilon \)

iii) \( p_1^* = p_2^* < p_3^* \) \( p_2 = p_2^* - \varepsilon \)

iv) \( p_1^* > p_2^* = p_3^* \) \( p_2 = p_2^* - \varepsilon \)

v) \( p_1^* > p_2^* > p_3^* \) \( p_2 = p_2^* + \varepsilon < p_1^* \)

vi) \( p_1^* > p_3^* > p_2^* \) \( p_3 = p_3^* + \varepsilon < p_1^* \)

vii) \( p_3^* > p_1^* > p_2^* \) \( p_1 = p_1^* + \varepsilon < p_3^* \)

viii) \( p_1^* = p_3^* > p_2^* \) \( p_1 = p_1^* - \varepsilon \) or \( p_3 = p_3^* - \varepsilon \)

ix) \( p_1^* < p_2^* = p_3^* \) \( p_2 = p_2^* - \varepsilon \) or \( p_3 = p_3^* - \varepsilon \)

x) \( p_1^* < p_3^* < p_2^* \) \( p_3 = p_3^* + \varepsilon < p_2^* \)

xi) \( p_3^* < p_1^* < p_2^* \) \( p_1 = p_1^* + \varepsilon < p_2^* \)
For brevity, we explain for two of these cases how the price deviation results in higher profits such that 

\((p_1^*, p_2^*, p_3^*)\) is not a pure strategy equilibrium. For case \(i\), Firm 2 deviates to capture all switchers:

\[
\pi_2(p_1^*, p_2^*, p_3^*) = (n_2 + \frac{1}{2}s_{12} + \frac{1}{3}s_{123})p_2^*
\]

\[
\pi_2(p_1^*, p_2^*, p_3^*) = (n_2 + s_{12} + s_{123})(p_2^* - \varepsilon)
\]

We see that \(\pi_i(p_1^*, p_j^*, p_k^*) > \pi_i(p_1^*, p_2^*, p_3^*)\) when \(\varepsilon < \frac{p_2^*(3s_{12} + 4s_{123})}{6(n_2 + s_{12} + s_{123})}\). Thus, an \(\varepsilon > 0\) always exists whereby Firm 2’s profits are higher under the price deviation.

For case \(v\), Firm 2 deviates by increasing its price without exceeding Firm 1’s price, giving:

\[
\pi_2(p_1^*, p_2^*, p_3^*) = (n_2 + s_{12})p_2^*
\]

\[
\pi_2(p_1^*, p_2^*, p_3^*) = (n_2 + s_{12})(p_2^* + \varepsilon)
\]

Then \(\pi_i(p_1^*, p_j^*, p_k^*) > \pi_i(p_1^*, p_2^*, p_3^*)\) for \(\varepsilon > 0\).

It is trivial to show that all other cases are solved similarly such that an \(\varepsilon > 0\) exists, whereby at least one firm is better off deviating. Hence, no pure strategy exists. QED.

**LEMMA 2:** Let \(S_i^*\), \(i = \{1,2,3\}\), be the best-response strategy sets (i.e., the set of prices) in the mixed strategy equilibrium. There is no gap \((p_1^*, p_2^*)\) within the joint support \(S_1^* \cup S_2^* \cup S_3^*\) where \(f_i(p) \equiv 0\) for two or more firms. That is, there are at least two firms that possess positive support at any point within the joint support of prices.

**PROOF OF LEMMA 2.**

Assume that there is a gap, \(G = (p_1^*, p_2^*)\) within \(S_1^* \cup S_2^* \cup S_3^*\), where \(f_i(p) \equiv 0\) for two or three firms. We first show that \(f_i(p) \equiv 0\) for two firms contradicts the assumption of equilibrium. This argument is identical to the first part of Proposition 2’s proof in Narasimhan (1988). Let \(\tilde{p}\) be the highest price below \(p_1\) and \(\bar{p}\) be the lowest price above \(p_2\). Let Firm \(i\) be the firm with positive support in \(G\).

Since the profits of Firm \(i\) when it charges any price \(p \in G\)

\[
n_i p + [1 - F_j(p)]ps_{jk} + [1 - F_j(p)][1 - F_k(p)]ps_{ijk} \text{ are increasing in } p, \text{ Firm } i \text{ is better off charging } \bar{p} \text{ with probability } [F_i(\bar{p}) - [F_i(\bar{p})] \text{ compared to having any positive support in } G.
\]
Next we show that $f_i(p) \equiv 0$ in $G = (p_1, p_2)$ within the joint support $S_1^* \cup S_2^* \cup S_3^*$ for three firms contradicts the assumption of equilibrium. Again, let $\bar{p}$ be the highest price below $p_1$ and $\hat{p}$ be the lowest price above $p_2$. Consider Firm $i$’s profits $n_ip + [1 - F_j(p)]ps_{jk} + [1 - F_j(p)][1 - F_k(p)]ps_{ik}$. We see that $f_i(p) \equiv 0$ in $G = (p_1, p_2)$ for three firms implies that neither of $F_i(p), F_j(p), F_k(p)$ change over the set $G = (p_1, p_2)$, and hence $\Delta \pi_i = \pi_i(\hat{p}) - \pi_i(\bar{p}) > 0$, contradicting an equilibrium.

Also note that none of the above arguments rules out gaps $(p_1, p_2)$ within the joint support $S_{3}^* \cup S_{2}^* \cup S_{1}^*$, where $f_i(p) \equiv 0$ for none of the firms or for only one firm. QED.

**Lemma 3:** The cumulative distribution functions of firms’ prices $F_i, i \in \{1,2,3\}$, are continuous, except possibly at $r$. That is, there are no mass points in the interior or at the lower boundary of the joint support $S_{3}^* \cup S_{2}^* \cup S_{1}^*$.  

**Proof of Lemma 3.**

The proof proceeds similar to that of Proposition 3 in Narasimhan (1988). Contrary to the argument, let Firm $i$ have a mass $m$ at point $p \in S_{3}^* \cup S_{2}^* \cup S_{1}^*, p \neq \sup(S_{3}^* \cup S_{2}^* \cup S_{1}^*)$. Because of Lemma 2, there will be no holes around point $p$ and there will be at least one other firm with positive support at $p$. Assume Firm $k$ is the only other firm with positive support at $p$. If Firm $k$ were to transfer some mass from $p + \varepsilon$ to $p - \varepsilon$, we would see that $\Delta \pi_k = \pi_k(p - \varepsilon) - \pi_k(p + \varepsilon) > 0$ for all $\varepsilon > 0$. To see that this is indeed the case, as in Narasimhan (1988), we calculate $\Delta \pi_i$, which is approximately equal to $Sm(p + \varepsilon) - 2\varepsilon(n_k + S)$. In this formula, $S$ represents the switcher segments for which Firm $k$ and Firm $i$ compete at $p$. Hence, for small enough $\varepsilon > 0$, $\Delta \pi_i > 0$. Therefore, in equilibrium, a firm can not have a mass point in the interior of the support, because if it did, another firm could increase its profit by moving some of its mass below the other mass, contradicting Lemma 2. Calculation of similar $\Delta \pi_k$ and $\Delta \pi_j$ is straightforward, if both Firms $k$ and $j$ were to have positive support at $p$. A similar argument would also hold if both Firms $i$ and $j$ were to have masses at $p$, in which case Firm $k$ again would increase its profits by shifting some mass from $p + \varepsilon$ to $p - \varepsilon$. QED.

**Proposition 1:** When $\phi_3 > \phi_1$, Firms 1 and 3 have mutually exclusive price ranges that, when combined, form Firm 2’s price range. Firm 2 competes with Firm 3 in the lower part of its price range.
and with Firm 1 in the upper part of its price range. The equilibrium cumulative distribution functions $F_i(p)$ of the firms’ prices are given by:

$$F_1(p) = \begin{cases} 
0 & p < p_1 \\
(p - p_1)(n_2 + s_{12})/(ps_{12}) & p_1 \leq p < r \\
m & p = r \\
1 & p > r 
\end{cases}$$

$$F_2(p) = \begin{cases} 
0 & p < p_2 \\
(p - p_2)(n_2 + s_{123})/(ps_{123}) & p_2 \leq p \leq p_1 \\
1 - n_1(r - p)/(ps_{12}) & p_1 \leq p \leq r \\
1 & p \geq r 
\end{cases}$$

$$F_3(p) = \begin{cases} 
0 & p < p_2 \\
1 - (p_1 - p)(n_2 + s_{12})/(ps_{123}) & p_2 \leq p \leq p_1 \\
1 & p \geq p_1 
\end{cases}$$

where $m$ is the mass point Firm 1 has at the reservation price, $p_1$ is the lower bound of Firm 1’s support, and $p_2$ is the common lower bound of Firms 2 and 3’s supports given by:

$$p_1 = \frac{n_1 r(n_2 + s_{12} + s_{123})}{s_{12}(n_2 - n_3 + s_{12}) + n_1(n_2 + s_{12} + s_{123})} \geq p_1^{\text{min}}$$

$$p_2 = \frac{n_1 r(n_2 + s_{12})}{s_{12}(n_2 - n_3 + s_{12}) + n_1(n_2 + s_{12} + s_{123})} \geq p_2^{\text{min}}, p_3^{\text{min}}$$

**Proof of Proposition 1.**

Lemma 1 proves that there is no pure strategy. A detailed exposition of mixed strategy solution mechanics for models similar to ours is found in Narasimhan (1988). We first define the upper and lower boundaries of the firms’ supports. The upper bound of the feasible price set is $r$. Prices higher than the reservation price will result in no sales, while positive profits are possible when the reservation price is quoted. Therefore, the highest price that any firm can charge is the common reservation price $r$. To determine the lower boundaries, note that there will likely be two price regions. The lower price region is where only Firms 3 and 2 compete, with an upper bound determined by the lowest price that will be
quoted by Firm 1. The higher price region is determined from this price upward. The minimum price for any firm is when it is indifferent between selling only to its loyals and offering a deep discount to capture the switchers. The minimum prices are \( p_{1}^{\text{min}} = n_{1}r/(n_{1} + s_{12} + s_{123}) \) for Firms 1 and 2 and \( p_{3}^{\text{min}} = n_{3}r/(n_{1} + s_{123}) \) for Firm 3. Since \( n_{1} > n_{2} > n_{3} \) it is always true that \( p_{2}^{\text{min}} < p_{1}^{\text{min}} \). Under the Proposition’s assumption that \( p_{3}^{\text{min}} < p_{1}^{\text{min}} \), we must consider two cases of whether Firm 3’s minimum price is less than or greater than that of Firm 2.

Under the condition that \( p_{3}^{\text{min}} < p_{2}^{\text{min}} < p_{1}^{\text{min}} \), Firm 2 can compete with Firm 3 at prices below \( p_{1}^{\text{min}} \), such that both Firms 2 and 3 have positive support below \( p_{1}^{\text{min}} \). Therefore, Firm 1 cannot capture the switcher segments with certainty, even if it prices at \( p_{1}^{\text{min}} \). This conclusion means that the lowest price to which Firm 1 is willing to discount, \( p_{1} \), must be higher than \( p_{1}^{\text{min}} \) in order to balance the prospect of receiving fewer switchers in expectation. Denoting \( F_{i}(p) \) as the cumulative distribution probability of Firm \( i \)’s prices, we equate Firm 1’s profit selling only to its loyals and its profit when also selling to the switchers at \( p_{1} \), given the probability Firms 2 and 3 quote higher prices:

\[
\begin{align*}
n_{1}r &= n_{1}p_{1} + [1 - F_{2}(p_{1})]p_{2}s_{12} + [1 - F_{2}(p_{1})][1 - F_{3}(p_{1})]p_{3}s_{123} \\
&\Rightarrow p_{1} = \frac{n_{1}r}{n_{1} + [1 - F_{2}(p_{1})]s_{12} + [1 - F_{2}(p_{1})][1 - F_{3}(p_{1})]s_{123}}
\end{align*}
\]

At prices lower than \( p_{1} \), Firms 2 and 3 compete for segment \( s_{123} \) and Firm 2 receives all of segment \( s_{12} \) with certainty. Firm 3 has the lowest minimum price, so it will only find it profitable to include as a lower support bound the lowest price Firm 2 will quote. However, given Firm 2 also competes with Firm 1 for \( s_{12} \) and that Firm 1 has a lower support above \( p_{1}^{\text{min}} \), Firm 2 may find it profitable to adapt a lower support that is higher than \( p_{2}^{\text{min}} \). Hence, we see that Firms 2 and 3 will compete with prices at least up to \( p_{1} \). In so doing, they share a common lower bound \( p_{2} \), which may be higher than \( p_{2}^{\text{min}} \).

To establish the equilibrium profits, all firms can guarantee the profit \( n_{1}r \) by choosing to price at \( r \). However, in terms of undercutting other firms and serving the switcher segment, Firms 2 and 3 are at an advantage. Firm 3 can improve its profit above \( n_{1}r \) by pricing at the lowest price any other firm ever discounts, \( p_{2} \), and serving \( s_{123} \), which results in a profit of \( (n_{3} + s_{123})p_{2} \) for Firm 3. Pricing below \( p_{2} \),
is never optimal for Firm 3, since it could then raise its price and still capture $s_{123}$ for sure. Similarly, Firm 2 can improve its profit above $n_2r$, by pricing at the minimum price Firm 1 will ever feasibly reduce its price, $p_1$, and serving $s_{12}$, which results in a profit of $(n_2 + s_{12})p_1$ for Firm 2. The equilibrium solution reveals that Firm 2 would never deviate and price below the lower bound $p_2$, since it would lose more profit from selling at a lower price to $s_{12}$ and $n_2$ than it could gain by capturing $s_{123}$ with higher probability.

When Firms 2 and 3 compete with prices between $p_2$ and $p_1$, both have lower prices than Firm 1 with probability 1. Hence, they can capture the switcher segment $s_{123}$ if one can price lower than the other. The competition in this interval is somewhat similar to the base model of Narasimhan (1988) with two exceptions. First, the upper limit of the interval is not $r$ but rather $p_1$, which is less than $r$. Second, Firm 2 also considers the fact that whenever it prices in $[p_2, p_1]$, it will serve the switcher segment $s_{12}$ with probability 1. Firms 2 and 3 will randomize their prices in this interval so that the expected profit will be equal to their equilibrium profits. We can write the equilibrium conditions for the interval $[p_2, p_1]$, with the exception of $p_1$, as:

\[
E \pi_2 = (n_2 + s_{12})p_1 = n_2p + s_{12}p + [1 - F_3(p)]ps_{123} \quad (A1)
\]
\[
E \pi_3 = (n_3 + s_{123})p_2 = n_3p + [1 - F_2(p)]ps_{123} \quad (A2)
\]

Note that in Equation (A1), Firm 2 serves its loyal segment and switcher segment $s_{12}$ with any price it quotes. It serves switcher segment $s_{123}$ only if its price is lower than Firm 3’s price. In Equation (A2), Firm 3 serves its loyal segment with any price it quotes, while it serves switcher segment $s_{123}$ only if its price is lower than Firm 2’s price. While attempts to price low in this interval increase Firm 2’s chances of serving $s_{123}$, they also decrease Firm 2’s guaranteed profit from $s_{12}$. Hence, as $p_3^{\text{min}} < p_2^{\text{min}} < p_2$, both firms will share $p_2$ as the lower bounds of their supports, as in Narasimhan (1988). This also means that neither firm will have a mass point at $p_2$, because in that case, the other firm would have a motivation to undercut $p_2$. Therefore, $F_2(p_2)$ and $F_3(p_2)$ both equal zero.
To solve equations (A1) and (A2), we also need to specify values for $p_2$ and $p_1$. First note that, $p_1$ is the lowest price Firm 1 will quote. Hence, the profit Firm 1 makes with the price $p_1$ must be equal to its expected profit:

$$E\pi_1 = n_1r = n_1p_1 + [1 - F_2(p_1)]s_{12} + [1 - F_2(p_1)][1 - F_3(p_1)]p_1s_{123} \tag{A3}$$

Solving Equations (A1), (A2), and (A3) simultaneously, in combination with the cumulative distribution conditions at $p_2$, we find the solutions to this set of equilibrium conditions in the interval $[p_2, p_1]$, with the exception of $p_1$, as:

$$F_2(p) = \frac{(p - p_2)(n_2 + s_{123})}{ps_{123}} \tag{A4}$$

$$F_3(p) = 1 - \frac{(p_1 - p)(n_2 + s_{12})}{ps_{123}} \tag{A5}$$

$$p_1 = \frac{n_1r(n_2 + s_{12} + s_{123})}{s_{12}(n_2 - n_3 + s_{12}) + n_1(n_2 + s_{12} + s_{123})} \tag{A6}$$

$$p_2 = \frac{n_1r(n_2 + s_{12})}{s_{12}(n_2 - n_3 + s_{12}) + n_1(n_2 + s_{12} + s_{123})} \tag{A7}$$

Based on this solution set, we also see that $F_3(p_1)$ equals 1, thereby showing that in the next interval, upwards of $p_1$, only Firms 1 and 2 will be competing. Furthermore, the solution holds as long as $p_2 < p_1^{\min}$, since otherwise, Firm 1 would have an incentive to discount below $p_1$. For $n_1 \geq n_2 + s_{12} + n_3 \frac{s_{12}}{s_{123}}$, $p_2$ will never exceed $p_1^{\min}$. Lemma 2 generally proves that there are no gaps in the support. Lemma 3 proves continuity in the distribution functions.

To solve for the pricing behavior in the next support interval $[p_1, r]$, we write the equilibrium conditions, with the exception of $r$, as:

$$E\pi_1 = n_1r = n_1p + [1 - F_2(p_1)][1 - F_3(p)]ps_{12} \tag{A8}$$

$$E\pi_2 = (n_2 + s_{12})p_1 = n_2p + [1 - F_1(p)]ps_{12} \tag{A9}$$
where $F_2(p)$ is the conditional cumulative distribution function given that $p > p_1$ for Firm 2. Firm 2’s unconditional cumulative distribution function in the interval $[p_1, r]$ is given by $F_2(p_1) + (1 - F_2(p_1))F_2(p)$. The solution to this set of equations gives the final results, where the mass point for Firm 1 at $r$ is a straightforward calculation, given $F_1(p)$:

$$m = \frac{n_1(n_2 + s_{12} + s_{123}) - n_2(n_2 - n_3 + s_{12})}{s_{12}(n_2 - n_3 + s_{12}) + n_1(n_2 + s_{12} + s_{123})}$$

This concludes the solution for $p_3^{\text{min}} < p_2^{\text{min}} < p_1^{\text{min}}$.

For the second case of $p_2^{\text{min}} < p_3^{\text{min}} < p_1^{\text{min}}$ (i.e., $\phi_2 \geq \phi_3 > \phi_1$), the mixed strategy equilibrium is identical to that described above for $p_3^{\text{min}} < p_2^{\text{min}} < p_1^{\text{min}}$. The lower-priced region is where Firms 3 and 2 compete with an upper bound, which is determined by the lowest price that will be quoted by Firm 1. The higher-priced region is established from this lowest price on. Although now $p_2^{\text{min}} \leq p_3^{\text{min}}$, the dynamics of the competition remain the same in both of the support intervals. Firms 2 and 3 share a lower bound, $p_2$ which is greater than both $p_3^{\text{min}}$ and $p_2^{\text{min}}$ but does not exceed $p_1^{\text{min}}$ (note that when $p_2 = p_2^{\text{min}}$ at the extreme $s_{12} = 0$, $\phi_3 > \phi_2$). Neither Firm 2 nor Firm 3 has a motivation to choose any lower bound other than $p_2$, because independent of whether $p_3^{\text{min}} \leq p_2^{\text{min}}$ or $p_2^{\text{min}} \leq p_3^{\text{min}}$, it is easy to verify that both firms’ profits are strictly higher in comparison to a lower bound below $p_2$. For example, Firm 2 could secure a profit of $(n_2 + s_{12} + s_{123})p_3^{\text{min}}$ by pricing at $p_3^{\text{min}}$ and by serving both switcher segments. This profit, however, is strictly less than the profit $(n_2 + s_{12})p_1$ it makes with the lower support of $p_2$. Thus, with the same lower bound, the resulting competition between Firms 2 and 3 in the interval $[p_2, p_1]$ also remains the same, as does the competition in the interval $[p_1, r]$. Hence, the equilibrium is identical independent of whether $p_3^{\text{min}} \leq p_2^{\text{min}}$ or $p_2^{\text{min}} \leq p_3^{\text{min}}$. QED

**PROPOSITION 2:** When $\phi_3 \leq \phi_1$, only Firms 1 and 2 discount while Firm 3’s price is set at $r$.

The resulting cumulative distribution functions are:
PROOF OF PROPOSITION 2.

Under \( p_2^{\min} < p_1^{\min} \leq p_3^{\min} \), Firm 3 has the highest minimum price and, thus, has no advantage in offering deep enough discounts to serve the switcher segment \( s_{123} \). However, Firms 2 and 3 will be competing for the business of \( s_{12} \) and \( s_{123} \). When compared to Firm 1’s position in Proposition 1, Firm 3 is essentially a high-priced niche player that serves only its loyals. Firm 3 will not serve segment \( s_{123} \) because both Firm 1 and Firm 2 quote lower prices with positive probability as they compete for \( s_{12} \).

Thus, the candidate equilibrium profits for Firms 1, 2, and 3 are \( n_1 r, (n_2 + s_{12} + s_{123}) p_1^{\min}\), and \( n_3 r\), respectively. While Firm 2 can offer the lowest price, it will never discount below \( p_1^{\min}\), where it can successfully capture both switcher segments. In this case, Firms 1 and 3 have equilibrium profits they would make from sales to their loyal segments only. For Firms 1 and 2, we solve as follows:

\[
E \pi_1 = n_1 r = n_1 p + [1 - F_2(p)] p(s_{12} + s_{123}) \quad (A10)
\]

\[
E \pi_2 = (n_2 + s_{12} + s_{123}) p_1^{\min} = n_2 p + [1 - F_1(p)] p(s_{12} + s_{123}) \quad (A11)
\]

The solution to this set is:
To show that Firm 3 will indeed never discount in equilibrium, note that the lowest price Firm 3 will ever quote is $p_{3 \text{min}}$. At this price, its expected profit is represented by the following equation:

$$\pi_3(p_{3 \text{min}}) = n_3 p_{3 \text{min}} + [1 - F_2(p_{3 \text{min}})][1 - F_1(p_{3 \text{min}})] p_{3 \text{min}} s_{123}$$  \hspace{1cm} (A14)

Inserting values from (A12) and (A13) into (A14), we indeed see that $\pi_3(p_{3 \text{min}}) < n_3 r$, which means that Firm 3 will never price at $p_{3 \text{min}}$ given that Firms 1 and 2 are already competing for the switcher segments below this price. Also note that since it is only Firms 1 and 2 that can compete at $p_{3 \text{min}}$—and possibly above as we have just shown—the cumulative distribution functions presented by Equations (A12) and (A13) will also remain valid above $p_{3 \text{min}}$. In fact, we can solve for the lowest price point above $p_{3 \text{min}}$ to which Firm 3 will ever reduce its price by solving the equation:

$$n_3 r = n_3 p + [1 - F_1(p)][1 - F_2(p)] p s_{123}$$  \hspace{1cm} (A15)

The only solution to this equation that rises above $p_{3 \text{min}}$ is $r$. Hence, given that Firms 1 and 2 are already competing for the switcher segment below $p_{3 \text{min}}$, Firm 3 will never price in the interval $[p_{3 \text{min}}, r]$. Rather, it will only price at $r$. Hence, the solutions (A12) and (A13) remain valid until $r$. With this solution, Firm 1 also has a mass point at $r$ that equals $(n_1 - n_2)/(n_1 + s_{12} + s_{123})$. While both Firms 1 and 3 have positive masses at $r$, since Firm 2 has a lower price than $r$ with probability 1, Firms 1 and 3 will receive their guaranteed profits $n_r$, while Firm 2’s profit will be higher than $n_2 r$. QED.