# Managing Customer Relationships Under Competition: Punish Or Reward Current Customers?

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# Abstract

Companies spend enormous resources on customer relationship management (CRM), but there is no clear understanding on two seemingly simple, but critical questions: (1) Should firms reward or punish their current customers? (2) Can CRM be profitable in a competitive setting?

While CRM practitioners are enthusiastic about its win-win potential for firms and customers, the extant theoretical literature on CRM-based pricing is not so sanguine. Much of the theoretical literature finds that CRM-based pricing "punishes" existing customers by giving better deals to the competitors' customers; worse CRM-based pricing leads to lower firm profits. In this paper, we present a unified model of CRM-based pricing that helps identify conditions under which to reward/punish current customers and when CRM can increase/decrease profits. We thus bridge the gap between the practitioner's optimism and the theorist's skepticism about CRM.

Key Words: CRM, behavior-based price discrimination, competitive strategy, game theory.

## **1. Introduction**

Over the last decade, firms across a wide variety of industries (for example, banking, insurance, telephone, retailing and airlines to name a few) have increasingly moved towards a customer (as opposed to a product or brand) management strategy. With a customer management focus, these firms have changed from a transactional to a relationship orientation, where they differentiate customers as a function of the lifetime value of the relationship to the firm (Blattberg and Deighton 1996; Peppers and Rogers 2001; Gupta et al. 2004). To implement such a customer relationship strategy, firms have not only made massive investments in information infrastructure to store and analyze customer information, but also changes in organizational structure, employee incentives, accounting and operations management practices to facilitate the implementation of the strategy (Day 2003). Yet, despite such massive investments in Customer Relationship Management (CRM), the current state of the literature provides conflicting guidelines on the optimal strategies for firms in setting differential prices to their new versus existing customers.

Consider the experience of "Bob" with "*WLC*" (We Love Our Customers) Bank. Bob obtained a home equity line of credit a few years ago from *WLC* at an interest rate of prime + 0.25% when the prime rate was 3.5%.<sup>1</sup> With the Federal Reserve raising discount rates, the prime rate is now 8.25%. The rising prime rates have made home equity lines of credit very profitable for banks; therefore market rates for new home equity lines of credit have fallen below the prime rate—the current rate for new customers is prime – 1%. *WLC* recognized that Bob was one of its most valuable customers, because he maintained a high balance on his equity line of credit. To retain him against potential offers from competitors, *WLC* proactively reduced Bob's interest rate to Prime – 0.5%; while this rate was higher than what it offered its new customers, it was lower than the rates that most existing customers were paying. Bob considered *WLC*'s offer, but switched to a rival bank as a new customer and obtained a rate of prime – 1%.

Should *WLC* have offered the same rate as it offered its new customers to retain Bob as a customer? Or, given that *WLC* recognizes Bob as a most valuable customer, should it have offered him an even lower rate than what it offers new customers? However, would such targeted

<sup>&</sup>lt;sup>1</sup> The Prime Interest Rate is the interest rate charged by banks to their most creditworthy customers (usually the most prominent and stable business customers). The rate is almost always the same amongst major banks. The most commonly recognized prime rate is the Wall Street Journal prime rate defined as "the base rate on corporate loans posted by at least 75% of the nation's 30 largest banks."

rate reductions to the most valuable customers be counterproductive as competitors also match the offers? Two key questions naturally arise in this context: Who should get the better value: current or new customers? And which strategy would be more profitable in the long run in a competitive environment?

Despite the massive investments of organizational resources (human, technical and financial) being made by firms in Customer Relationship Management, the answers to what appear to be fairly straightforward questions about CRM-based pricing are not clear. In fact, the practitioner and academic literature arrive at fairly opposite answers to these questions. In their HBR article, O'Brien and Jones (1995) state the conventional wisdom among CRM practitioners: "In order to maximize loyalty and profitability, a company must give its *best value to its best customers*. As a result, they will then become even more loyal and *profitable*" (italics, our emphasis). The argument is that CRM investments will pay off in more efficient *firm-customer* win-win (mutually beneficial) relationships through a virtuous cycle where the firm rewards its current customers with better value propositions that makes it optimal for these customers to deepen their relationship with the firm. In turn, this will increase customer satisfaction, loyalty and ultimately firm profitability (Peppers and Rogers 2004).

Yet, much of the theoretical literature in marketing and economics is skeptical of this conventional wisdom about the win-win potential of CRM-based pricing.<sup>2</sup> In most extant models of CRM-based pricing, current customers are "punished" in that they do not receive the best value. The rationale behind these models is quite compelling. If the firm can price discriminate based on consumers' past purchase behavior, it is logical that the firm charge their existing consumers more than their competitor's customers, because existing customers have already revealed a higher willingness to pay for the product. Therefore, if consumers are forward looking, they fully recognize the possibility that they can be taken advantage of in the future by having to pay higher prices if they reveal information about their preferences through their choices. In one set of models (e.g., Villas-Boas 2004), where a monopolist is faced with strategic forward looking customers, customers will not purchase from the firm to prevent the firm from inferring their true preferences, which could be used to hurt them in the future. Even worse, firms are less

<sup>&</sup>lt;sup>2</sup> We refer to customized pricing based on past purchases as CRM-based pricing. The literature variously refers to it as *pricing with customer recognition* and *behavior-based price discrimination* (e.g., Villas-Boas 1999; Fudenberg and Tirole 2000).

profitable in equilibrium when they use customers' past behavior to set prices relative to the case when they commit not to use the information to harm their own customers.

These issues are magnified in the presence of competition. Extant models still do not find it optimal for firms to offer the best value to their existing customers. Even when consumers are not strategically forward looking and are willing to end up in a relationship trap, competing firms can still be unprofitable relative to a scenario where past purchase information is not used. Thus, in a competitive market, firms are in a prisoner's dilemma by using information about customer purchase history (Villas-Boas 1999, Fudenberg and Tirole 2000). Fudenberg and Villas-Boas (2006) summarize the conclusions of the literature in their comprehensive review of the extant literature on behavior-based price discrimination succinctly: "One recurrent theme throughout the article is that...the seller may be better off if it can commit to ignore information about buyer's past decisions. A second theme is that... more information will lead to more intense competition between firms."

How can this discrepancy between theoretical predictions and the industry/practitioner excitement for CRM be explained?<sup>3</sup> Are customers short-sighted and, therefore, entering a relationship "trap" with firms? Are firms simply making a mistake by investing heavily in CRM, because they are short-sighted and cannot anticipate competitive price matching from their competitors? Or conversely, while the extant results about CRM being unprofitable is correct under the many specific cases, has the literature not yet captured certain important features of real world markets that prevent them from nesting outcomes where CRM-based customized pricing is more profitable for firms and existing customers?

Our goal, therefore, is to develop a unified model that integrates both practitioner intuition and current theoretical results by enriching current theoretical models. We thus seek to have a clearer understanding of the conditions under which practitioner intuition and theoretical results are valid. We accomplish this by incorporating two simple but important features of customer behavior in real-world markets into our model that have been assumed away in the most extant literature.

<sup>&</sup>lt;sup>3</sup> One potential answer is that CRM may reduce future selling costs (Shin 2006). If a firm's selling cost to serve existing customers is lower relative to the cost of serving newly acquired customers, CRM may be a profitable strategy. (Dowling and Uncles 1997). In this paper, our focus is only on CRM-based pricing.

First, we recognize that not all customers are equally valuable. For example, some customers purchase more than others. This feature is critical in capturing the practitioner's view of a "best" customer. There is widespread empirical support for *customer heterogeneity in purchase quantity* or the *80/20 rule*; i.e., the idea that a small proportion of customers contribute to a large number of purchases/profits in a category. Researchers have found support for this across a large number of categories (Schmittlein et al. 1993).

Allowing for customer heterogeneity in purchase quantity allows us to capture another important benefit of CRM investments. When the customer heterogeneity in purchase quantity is modeled, CRM generates an intrinsic *information asymmetry* between competing firms about the customers. A firm can identify heavy users ("best customers") and light users only among its own customers; among its competitor's customers, it would only know the mix of heavy and light users. Note that in all existing models, where all customers buy just one unit of the product and the market is fully covered, there is no information asymmetry, because if a consumer does not buy from one firm, it is known that the customer bought from the other firm. These models miss a major reason for why firms invest in customer relationship management program: that is to obtain an information advantage over the competition on their existing customers.

Second, we recognize the fact that in many markets there is a certain level of intrinsic consumer switching across firms that is independent of the marketing mix. In extant models, switching can occur only due to a sufficiently large price differential between different firms. However, switching can occur for a variety of reasons that can be independent of prices. First, *consumers' preference for a product can change across purchase occasions* because her needs or wants depends on her specific situation at the time of purchase and this situation can change over time (Wernerfelt 1994). The assumption of changing consumer preferences across purchase occasions is relevant in the context of store choice, where consumer's geographic location may be stochastic. For example, a customer may generally prefer *Lowe's* for home improvement products because it is close to his home and likes the superior quality offerings there, but goes to *Home Depot* on his way home from the office, because it is on his way<sup>4</sup>.

<sup>&</sup>lt;sup>4</sup> Caminal and Matutes (1990) and Fudenberg and Tirole (2000) consider the extreme case when consumers' preferences are completely independent over time. However, when preferences are completely independent, purchase histories do not have any predictive power on future purchases. Hence the benefit of CRM investments in predicting future behavior is lost. Further, these models do not allow for customer heterogeneity in quantities.

The idea of stochastic customer preferences is not restricted to store choice and geographic locations. Consider the following example in the context of a product choice problem. A college student who lives in New York may have a preference for American Airlines in general because she likes its service or it has the best connection to her hometown. But, when she needs to visit a friend at Houston, she may prefer Continental because there are more direct flights. A similar logic may apply to consumer's choice of hotels. Even though a customer may prefer the Marriott in general, a customer may find that the Sheraton satisfies her needs better on a particular trip because of proximity to conference venue; business versus family trip etc. <sup>5</sup>

With these two features added to the model, we are able to identify conditions under which (1) firms find it optimal to reward their own best customers or competitor's customers and (2) CRM increases or decreases firm profits in a competitive environment when both firms and consumers are strategic and forward-looking. A by-product of our analysis is that we are able to provide insights on the relative emphasis between customer acquisition and customer retention. In the literature, while practitioners and empirical researchers strongly emphasize the relative importance of customer retention and reducing customer churn (Gupta and Lehmann, 2003), the theoretical literature tends to be more focused on customer acquisition.<sup>6</sup> We also contrast our results from the main model with benchmark models (i) only with heterogeneity in purchase quantity, and (ii) only with intrinsic switching to get better insight on the role that these two features have on the market outcomes. This helps us to see that CRM can improve the profits even under competition when either heterogeneity in customer quantities or intrinsic switching exists; while *both* intrinsic switching and heterogeneity in customer quantities are critical for the "reward best customer" result.

The rest of this paper is organized as follows: Section 2 discusses the related literature and contrasts the contribution of the current paper with respect to the extant literature. Section 3 describes the model and we analyze it in Section 4. Section 5 concludes.

<sup>&</sup>lt;sup>5</sup> Further, consumer preferences cannot be perfectly observed or inferred by a firm even with long purchase history (Pancras and Sudhir 2006). Lee et al. (2002) also find evidence that a consumer's preference (ideal point) varies stochastically over time.

<sup>&</sup>lt;sup>6</sup> In a model with exogenous churn, Syam and Hess (2006) find that competitive firms may differentiate with one using a retention strategy and the other using an acquisition strategy. Retention is never an equilibrium for both firms.

# 2. Literature Review

Our research ties into several interrelated areas of marketing and economics. Our research is most closely aligned to the literature on behavior-based price discrimination and pricing with customer recognition (see Fudenberg and Villas-Boas 2006, for an excellent review). Fudenberg and Tirole (2000) analyze a duopoly in which some consumers remain loyal and others defect to the competitor, a phenomenon they refer to as "customer poaching." Firms price discriminate based on customers' past purchase behavior that reveals the customer's relative preference between two firms. Villas-Boas (1999) extends the Fudenberg and Tirole model to the case of two infinite-lived firms facing overlapping generations of consumers. Each consumer lives for two periods, and each generation has unit mass. Each firm knows the identity of its own past customers, but not those of its competitor's customers, and it does not observe the consumer's age, so it cannot distinguish young consumers from old ones who bought from the competitor in the previous period. In this case where both firms and customers are forward looking, the firms are worse off than when they could credibly share their information. Our work can also be compared to Shaffer and Zhang (2000), who look at a static game similar to the last period of the two-period model in Fudenberg and Tirole (2000), with the additional feature that switching cost may be asymmetric. With symmetric switching costs, firms always charge a lower price to their rival's consumers, but this need not be true when switching costs are sufficiently asymmetric. Villas-Boas (2004) shows that targeted pricing by a monopolist who cannot commit to future prices may make it worse off. However, in a duopoly, Chen and Zhang (2004) demonstrate that profits can increase as competing firms set high prices to learn about customer valuation; and this "price for information" strategy moderates price competition. The paper is also related to Fudenberg and Tirole (1998) who identify conditions under which a monopolist should punish or reward current customers when selling successive generations of a durable good.

The paper also relates to theoretical and empirical literature on targeted pricing based on customer information. Vives and Thisse (1988) and Shaffer and Zhang (1995) show that price discrimination effects of targeting are overwhelmed by price competition effects of targeted pricing leading to a prisoner's dilemma. Liu and Zhang (2006) show that targeted pricing not only reduces profits of competing manufacturers, but those of retailers as well. Chen et al. (2001), however, show that the profitability result is moderated by targeting accuracy. At low levels of targeting accuracy, the positive effect of price discrimination on profit is stronger, but at

high levels of targeting accuracy, the negative effect of competition on profit is stronger. Hence profits are maximized at moderate levels of targeting accuracy. In a sense, our model of intrinsic switching may be thought of as a consumer-behavior based approach to endogenize targeting accuracy. One may map low levels of intrinsic switching to environments where targeting accuracy is high; and high levels of intrinsic switching to environments where targeting accuracy is low.

Related theoretical papers on targeted pricing using purchase history information include Chen and Iyer (2002) and Acquisti and Varian (2005). The empirical literature on this topic (McCulloch et al. 1996, Besanko et al. 2003, Pancras and Sudhir 2006) finds that firms are able to improve profits for firms practicing targeted pricing. Interestingly, the empirical models that find improvements in profits from targeted pricing include both the two key features of consumers that we model in the paper: customer heterogeneity in usage (heavy/light users) and variability in consumer needs/preferences over time (for example, the logit model).

There are two related theoretical papers on CRM that have accommodated heterogeneity in purchase quantities or customer life time value. Kumar and Rao (2006), allow for customers to differ in their basket size and show analytically that profits can increase with the use of purchase history information even under competition. Kim et al. (2001), study personalized reward programs and distinguish between heavy and light users in terms of repeat consumers/one-time consumers, where repeat consumers are assumed to be more price sensitive. Repeat customers are distinguished in terms of rewards promised a priori, but not in terms of prices. They show that a priori commitment to rewards and their associated cost soften the competition to obtain the price sensitive repeat buyers; the resulting softened competition helps increase profits. Neither paper, however, addresses the issue of behavior-based price discrimination; in other words, different prices for own customers and competitor's customers.

Finally, it relates to the literature on lifetime value and loyalty programs in marketing. Many marketing researchers have studied the importance of relationships between customers and firms (Morgan and Hunt 1994, Reinartz and Kumar 2003, and Boulding et al.(2005) for a review on this topic), and the effectiveness of loyalty programs (for example, Kopalle and Neslin 2003, Lal and Bell 2003, Shugan 2005, Uncles et al. 2006). A large body of research uses data on customer's past behavior to estimate the customer's life time value so that a firm can identify its most valuable customers (Jain and Singh 2002, Venkatesan and Kumar 2003, Fader et al. 2005,

Gupta et al. 2004). Researchers have also addressed the issues of identifying marketing mix strategies that increase loyalty and reduce churn among customers. Several papers have shown that loyalty programs increase loyalty (Bolton et al. 2000, Leenheer et al. 2004, Verhoef 2003) and customer's share of wallet (Sharp and Sharp 1997). Organizations such as Harrah's and Hilton insist that loyalty programs are an important key to their growth. While some researchers (Dowling and Uncles 1997) have questioned the effectiveness of loyalty programs, Koppalle and Neslin (2003) demonstrate empirically that loyalty programs can be profitable even in a competitive environment.

We note that there are other ways in which a firm can address the issue of identifying consumer types or preferences without using past purchase information that is used in CRM. In traditional models of third-degree price discrimination (Tirole 1988), firms offer discounts on observable and exogenous characteristics of the consumers (for example, student and senior citizen discounts). Alternatively, firms can use second degree price discrimination by offering a menu of bundles (price and quantity) to choose from, such that consumers voluntarily reveal their preferences or types. We abstract away from these possibilities and focus only on behavior based price discrimination using CRM data on past purchases.

## **3. Model**

We consider a variant of the standard Hotelling model with two retailers indexed by  $i \in \{A, B\}$  geographically located on the two ends of a unit segment, selling an identical nondurable good. We denote the retailer located at point 0 as retailer *A* and the retailer at point 1 as retailer *B*, and the price charged by retailers *A* and *B* at period *t* as  $p_t^A$  and  $p_t^B$ , respectively. We assume a constant marginal cost for the product to be zero without loss of generality.

The market has two periods. Consumers make a purchase decision in both periods. To capture the feature of customer heterogeneity of purchase quantity in the market (the 80/20 idea), we distinguish between two types of consumers in the market: consumers in a high type segment (*H*) purchase *q* units of the good in each period, and consumers in a low quantity segment (*L*) purchase only one unit of the good. Both the *H*-type and *L*-type consumer's geographic locations or preferences (denoted by  $\theta$ ) are uniformly distributed along the Hotelling line,  $\theta \sim U[0,1]$  and we normalize the size of the each market to one. Therefore, an *H*-type consumer and an *L*-type consumer located at  $\theta$  receive the following utility from purchasing the product:

$$U^{H}(p_{t}^{A}, p_{t}^{B} | \theta) = \begin{cases} q(v - p_{t}^{A}) - \theta & \text{if purchase from retailer } A \\ q(v - p_{t}^{B}) - (1 - \theta) & \text{if purchase from retailer } B \end{cases}$$
$$U^{L}(p_{t}^{A}, p_{t}^{B} | \theta) = \begin{cases} v - p_{t}^{A} - \theta & \text{if purchase from retailer } A \\ v - p_{t}^{B} - (1 - \theta) & \text{if purchase from retailer } B \end{cases}$$

and

As described in the introduction, a second key feature that we seek to model is "intrinsic switching" among brands that is independent of the marketing mix (price). We operationalize this by allowing a consumer's locations to be different over the two periods. The second period locations may change due to the external situational shock that is drawn from a uniform distribution ( $\varepsilon \sim U[0,1]$ ) with probability  $\beta$ , where  $\beta \in [0,1]$  captures the extent of the variability in customer location across time. With  $1-\beta$  probability, customer locations do not change, in which case the customer's second period location is the same as the first period location ( $\theta_1$ ). Hence,  $\theta_2 = \varepsilon$  with probability  $\beta$  or  $\theta_2 = \theta_1$  with probability  $1-\beta$ . When  $\beta = 0$ , there is no intrinsic switching because consumer locations are stable and do not change over time, in other words,  $\theta_2 = \theta_1$  all the time. In contrast, when  $\beta = 1$ , there is maximum switching because consumer locations are completely independent.

In the first period, retailers A and B offer a single price  $p_1^A$  and  $p_1^B$  respectively to all consumers. Consumers purchase from retailer A or B, depending on what is optimal for them. Note that we allow for consumers to be forward-looking; so they can correctly anticipate how their purchase behavior will affect the prices they will have to pay in the future.

At the end of period 1, a retailer can now distinguish between three types of customers: (1) customers who bought q units from it; (2) customers who bought one unit and (3) customers who bought no units (and therefore must have bought from the competitor). On the one hand, in the second period retailers know the relative location proximity (closer to A or B) of *all* consumers in the market. This information is symmetric to both retailers. On the other hand, among each retailer's own customers, it knows whether the customer is an H- or L-type in terms of quantity, but it does not know about the quantity type of its competitor's customers. Hence, this information is asymmetric; each retailer knows the type information only for its own customers. Thus, the customer heterogeneity of purchase quantity also confers an *endogenous information* 

*advantage* to retailers with respect to its current customers in the second period.<sup>7</sup> This is a key point of departure with respect to extant models where there is no heterogeneity in purchase quantity.

Further, the retailers know that consumers who purchased from them in the first period have a relative preference for them over the competition. However, since consumer preferences are stochastic, it is not guaranteed that they would continue to prefer the same retailer in the second period. As we can imagine, at sufficiently low levels of intrinsic switching, the purchase information in the first period does indicate that the probability of the customer continuing to be relatively close to the same retailer is greater than the probability of the customer switching to the other retailer. Thus, retailers have useful probabilistic information about the relative location of the customer in the second period. We formally analyze and state what relative location means more precisely later in Section 4.1.; but for now, it suffices to say that first period choice reveals information about relative location even when consumer locations are stochastic.

In period 2, based on this information set, each retailer offers three different prices to the three groups of customers: (1) a poaching price for competitor's customers ( $p_2^{AO}, p_2^{BO}$ ), (2) a price for its own *L*-type customers ( $p_2^{AL}, p_2^{BL}$ ), and (3) a price for its own *H*-type customers ( $p_2^{AH}, p_2^{BH}$ ). Consumers decide where to purchase in the second period after observing all these prices.

Figure 1 summarizes the outline of the game and Table 1 summarizes the notation used in the paper.

<sup>&</sup>lt;sup>7</sup> For the idea that firms have different amount of information about their own customers versus non-customers, see Villas-Boas (1999). Villas-Boas incorporates information asymmetry by assuming that customers can be either new customers or competitor's customers. In contrast, our information asymmetry comes from the customer type (quantity). Also, Villas-Boas and Schmidt-Mohr (1999) consider the impact of asymmetric information between firms and consumers.



Τ	able	1
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$q^{j}$	Purchase quantity of customer type $j \in \{L, H\}$ where $q^{L} = 1$ , $q^{H} = q$ .
$p_1^i$	Retailer $i \in \{A, B\}$ 's first period price to all consumers.
$p_2^{iL}$	Retailer $i \in \{A, B\}$ 's second period price to its <i>L</i> -type customers.
$p_2^{^{iH}}$	Retailer $i \in \{A, B\}$ 's second period price to its <i>H</i> -type customers.
$p_2^{iO}$	Retailer $i \in \{A, B\}$ 's second period price to its <i>competitor</i> 's customers.
β	The probability that consumer location changes in period 2, $\beta \in [0,1]$
Е	If consumer location changes, consumer location in period 2. $\varepsilon \sim U[0,1]$
$oldsymbol{ heta}_t$	A consumer's preference or geographical location at period $t \in \{1, 2\}$ . In particular, $\theta_2 = \varepsilon$ with prob $\beta$ and $\theta_2 = \theta_1$ with prob 1- $\beta$
$ ilde{ heta}_1^j$	First period threshold for customer type $j \in \{L, H\}$ such that all consumers of type <i>j</i> whose $\theta \leq \tilde{\theta}_1^j$ purchase from retailer <i>A</i> and the rest purchase from retailer <i>B</i>
$ ilde{ heta}_2^{Aj}$	Second period threshold for customer type $j \in \{L, H\}$ , who was on retailer <i>A</i> 's turf in the first period such that all consumers of type <i>j</i> whose $\theta \leq \tilde{\theta}_2^{Aj}$ repeat purchase from retailer <i>A</i> and the rest switch to <i>B</i> .
$\widetilde{ heta}_2^{Bj}$	Second period threshold for customer type $j \in \{L, H\}$ , who was on retailer <i>B</i> 's turf in the first period such that all consumers of type <i>j</i> whose $\theta \ge \tilde{\theta}_2^{B_j}$ repeat purchase from retailer <i>B</i> and the rest switch to <i>A</i> .

Pr <sup>Aj</sup>	Probability of repeat purchasing in second period from Retailer A for customer type $j \in \{L, H\}$ who was in A's turf in the first period
$\Pr^{B_j}$	Probability of repeat purchasing in second period from Retailer <i>B</i> for customer type $j \in \{L, H\}$ who was in <i>B</i> 's turf in the first period
$\pi^i_t$	Profit of Retailer $i \in \{A, B\}$ 's in period t. Total profit for retailer i is $\pi^i = \pi_1^i + \delta \pi_2^i$ .
$\delta$	Discount rate.
$E^{A}[U_{2}^{j} \theta_{1}=\tilde{\theta}_{1}^{j}]$	The expected second period utility that marginal customer of type $j \in \{L, H\}$ gets when he/she purchases from retailer A. A marginal customer is an individual who is indifferent between purchasing a product from A and B in the first period.
$E^{B}[U_{2}^{j} \theta_{1}=\tilde{\theta}_{1}^{j}]$	The expected second period utility that marginal customer gets when he/she purchases from retailer B.

## 4. Analysis

We solve the game using backward induction, by first solving for the second period equilibrium strategies and then the first period strategies. Before we solve the game, we define the term "retailer turf" and formally show the value of customer purchase history information in pricing even in the presence of intrinsic switching.

## 4.1 Preliminary: Retailer Turf and the Value of Purchase History Information

At any pair of first-period prices (such that all consumers purchase and both retailers have positive sales), it can be shown that there is a cut-off  $\tilde{\theta}_1^j$  ( $j \in \{L, H\}$ ) such that all consumers of type j whose  $\theta \leq \tilde{\theta}_1^j$  purchase from retailer A and the rest purchase from retailer B in the first period. Following Fudenberg and Tirole (2000), we say that consumers to the left of  $\tilde{\theta}_1^j$  lie in 'retailer A's turf' and the consumers on the right lie in 'retailer B's turf' to emphasize a consumer's relative location on the Hotelling line.

For consumers who purchased from retailer *A* in the first period, retailer *A* offers prices  $p_2^{AH}$ ,  $p_2^{AL}$  to its *H*-type customers and *L*-type customers while retailer *B* offers price  $p_2^{BO}$  to both types at the beginning of the second period. Symmetrically, for consumers who purchased from retailer *B* in the first period, retailer *B* charges  $p_2^{BH}$ ,  $p_2^{BL}$  and retailer *A* charges  $p_2^{AO}$ .<sup>8</sup>

<sup>&</sup>lt;sup>8</sup> As we analyze the symmetric case, "no poaching" does not arise in equilibrium. But in the asymmetric case, for example, when  $\tilde{\theta}_1 < \frac{1}{4}$ , *A*'s turf is very small and consists only of consumers with a strong preference for *A*, and retailer *A* can charge the monopoly price in this market and not lose any sales to retailer *B*.

Given that consumers' location changes in the second period ( $\theta_2 = \theta_1$  with probability  $1 - \beta$ , and  $\theta_2 = \varepsilon$  with probability  $\beta$ , where  $\beta \in [0,1]$  and  $\varepsilon \sim U[0,1]$ ), we can compute the conditional probability that a consumer will locate in a certain range of the Hotelling line, given their first period purchase choice of A or B as the follows:

$$\Pr[\theta_{2} \leq x | \theta_{1} \leq \tilde{\theta}_{1}] = \begin{cases} (1-\beta) + \beta x & \text{if } \tilde{\theta}_{1} \leq x, \\ (1-\beta)\frac{x}{\tilde{\theta}_{1}} + \beta x & \text{if } \tilde{\theta}_{1} > x, \end{cases}$$
(1)  
$$\Pr[\theta_{2} > x | \theta_{1} > \tilde{\theta}_{1}] = \begin{cases} (1-\beta) + \beta(1-x) & \text{if } \tilde{\theta}_{1} \geq x, \\ (1-\beta)\frac{1-x}{1-\tilde{\theta}_{1}} + \beta(1-x) & \text{if } \tilde{\theta}_{1} < x. \end{cases}$$
(2)

Note that equations (1) and (2) give us general conditional probabilities of second period location given that a consumer purchases from retailer *A* and *B* in the first period, respectively. Given these conditional probabilities, we can now state the following proposition.

Lemma 1 (The Value of Purchase History Information): When intrinsic switching is not extreme ( $\beta \le \frac{1}{2(1-z)}$ , where z is the first period market share), a consumer who purchases from the retailer *i* ( $i \in \{A, B\}$ ) in period 1 is more likely to stay in the same retailer's turf rather than move to the competitor's turf.

## Proof: See Appendix.

The lemma shows that the information about consumers' relative locations revealed from the first period purchase is relevant for retailers in the second period when intrinsic switching is not extreme. In particular, when the retailers' turf is symmetric ( $\tilde{\theta}_1 = \frac{1}{2}$ ), the past purchase information is *always* relevant  $\forall \beta \in [0,1)$ , except when preferences are completely independent across periods ( $\beta = 1$ ). For example, when  $\tilde{\theta}_1 = \frac{1}{2}$  and  $\beta = \frac{1}{2}$ , a consumers in *A*'s turf will relocate in the same turf with probability  $\frac{3}{4}$  but may re-locate in *B*'s turf with only probability  $\frac{1}{4}$ .

<sup>&</sup>lt;sup>9</sup> This lemma focuses on the *horizontal* information about customer's first period relative location as observed from the customer's past purchase. As noted in the introduction, past purchases also reveal *vertical* information about the customer quantities. Note that the horizontal "relative information" information is symmetric in that both firms arrive at the same probability inference. In contrast, as discussed in the introduction, the vertical "quantity" information is asymmetric.



Figure 2: Redistribution of Consumer Location for Consumers in A's turf

Figure 2 demonstrates the redistribution of consumer locations in the second period for four *H*-type and *L*-type *A*'s first period customers in the symmetric case when  $\tilde{\theta}_1 = \frac{1}{2}$  and  $\beta = \frac{1}{2}$ . Each letter *H* and *L* represents one *H*- and *L*-type consumer. Probabilistically, three *H*- and *L*-type consumers still remain relatively close to retailer *A*, and one (out of four) of each type consumer changes their locations closer to retailer *B* in the second period as indicated by the arrows in Figure 2. Retailers do not know the exact locations of their first-period customers in the second period, but can assess the average probability of relative proximity (whether closer to *A* or *B*) of their first period customers. In the symmetric case, this implies that the purchase history information is relevant for predicting the customer's future preference for all  $\beta \in [0,1)$ .

#### 4.2 Second-period

A consumer on retailer *A*'s turf will repeat purchase from retailer *A* in the second period if and only if  $q^{j}v - q^{j}p_{2}^{Aj} - \theta_{2} \ge q^{j}v - q^{j}p_{2}^{BO} - (1 - \theta_{2}) \Leftrightarrow \theta_{2} \le \frac{1 + (q^{j}p_{2}^{BO} - q^{j}p_{2}^{Aj})}{2} \equiv \tilde{\theta}_{2}^{Aj}$ , where  $j \in \{L, H\}$ and  $q^{L} = 1$ ,  $q^{H} = q$ . Otherwise, consumers will switch to retailer *B*. Denote the repeat purchase probability of the high and low types for retailer *A* as  $\Pr^{AH}$  and  $\Pr^{AL}$  respectively. It is easy to see that  $\Pr^{AH} = \Pr[\theta_{2} \le \frac{\left[1 + q(p_{2}^{BO} - p_{2}^{AH})\right]}{2} | \theta_{1} \le \tilde{\theta}_{1}^{H} ]$  and  $\Pr^{AL} = \Pr[\theta_{2} \le \frac{\left[1 + (p_{2}^{BO} - p_{2}^{AL})\right]}{2} | \theta_{1} \le \tilde{\theta}_{1}^{L} ]$ , where  $\tilde{\theta}_1^j$  is the first period cut-off for type  $j \in \{L, H\}$ . The repeat purchase probabilities for retailer *B* are  $\Pr^{BH} = \Pr[\theta_2 > \frac{\left[1+q(p_2^{BH} - p_2^{AO})\right]}{2} | \theta_1 > \tilde{\theta}_1^H]$  and  $\Pr^{BL} = \Pr[\theta_2 > \frac{\left[1+p_2^{BL} - p_2^{AO}\right]}{2} | \theta_1 > \tilde{\theta}_1^L]$ .

First, we assume that  $\beta \ge \overline{\chi}(q)$ , where  $\overline{\chi}(q) = \frac{2q^2 - q - 6 + \sqrt{4q^4 - 4q^3 + 25q^2 + 24q}}{4q^2 + q - 3}$ , which ensures that in equilibrium the market is  $\tilde{\theta}_1^L > \tilde{\theta}_2^{AL}$  and  $\tilde{\theta}_1^H \le \tilde{\theta}_2^{AH}$ . From equations (1) and (2), we know  $\Pr^{AH} = (1 - \beta) + \beta \left(\frac{1 + q(p_2^{BO} - p_2^{AH})}{2}\right)$ ,  $\Pr^{AL} = \left(\frac{1 - \beta}{\tilde{\theta}_1^L} + \beta\right) \left(\frac{1 + p_2^{BO} - p_2^{AL}}{2}\right)$ ,  $\Pr^{BH} = (1 - \beta) + \beta \left(\frac{1 - q(p_2^{BH} - p_2^{AO})}{2}\right)$ , and  $\Pr^{BL} = \left(\frac{1 - \beta}{1 - \tilde{\theta}_1^L} + \beta\right) \left(\frac{1 - p_2^{BL} + p_2^{AO}}{2}\right)$ . Thus, the second period profits of retailer A and B are

$$\pi_{2}^{A} = (p_{2}^{AH})q\tilde{\theta}_{1}^{H} \operatorname{Pr}^{AH} + (p_{2}^{AL})\tilde{\theta}_{1}^{L} \operatorname{Pr}^{AL} + (p_{2}^{AO})\left\{q(1-\tilde{\theta}_{1}^{H})\left(1-\operatorname{Pr}^{BH}\right) + (1-\tilde{\theta}_{1}^{L})\left(1-\operatorname{Pr}^{BL}\right)\right\}$$

$$\pi_{2}^{B} = (p_{2}^{BH})q(1-\tilde{\theta}_{1}^{H})\operatorname{Pr}^{BH} + (p_{2}^{AL})(1-\tilde{\theta}_{1}^{L})\operatorname{Pr}^{BL} + (p_{2}^{BO})\left\{q\tilde{\theta}_{1}^{H}\left(1-\operatorname{Pr}^{AH}\right) + \tilde{\theta}_{1}^{L}\left(1-\operatorname{Pr}^{AL}\right)\right\}$$
(3)

Each retailer's second-period demand consists of three parts. For example, retailer A has demand: (1) from its own previous H- type customers  $(\tilde{\theta}_1^H)$  who continue to be in Retailer A's turf in the second period (with probability  $\Pr^{AH}$ ) and pay a price  $p_2^{AH}$ , (2) from its own previous L- type customers  $(\tilde{\theta}_1^L)$  who continue to be in Retailer A's turf in the second period (with probability  $\Pr^{AH}$ ) and pay a price  $p_2^{AH}$ , (2) from its own previous L- type customers  $(\tilde{\theta}_1^L)$  who continue to be in Retailer A's turf in the second period (with probability  $\Pr^{AL}$ ) and pay a price  $p_2^{AL}$ , and (3) from a mix of the competitor's previous high and low type customers  $((1-\tilde{\theta}_1^H)+(1-\tilde{\theta}_1^L))$  who have now shifted to Retailer A's turf (with probability  $1-\Pr^{Bj}$ , where  $j \in \{L, H\}$ ) and pay a price  $p_2^{AO}$ . We obtain the second period prices by solving the retailers' first-order conditions:

$$p_{2}^{AH} = \frac{2-\beta}{2q\beta} + \frac{(2+\beta)\overline{\theta}_{1} + (1-\beta)(2\overline{\theta}_{1}^{L} - 1)}{6(1-\beta+\beta\Lambda)}, \qquad p_{2}^{BH} = \frac{2-\beta}{2q\beta} + \frac{3(1+q)-(2+\beta)\overline{\theta}_{1} - (1-\beta)(q+2\overline{\theta}_{1}^{L})}{6(1+q^{2}\beta-\beta\Lambda)}, \qquad p_{2}^{BL} = \frac{1}{2} + \frac{3(1+q)-(2+\beta)\overline{\theta}_{1} - (1-\beta)(q+2\overline{\theta}_{1}^{L})}{6(1+q^{2}\beta-\beta\Lambda)}, \qquad (4)$$

$$p_{2}^{AO} = \frac{3(1+q)-(2+\beta)\overline{\theta}_{1} - (1-\beta)(q+2\overline{\theta}_{1}^{L})}{3(1+q^{2}\beta-\beta\Lambda)}, \qquad p_{2}^{BO} = \frac{(2+\beta)\overline{\theta}_{1} + (1-\beta)(2\overline{\theta}_{1}^{L} - 1)}{3(1-\beta+\beta\Lambda)}, \qquad (4)$$
where  $\overline{\theta}_{1} = q \widetilde{\theta}_{1}^{H} + \widetilde{\theta}_{1}^{L}$  and  $\Lambda = q^{2} \widetilde{\theta}_{1}^{H} + \widetilde{\theta}_{1}^{L}.$ 

Note that the first period symmetric equilibrium will have equal market share and both retailers charge the same price in the pure strategy equilibrium.<sup>10</sup> Specifically, when  $\tilde{\theta}_1^j = \frac{1}{2}$ , the second period prices are  $p_2^{AH} = p_2^{BH} = \frac{2-\beta}{2q\beta} + \frac{(2+\beta)(1+q)}{12+6(q^2-1)\beta}$ ,  $p_2^{AL} = p_2^{BL} = \frac{1}{2} + \frac{(2+\beta)(1+q)}{12+6(q^2-1)\beta}$ , and  $p_2^{AO} = p_2^{BO} = \frac{(2+\beta)(1+q)}{6+3(q^2-1)\beta}$ . We confirm that  $\tilde{\theta}_1^L > \tilde{\theta}_2^{AL}$  and  $\tilde{\theta}_1^H \le \tilde{\theta}_2^{AH}$  when q > 1 and  $\beta \ge \overline{\chi}(q)$ . Further, the equilibrium second period profits are  $\pi_2^A = \pi_2^B = \frac{1}{72\beta} + \frac{72+\beta(80q^2+88q+40(1+q)\beta-(1+q)^2\beta-32)}{144\beta(2+(q^2-1)\beta)}$ .

We next solve for case when  $\beta < \underline{\chi}(q) = \frac{2(3-q+2q^2)}{3+q+4q^2}$  (where  $\underline{\chi}(q) < \overline{\chi}(q)$ ), which ensures that  $\tilde{\theta}_1^L > \tilde{\theta}_2^{AL}$  and  $\tilde{\theta}_1^H > \tilde{\theta}_2^{AH}$  in equilibrium. Again, using the equations (1) and (2), we know  $\Pr^{AH} = \left(\frac{1-\beta}{\tilde{\theta}_1^H} + \beta\right) \left(\frac{1+q(p_2^{BO} - p_2^{AH})}{2}\right)$ ,  $\Pr^{AL} = \left(\frac{1-\beta}{\tilde{\theta}_1^L} + \beta\right) \left(\frac{1+p_2^{BO} - p_2^{AL}}{2}\right)$ ,  $\Pr^{BH} = \left(\frac{1-\beta}{1-\tilde{\theta}_1^L} + \beta\right) \left(\frac{1-q(p_2^{BH} - p_2^{AO})}{2}\right)$ , and  $\Pr^{BL} = \left(\frac{1-\beta}{1-\tilde{\theta}_1^L} + \beta\right) \left(\frac{1-p_2^{BL} + p_2^{AO}}{2}\right)$ .

Similar to the previous case where  $\beta \ge \overline{\chi}(q)$ , we solve the first order conditions. When  $\tilde{\theta}_1^j = \frac{1}{2}$ , the second period prices are  $p_2^{AH} = p_2^{BH} = \frac{1}{2q} + \frac{(2+\beta)(1+q)}{6(q^2+1)(2-\beta)}$ ,  $p_2^{AL} = p_2^{BL} = \frac{1}{2} + \frac{(2+\beta)(1+q)}{6(q^2+1)(2-\beta)}$ , and  $p_2^{AO} = p_2^{BO} = \frac{(2+\beta)(1+q)}{3(q^2+1)(2-\beta)}$ , which confirm that  $\tilde{\theta}_1^L > \tilde{\theta}_2^{AL}$  and  $\tilde{\theta}_1^H > \tilde{\theta}_2^{AH}$  when q > 1 and  $\beta < \underline{\chi}(q)$ . The second period profits are  $\pi_2^A = \pi_2^B = \frac{(q^2+1)(116-(52-17\beta)\beta)+2q(22-\beta)(2+\beta)}{144(q^2+1)(2-\beta)}$ .

We now summarize our first main result in the following proposition.

#### **Proposition 1:**

(a) **Reward Competitor's Customers**: When intrinsic switching is low ( $\beta < \underline{\chi}(q)$ ), then there exists a symmetric pure strategy equilibrium in second period prices that follows the following ordinal relationship:  $p_2^{iO} \le p_2^{iH} \le p_2^{iL}$  where  $i \in \{A, B\}$ ; that is, competitor's customers receive the lowest price.

(b) Reward Own Customers: When intrinsic switching is sufficiently high ( $\beta \ge \chi(q)$ ) and there exists consumer heterogeneity in purchase quantity ( $q \ge 2$ ), there exists a symmetric pure strategy equilibrium in second period prices that follows the following ordinal relationship:

<sup>&</sup>lt;sup>10</sup> We look for only the pure strategy equilibrium in a symmetric game. The first period analysis will show that the symmetric outcome where both firms charge the same price in the first period is indeed the equilibrium solution.

 $p_2^{iH} \le p_2^{iO} \le p_2^{iL}$  where  $i \in \{A, B\}$ ; that is, a retailer's own high type customers receive the lowest price.<sup>11</sup>

**Proof.** See Appendix.

Proposition 1 leads to several interesting implications: (1) Rewarding own customers is *never* optimal when there is neither heterogeneity in customer quantity nor intrinsic switching. When there is heterogeneity, (2) it is *never* optimal to reward one's own low type customers; they should always receive the highest prices, and (3) rewarding one's own high type customers is optimal only when intrinsic switching is sufficiently high; otherwise one should reward competitor's customers (see Figure 3 below).

The proposition highlights the importance of the two new features that we added to our model. Consistent with the extant literature, it is indeed optimal to reward one's competitor's customers when there is neither heterogeneity nor intrinsic switching as shown in Fudenberg and Tirole (2000). Heterogeneity in quantity and high levels of intrinsic switching are both *necessary* conditions for rewarding one's own customers! The intuition is as follows: Consider first the case when there is no heterogeneity in quantity. When intrinsic switching is low, customer preferences are relatively stable and the probability of retention of current customers (irrespective of whether they are high or low types) is very high. Hence, retailers spend greater effort at acquiring competitor customers by offering a low poaching price to competitor's customers.

Even when intrinsic switching is high, Lemma 1 shows that customers are always at least as likely to stay with the retailer as to switch to the rival in a symmetric market. Therefore, a price cut targeted towards competitor's customers is always more effective than a price cut targeted towards own customers, when the customers are all equal in value (in other words, there is no heterogeneity in quantities). Therefore, even when there is switching from the first to the second period, retailers do not find it optimal to give a better value to their current customers; in other words, retention is less critical than acquisition. Such a strategy where competitor customers are given better values through discounts targeted to buyers of competing products is particularly common in markets for magazines and software as a form of introductory low prices –

<sup>&</sup>lt;sup>11</sup> There exists a small range  $(\underline{\chi}(q) < \beta < \overline{\chi}(q))$  of  $\beta$  where the pure strategy equilibrium does not exist. We focus our analysis only in the pure strategy equilibrium area.

'punishing its own customers'. Perhaps, this could be due to the fact that customers are more likely to buy only one copy of magazine or software.



Figure 3: Prices when q = 2

However, when there is heterogeneity in quantity, the retailers need to assess whether selective retention (rewarding one's best customers) can be profitable. Since the value of one's own low type is lower than the expected average value of the competitor's customer, it is never optimal to offer a better value to retain one's own low type customer. However, as intrinsic switching increases, there is a threshold at which the marginal gain in profit from cutting prices to retain the high type customers becomes greater than the marginal benefit from poaching a mix of high and low type competitor's customers. Hence, retailers seek to retain their high-type customers when intrinsic switching is high. This is the reason why both heterogeneity in quantities and high levels of intrinsic switching are necessary for rewarding own high-type customers.

Finally, we illustrate the customer switching behavior under CRM in Figure 4. Figure 4a shows the case when  $\beta$  is low, where retailers use the acquisition strategy (rewarding competitor's customers). The second period cutoff thresholds for both the high and low types  $(\tilde{\theta}_2^{AH} \text{ and } \tilde{\theta}_2^{AL})$  have shifted to the left of the first period threshold, though the shift is greater for the low-types given that they are offered the highest price. Therefore, *the observed level of switching* is greater for both the high and the low types relative to their intrinsic switching levels.

Figure 4b shows the case when  $\beta$  is high, where retailers use the retention strategy (rewarding one's best customers). An *H*-type customer (*H*<sub>1</sub>) who bought from retailer *A* in the first period, but gets a shock in the second period that puts him close to retailer *B* in the second period, still remains with retailer *A*, while an *L*-type customer (*L*<sub>1</sub>) who bought from retailer *A* in the first period, but gets a shock that makes him even closer to the retailer *A* may still switch to retailer *B* in the second period. In effect, the *observed level of switching* among the high types is lowered relative to their intrinsic switching level, while the observed levels of switching for the low types is greater than their intrinsic switching level.



## 4.3 First-period

To solve for the first period prices, it is useful to describe the consumer's decision tree in Figure 5 over the two periods. As can be seen from the figure, the forward-looking consumer solves a dynamic program in the first period that takes into account the probabilities of second period location and the prices that he will face in both periods. Since these prices are the outcome of a dynamic strategic game played by the two retailers, solving for the equilibrium retailer and consumer strategies requires us to embed the consumer's dynamic programming problem within a dynamic strategic game involving one price for each retailer in the first period

and the three prices (one price each for one's own high and low types and one for the competitor's customers) for each retailer in the second period.



Figure 5: Consumer Decision Tree

Let retailer *A*'s first-period price be  $p_1^A$  and let retailer *B*'s first-period price be  $p_1^B$ . If firstperiod prices lead to a cutoff  $\tilde{\theta}_1^j$ , the marginal consumer of type *j* where  $j \in \{L, H\}$  with location  $\tilde{\theta}_1^j$  must be indifferent between buying a product from *A* or *B* in period 1. Therefore, he compares the utility of purchasing from either retailer *A* or retailer *B* recognizing that his or her locations may change due to intrinsic switching. Note that consumers are *forward-looking* so that they rationally anticipate the consequence of their first period choice in terms of the prices they will receive in the second period. Thus, the following equation holds for the marginal consumer:

$$q^{j}v - q^{j}p_{1}^{A} - \tilde{\theta}_{1}^{j} + \delta\left\{E^{A}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}]\right\} = q^{j}v - q^{j}p_{1}^{B} - (1 - \tilde{\theta}_{1}^{j}) + \delta\left\{E^{B}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}]\right\}$$
(5)

where  $\delta < 1$  is the discount rate, and  $E^{A}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}] = E^{Aj}$ ,  $E^{B}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}] = E^{Bj}$  represent the expected second period utility that the "marginal" consumer gets for the cases when a consumer purchases from retailer *A* or *B* in the first period, respectively. So,

$$E^{Aj} = E^{A}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}] = \int_{\theta_{2}=0}^{\tilde{\theta}_{2}^{Aj}} \Pr(\theta_{2}|\theta_{1} = \tilde{\theta}_{1}^{j}) \times (q^{j}v - q^{j}p_{2}^{Aj} - \theta_{2})d\theta_{2} + \int_{\theta_{2}=\tilde{\theta}_{2}^{Aj}}^{1} \Pr(\theta_{2}|\theta_{1} = \tilde{\theta}_{1}^{j}) \times (q^{j}v - q^{j}p_{2}^{BO} - (1 - \theta_{2}))d\theta_{2},$$
(6)

$$E^{Bj} = E^{B}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}] = \int_{\theta_{2}=0}^{\tilde{\theta}_{2}^{Bj}} \Pr(\theta_{2}|\theta_{1} = \tilde{\theta}_{1}^{j}) \times (q^{j}v - q^{j}p_{2}^{AO} - \theta_{2})d\theta_{2} + \int_{\theta_{2}=\tilde{\theta}_{2}^{Bj}}^{1} \Pr(\theta_{2}|\theta_{1} = \tilde{\theta}_{1}^{j}) \times (q^{j}v - q^{j}p_{2}^{Bj} - (1 - \theta_{2}))d\theta_{2},$$
(7)

where  $\tilde{\theta}_2^{Aj} = \frac{\left[1+q^j \left(p_2^{B^O} - p_2^{Aj}\right)\right]}{2}$  and  $\tilde{\theta}_2^{Bj} = \frac{\left[1+q^j \left(p_2^{B^j} - p_2^{A^O}\right)\right]}{2}$  represent the second period cut-off locations of the *j* type customers who purchase from retailer *A* and *B* in the first period, respectively.

The expected second period utility, equation (6) and (7), has two components in each case. For example, the first term in equation (6),  $\int_{\theta_2=0}^{\tilde{\theta}_2^{H}} \Pr(\theta_2 | \theta_1 = \tilde{\theta}_1^{J}) \times (q^j v - q^j p_2^{Aj} - \theta_2) d\theta_2$ , represents the case when a second period location ( $\theta_2$ ) is such that the first period marginal consumer decides to repurchase from the retailer A at its repeat purchase price and the second term,  $\int_{\theta_2=\tilde{\theta}_2^{H}}^{1} \Pr(\theta_2 | \theta_1 = \tilde{\theta}_1^{J}) \times (q^j v - q^j p_2^{BO} - (1 - \theta_2)) d\theta_2$ , represents the case when the second period location is such that the first period marginal consumer decides to purchase from the retailer B with its poaching price. In contrast, in equation (7), the first term,  $\int_{\theta_2=\tilde{\theta}_2^{H}}^{\tilde{\theta}_2^{BO}} \Pr(\theta_2 | \theta_1 = \tilde{\theta}_1^{J}) \times (q^j v - q^j p_2^{AO} - \theta_2) d\theta_2$ , represents the case when the second period location is such that the first period marginal consumer decides to purchase from the retailer B with its poaching price. In contrast, in equation (7), the first term,  $\int_{\theta_2=\tilde{\theta}_2^{H}}^{\tilde{\theta}_2^{BO}} \Pr(\theta_2 | \theta_1 = \tilde{\theta}_1^{J}) \times (q^j v - q^j p_2^{AO} - \theta_2) d\theta_2$ , represents the case when the second period location is such that a marginal consumer decides to purchase from A at its poaching price and the second term,  $\int_{\theta_2=\tilde{\theta}_2^{H}}^{1} \Pr(\theta_2 | \theta_1 = \tilde{\theta}_1^{J}) \times (q^j v - q^j p_2^{BO} - (1 - \theta_2)) d\theta_2$ , represents the case of repeat purchase from the retailer B with its repeat purchase from A at its poaching price and the second term,  $\int_{\theta_2=\tilde{\theta}_2^{H}}^{1} \Pr(\theta_2 | \theta_1 = \tilde{\theta}_1^{J}) \times (q^j v - q^j p_2^{BO} - (1 - \theta_2)) d\theta_2$ , represents the case of repeat purchase from the retailer B with its repeat purchase price.

From equation (5), it follows that the marginal first period customer of type j is,

$$\tilde{\theta}_{1}^{j} = \frac{\left\{1 + q^{j} p_{1}^{B} - q^{j} p_{1}^{A} + \delta\left(E^{A}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}] - E^{B}[U_{2}^{j}|\theta_{1} = \tilde{\theta}_{1}^{j}]\right)\right\}}{2}$$
(8)

The added complexity is that  $p_2^{AO}, p_2^{BO}$  are functions of both  $\tilde{\theta}_1^L, \tilde{\theta}_1^H$ . Hence,  $E^{AL}, E^{BL}, E^{AH}, E^{BH}$  are functions of both  $\tilde{\theta}_1^L, \tilde{\theta}_1^H$ .

Since consumers are distributed along the Hotelling line,  $\tilde{\theta}_1^j$  is the demand from type *j* consumers for retailer *A* and  $1 - \tilde{\theta}_1^j$  is the demand from type *j* consumers for retailer *B*. By symmetry, we can expect that  $p_1^A = p_1^B$ , and  $\tilde{\theta}_1^j = \frac{1}{2}$ ; in other words, marginal customer of both types *j* in the first period will be at the center and, therefore, the two retailers will split demand

equally in the first period. We confirm that this symmetric outcome is indeed an equilibrium. However, the level of the first period equilibrium price depends on how elastic demand is to a change in price. Since consumers are forward looking, this elasticity is affected by consumer expectations about prices in the second period. Since the high and low type consumers face different prices in the second period, the price elasticity of the two types of customers to first period prices will be different and the optimal first period prices will require retailers to balance the effect of a change in prices on the demand from the two types of customers.

Applying the implicit function theorem, we have the following lemma.

#### Lemma 2.

The first period price sensitivities for L- and H-type consumers are,

$$\frac{d\tilde{\theta}_1^L}{dp_1^A} = -\frac{F_{\theta H}^H - q \cdot F_{\theta H}^L}{F_{\theta L}^L F_{\theta H}^H - F_{\theta H}^L \cdot F_{\theta L}^H} \quad \text{and} \quad \frac{d\tilde{\theta}_1^H}{dp_1^A} = -\frac{q \cdot F_{\theta L}^L - F_{\theta L}^H}{F_{\theta L}^L F_{\theta H}^H - F_{\theta H}^L \cdot F_{\theta L}^H}$$

where

 $F_{\theta L}^{L} = 2 - \delta \left( \frac{\partial E^{AL}}{\partial \tilde{\theta}_{1}^{L}} - \frac{\partial E^{BL}}{\partial \tilde{\theta}_{1}^{L}} \right), \ F_{\theta L}^{H} = -\delta \left( \frac{\partial E^{AH}}{\partial \tilde{\theta}_{1}^{L}} - \frac{\partial E^{BH}}{\partial \tilde{\theta}_{1}^{L}} \right), \ F_{\theta H}^{L} = -\delta \left( \frac{\partial E^{AL}}{\partial \tilde{\theta}_{1}^{H}} - \frac{\partial E^{BL}}{\partial \tilde{\theta}_{1}^{H}} \right), \ \text{and} \ F_{\theta H}^{H} = 2 - \delta \left( \frac{\partial E^{AH}}{\partial \tilde{\theta}_{1}^{H}} - \frac{\partial E^{BH}}{\partial \tilde{\theta}_{1}^{H}} \right).$  **Proof:** See Appendix.

Lemma 2 shows how price sensitivity in the first period is affected by the forward-looking behavior of consumers. When consumers are not forward-looking, the price sensitivity can be obtained by setting  $\delta = 0$ . In particular, *H*-types are more price sensitive than the *L*-types  $(\left|\frac{\partial \tilde{\theta}_{1}^{H}}{\partial p_{1}^{d}}\right| > \left|\frac{\partial \tilde{\theta}_{1}^{L}}{\partial p_{1}^{d}}\right|)$ ; a result that is consistent with empirical findings in the literature (Kim and Rossi 1994, Draeger 2000).

We now solve the first period equilibrium prices and the overall profits. Retailer *A* and *B*'s overall net present value of profits as viewed from period 1 are given by:

$$\pi^{A} = (p_{1}^{A}) \cdot \left(q\tilde{\theta}_{1}^{H} + \tilde{\theta}_{2}^{L}\right) + \delta\pi_{2}^{A},$$

$$\pi^{B} = (p_{1}^{B}) \cdot \left(q(1 - \tilde{\theta}_{1}^{H}) + (1 - \tilde{\theta}_{2}^{L})\right) + \delta\pi_{2}^{B}.$$
(9)

Taking first order conditions with respect to prices and solving for prices and profits, we find a symmetric pure strategy equilibrium where both retailers charge the same prices (see appendix):

$$p_{1}^{A} = p_{1}^{B} = \frac{(1+q)-2\delta\left(\Omega^{H}\left(-\frac{\partial\tilde{\theta}_{1}^{H}}{\partial\rho_{1}^{A}}\right) + \Omega^{H}\left(-\frac{\partial\tilde{\theta}_{1}^{L}}{\partial\rho_{1}^{A}}\right)\right)}{2\left(q\left(-\frac{\partial\tilde{\theta}_{1}^{H}}{\partial\rho_{1}^{A}}\right) + \left(-\frac{\partial\tilde{\theta}_{1}^{L}}{\partial\rho_{1}^{A}}\right)\right)},$$
(10)  
where
$$\Omega_{L} = \frac{\partial\pi_{2}^{AA}}{\partial\rho_{2}^{BO}} \frac{dp_{2}^{BO}}{d\tilde{\theta}_{1}^{L}} + \frac{\partial\pi_{2}^{AB}}{\partial\rho_{2}^{BL}} \frac{dp_{2}^{BL}}{d\tilde{\theta}_{1}^{L}} + \frac{\partial\pi_{2}^{AB}}{\partial\rho_{2}^{BH}} \frac{dp_{2}^{BH}}{d\tilde{\theta}_{1}^{L}} + \frac{\partial\pi_{2}^{A}}{\partial\rho_{1}^{B}} \frac{dp_{2}^{BH}}{\partial\tilde{\theta}_{1}^{L}} + \frac{\partial\pi_{2}^{AB}}{\partial\rho_{2}^{BH}} \frac{dp_{2}^{BH}}{d\tilde{\theta}_{1}^{L}} + \frac{\partial\pi_{2}^{A}}{\partial\tilde{\theta}_{1}^{H}} + \frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}},$$

$$\Omega_{H} = \frac{\partial\pi_{2}^{AA}}{\partial\rho_{2}^{BO}} \frac{dp_{2}^{BO}}{d\tilde{\theta}_{1}^{H}} + \frac{\partial\pi_{2}^{AB}}{\partial\rho_{2}^{BL}} \frac{dp_{2}^{BH}}{d\tilde{\theta}_{1}^{H}} + \frac{\partial\pi_{2}^{AB}}{\partial\rho_{2}^{BH}} \frac{dp_{2}^{BH}}{d\tilde{\theta}_{1}^{H}} + \frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}} + \frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}}.$$

And the equilibrium profits are

$$\pi^{\text{CRM}} = \pi^{A} = \pi^{B} = \left\{ \begin{cases} \frac{(1+q)-2\delta\left[\Omega^{H}\left(-\frac{\delta\tilde{\theta}_{1}^{H}}{\delta p_{1}^{A}}\right)+\Omega^{L}\left(-\frac{\delta\tilde{\theta}_{1}^{L}}{\delta p_{1}^{A}}\right)\right)}{2\left(q\left(-\frac{\delta\tilde{\theta}_{1}^{H}}{\delta p_{1}^{A}}\right)+\left(-\frac{\delta\tilde{\theta}_{1}^{L}}{\delta p_{1}^{A}}\right)\right)}\right)\left(\frac{1+q}{2}\right) + \delta\left(\frac{1}{72\beta} + \frac{72+\beta\left(80q^{2}+88q+40(1+q)\beta-(1+q)^{2}\beta-32\right)}{144\beta\left(2+(q^{2}-1)\beta\right)}\right) & \text{if } \beta \geq \overline{\chi}(q), \end{cases}$$

$$= \begin{cases} \left(\frac{(1+q)-2\delta\left(\Omega^{H}\left(-\frac{\delta\tilde{\theta}_{1}^{H}}{\delta p_{1}^{A}}\right)+\Omega^{L}\left(-\frac{\delta\tilde{\theta}_{1}^{L}}{\delta p_{1}^{A}}\right)\right)}{2\left(q\left(-\frac{\delta\tilde{\theta}_{1}^{H}}{\delta p_{1}^{A}}\right)+\left(-\frac{\delta\tilde{\theta}_{1}^{L}}{\delta p_{1}^{A}}\right)\right)}\right)\left(\frac{1+q}{2}\right) + \delta\left(\frac{(q^{2}+1)(116-(52-17\beta)\beta)+2q(22-\beta)(2+\beta)}{144(q^{2}+1)(2-\beta)}\right) & \text{if } \beta < \underline{\chi}(q). \end{cases}$$

$$(11)$$

We now compare the profits obtained by CRM-based pricing with a model where customer purchase information is not used. Then the model reduces to a static pricing model, where in each period, the two retailers maximize their current profits. The comparison should help us understand the benefits if any of a CRM program.

In a static pricing scenario, both retailers would have charged the static price  $(p_1^s)$  which maximizes the static profit functions in each period such that

$$\pi_{1}^{A} = (p_{1}^{A}) \cdot \left(q\left(\frac{1-qp_{1}^{A}+qp_{1}^{B}}{2}\right) + \left(\frac{1-p_{1}^{A}+p_{1}^{B}}{2}\right)\right)$$
  
$$\pi_{1}^{B} = (p_{1}^{B}) \cdot \left(q\left(\frac{1-qp_{1}^{B}+qp_{1}^{A}}{2}\right) + \left(\frac{1-p_{1}^{B}+p_{1}^{A}}{2}\right)\right).$$
(12)

Taking the first order conditions and solving prices, the equilibrium price in the static case is given by  $p_1^{\text{No CRM}} = p_1^A = p_1^B = \frac{1+q}{1+q^2}$ , and per-period profit is  $\pi_1^A = \pi_1^B = \left(\frac{(1+q)^2}{2(1+q^2)}\right)$ . Therefore, the discounted net present value of the total profit across two periods for both retailers is:

$$\pi^{\text{No CRM}} = \pi^{A} = \pi^{B} = \left(\frac{(1+q)^{2}}{2(1+q^{2})}\right) (1+\delta).$$
(13)

We begin the profit discussion by first considering two special cases where there is (1) only intrinsic switching and (2) only customer heterogeneity in purchase quantity. These cases can be obtained by setting q = 1 and  $\beta = 0$ , respectively, in the general model and helps isolate the

effect of these features in isolation. Finally, we describe the general model with both customer heterogeneity and intrinsic switching to give insights on how the two key features interact.

## 4.3.1 Intrinsic Switching, No Customer Heterogeneity in Purchase Quantity

The case of no customer heterogeneity is captured by the special case of q = 1 in the model, when all customers buy one unit of the product. As Proposition 1-(a) states, when q = 1, then it is always optimal for firms to charge the lowest price to competitor's customers irrespective of the level of intrinsic switching (since the cut-off  $\beta \le \chi(1) = 1$ ). Figure 5 shows the total profits across the first and second periods with CRM and no CRM as a function of  $\beta$  with a discount rate  $\delta \approx 1$ . Further, the graph also shows how the total CRM profits are split across the first and second periods. The per period profits without CRM is 1 and with  $\delta \approx 1$ , the total profits over two periods without CRM is 2.

Note that Fudenberg and Tirole (2000) consider the special case of  $\beta = 0$  and q = 1 in our model. In this case, profit from CRM is lower than profit without CRM. As in Fudenberg and Tirole, we find that firms compete aggressively in the second period to poach competitor customers. On the other hand, consumer's dynamic consideration of future price reduces the demand elasticity in the first period, enabling firms to raise its first period price and profits. However, the increased profit from the first period does not offset the reduced profit from the second period and therefore firms are worse off with CRM when  $\beta = 0$ .

As we extend to the case of general intrinsic switching ( $\beta \in [0,1]$ ), the total profits take an inverted U shaped curve. To understand the intuition behind this, we need to decompose the total profits into profits from the first and second period as shown in Figure 6. The second period profit monotonically increases with  $\beta$  because intrinsic switching softens competition as firms do not wish to aggressively compete for customers who could possibly be on their own turf naturally through intrinsic switching. That is, firms do not wish to erroneously offer aggressive prices to customers who may prefer their own product. Therefore, both the poaching price offered to competitor's customers and retention prices offered to existing customers increase (see Figure 3). This competition softening "mis-targeting" effect identified by Chen et al. (2001) raises second period prices and profit.

On the other hand, the effect of intrinsic switching on first period profit is more subtle. There is an "indirect" effect due to the consumer's consideration of future price. As consumers

recognize that future price will increase (both second period repeat purchase and poaching prices will increase in  $\beta$ ), their choices become less sensitive to changes in first period price. The lower price sensitivity shifts first period price upward as  $\beta$  increases.<sup>12</sup>

However, there is a countervailing "direct" effect exerting downward pressure on first period price. As  $\beta$  increases, the linkage between customer's choices in the first and second period weakens, because consumer preferences become less correlated, the price elasticity in the first period is less affected by what happens in the second period. The direct effect interacts with the indirect effect and effectively weakens the upward pressure of the indirect effect. At the extreme, when  $\beta = 1$ , the demand in the two periods become independent and the price elasticity increases to the short-run elasticity without CRM; in turn, the profits with and without CRM become identical.

In sum, the net of these two effects on the first period price (upward pressure from indirect effect and downward pressure from the direct effect) leads to an inverted U-shape curve for the first period profits (and total profits as well). Therefore, the total equilibrium profit is maximized at  $\beta = 0.6435$ , increasing for  $\beta \in [0, 0.6435]$  and decreasing for  $\beta \in [0.6435, 1]$ . Not surprisingly at  $\beta = 1$ , the total profits from CRM are equal to profits without CRM because there are no linkages between demand in the first and second period.

<sup>&</sup>lt;sup>12</sup> More precisely, the indirect effect through consumer's future consideration affects the first period price in two ways: On the one hand, the second period high repeat purchase price decreases price elasticity in the first period because customers know that they will be ripped off by the same firm in the second period (*ratchet effect*). On the other hand, the second period low poaching price increases price elasticity in the first period causing a downward pressure on prices. As  $\beta$  increases, both poaching and repeat purchase price increase and the correct expectation of these high prices makes consumers less price sensitive in the first period (higher repeat purchase price further decreases price elasticity and higher poaching price weakens an upward pressure on price elasticity). Hence, the indirect effect through consumer's dynamic consideration makes the first period demand less elastic, causing firms to increase prices and profits in the first period as  $\beta$  increases.



4.3.2 No Intrinsic Switching, Only Customer Heterogeneity in Purchase Quantity

When there is no intrinsic switching ( $\beta = 0$ ), we know from Proposition 1-b that retailers offer the lowest price to their competitor's customers, therefore,  $p_2^{iO} \le p_2^{iH} \le p_2^{iL}$ . Hence, it is never optimal for firms to reward one's own customers when there is no intrinsic switching. What is particularly interesting is that when the heterogeneity in purchase quantities is sufficiently high, the total profit with CRM is greater than profits without CRM.

**Proposition 2.** Suppose that there is no intrinsic switching ( $\beta = 0$ ). If the heterogeneity in purchase quantities is sufficiently high (q>5), then both retailers increase their profits under CRM based targeted pricing.

# Proof. See Appendix.

This shows that CRM can increase both firms' profits even without any intrinsic switching, under competition. Thus, discrimination of customers on the basis of their value is profitable to firms when the extent of heterogeneity in quantities is large enough. We should note that it is not simply because of heterogeneity in quantities and the ability of CRM to distinguish between the high and the low type customers. What is critical is that information about customer types is asymmetric in a CRM environment; each firm only knows about its own customer's types and not those of its competitor's customers.

The intuition for the result is as follows: Since the retention price to high types is lower than the retention price to low types, firms recognize that poaching will disproportionately bring in *L*type customers relative to *H*-type customers, and, therefore, they do not compete intensively for attracting competitor's customers in equilibrium. In other words, under asymmetric information, the poacher faces a *lemon's problem* in attracting the competitor's customers since most of valuable customers are well protected from the incumbent retailer by CRM. Hence, this asymmetric informational advantage enables firms to price discriminate among their high and low type customers without competitors competing away the profits; in other words, it works to shield the firms' profits from competition.

## 4.3.3 Both Intrinsic Switching and Customer Heterogeneity in Purchase Quantity

We now study the full model by relaxing both the q = 1 and  $\beta = 0$  assumptions. Specifically, we consider the q = 2 case to allow for customer heterogeneity, as this helps build intuition for the customer heterogeneity case with the least complexity.



Figure 6: Profits when q = 2

Figure 6 shows total profits with and without CRM when q = 2. As anticipated from Proposition 1, now there are two regimes based on the pricing strategy in period 2. When intrinsic switching is low ( $\beta < \chi(2) = 0.857$ ), firms use an acquisition strategy, in that firms offer the best prices to competitor's customers; when intrinsic switching is high ( $\beta \ge \chi(2) \approx 0.894$ ), firms use an retention strategy, in that firms offer the best prices to its own best customers.

The intuition behind the inverted U shaped profit curve when firms follow the acquisition pricing strategy (Figure 6-a) is similar to the case when q = 1. However, with heterogeneity in

customer quantities, as discussed in Proposition 1, the retention strategy is optimal above a certain threshold level of  $\chi(2) \approx 0.894$ . Under the retention strategy, the total profits fall monotonically as  $\beta$  increases since both first and second period profits fall with  $\beta$  as seen in Figure 6-b. However, the second period profit with CRM is always greater than profit without CRM, irrespective of the level of intrinsic switching under the retention strategy. Moreover, there exists a range of intrinsic switching,  $\beta \in (0.894, 0.917)$ , in which the total profit with CRM is greater than without CRM even under the retention strategy.

Summarizing the discussion on profits above, we can now state our third and final proposition.

## Proposition 3 (Profitability of CRM).

(a) Reward Competitor's Customers in Second Period Case: When intrinsic switching is low  $(\beta < \chi(2) = 0.857)$ , the total profit with CRM is greater than profits without CRM if intrinsic switching is in the range  $\beta \in (0.115, 0.857)$ .

(b) Reward Own Customers in Second Period Case: When intrinsic switching is sufficiently high  $(\beta \ge \chi(2) = 0.894)$ , the total profit with CRM is greater than profits without CRM when intrinsic switching is in the range  $\beta \in (0.894, 0.917)$ .

# 5. Conclusion

We summarize the key results of the paper and conclude with suggestions for future research.

#### **5.1 Summary of Results**

Table 2 summarizes the key results on pricing and profits as a function of the two key market characteristics (i) customer heterogeneity in purchase quantity and (ii) intrinsic switching.

Table 2: Summary of Results

		Intrinsic Switching		
		No	Sufficiently High	
Heterogeneity in Quantity (Information Advantage on Current Customers)	No	<b>Prices</b> : Reward Competitor Customers (Proposition 1-a)	<b>Prices</b> : Reward Competitor Customers (Proposition 1-b)	
		<b>Profits</b> : CRM Based Pricing Less Profitable (Proposition 3-a)	<b>Profits</b> : CRM Based Pricing More Profitable (Proposition 3-a)	
	Sufficiently High	<b>Prices</b> : Reward Competitor Customers (Proposition 1-a)	<b>Prices</b> : Reward Current High Type Customers (Proposition 1-b)	
		<b>Profits</b> : CRM Based Pricing More Profitable (Proposition 2)	<b>Profits</b> : CRM Based Pricing More Profitable unless switching is extreme (Proposition 3-b)	

When there is neither heterogeneity in purchase quantity nor intrinsic switching, consistent with existing theoretical models, it is not optimal to reward current customers and CRM-based pricing is less profitable. However, the profit result deviates from existing models as we introduce either heterogeneity in purchase quantity or intrinsic switching in customer preference. With sufficiently high heterogeneity, CRM based pricing becomes more profitable, whether there is intrinsic switching or not. Also, with sufficient intrinsic switching, CRM based pricing becomes more profitable either when there is heterogeneity in customer quantity or not. Thus CRM can improve profits under competition, even when consumers and firms are strategic and forward looking when either heterogeneity in customer quantities or intrinsic switching exists.

Finally, the "reward current (high type) customers" result can be obtained only when both conditions (*i*) sufficient heterogeneity in purchase quantities and (*ii*) sufficiently high intrinsic switching are met. In the absence of intrinsic switching, current customers have revealed their relatively high utility for the firm's product; and there is very limited danger that they will switch to the competition. Hence, it is never optimal to offer a better price to current customers in the absence of variability in customer locations. However, the threat of switching is not sufficient to give current customers a better price; if customers are identical in their purchase quantities (life time value), offering better prices to new customers always (weakly) dominates offering better prices to current customers.

Therefore, with our extended model we reconcile the apparent conflict between the practitioner's optimism and the analytical literature's skepticism about CRM by nesting both the existing analytical results, and the practitioner's intuition. Since both heterogeneity in lifetime

value of customers and the threat of customer switching are characteristics of a wide variety of markets, understanding the extent of such heterogeneity in lifetime value and customer switching will be critical in valuing the benefits of CRM and arriving at the right balance between customer acquisition and retention.

Our results suggest the answer to the question related to *WLC* Bank that we asked in our illustrative anecdote in the introduction. Based on our experience with financial services data and the published literature, bank customers almost universally follow the 80/20 rule; furthermore, switching between banks is relatively uncommon. Given these characteristics, CRM-based pricing should increase the bank's profits, but they should indeed offer the best prices to new customers. Therefore, it would be indeed optimal to let even a highly valuable customer switch to the competition. It appears *WLC*'s decisions are consistent with our model's predictions.

Examples of markets with the 80/20 rule and high intrinsic switching can be seen in catalog retailing for items like apparel etc. In such markets, firms value CRM based pricing and often send special value catalogs to their existing customers consistent with the predictions of our model. Examples of markets with homogeneous purchase quantities where firms routinely reward competitor's customers through low introductory prices include magazines and software.

Overall, we recognize that both the extant analytical and CRM practitioner literature are correct in different circumstances. The key takeaway is that CRM is likely to be almost always profitable, because the 80/20 rule is prevalent in most markets; whether to offer rewards to current or existing customers is likely to be more situation dependent as a function of intrinsic switching propensities in these markets. Since high levels of intrinsic switching are required for the "reward current customer" result, we believe that offering rewards to competitor's customers is more likely to be observed in practice, though high lifetime value customers always will obtain a better value than low lifetime value customers.

## 5.2 Limitations and Suggestions for Future Research

We discuss certain limitations of our model that suggest interesting directions for future research. In this paper, we focused only on customer heterogeneity in quantities and intrinsic switching to isolate the critical characteristics that help reconcile practitioner intuition and current analytical results. However, several additional issues can be explored. In the current model, we have not allowed consumers to split their purchases across different firms. If customers split purchases, it would be harder for firms to infer the customer's true potential and to infer the firm's share of the customer wallet. Thus, in contrast to our model where purchases help firms to unambiguously identify the high and low types, the inference is only probabilistic when firms have only share of wallet information. This weakens the extent of information asymmetry in the model.

Many third parties sell estimates of customer spending potential, based on observed characteristics of the household (zip code, demographics etc.); but the potential information is far from perfect. Therefore, even with third party information, observed purchase histories will still provide the information asymmetry that is critical to the profitability of CRM. We therefore believe our findings are robust to the introduction of noisy potential information. However, it will weaken the information asymmetry in the market. A systematic analysis of how share of wallet and potential estimates affect information asymmetry and their resulting effect on CRM based pricing would be a very important next step both from an empirical and theoretical perspective.

We focused on CRM-based pricing, but many CRM programs differentiate customers through differentiated services and advertising. Iyer et al. (2005) study targeted advertising and pricing, but their model is built around a core where CRM-based pricing is unprofitable. It would be interesting to test how the implications of targeted advertising change in our model setting. Also, our analysis of rewards was restricted to price cuts. We need to investigate the effect of other types of rewards (for example, higher level of service such as faster check-in and "free" trips).

Our theoretical model also provides empirically testable hypotheses for future research. We find that CRM programs are most likely to be effective when there is sufficient heterogeneity in customer quantities and there is a threat of switching. We believe empirical research on CRM programs across categories would help ascertain whether these predictions of our model are empirically valid. We hope that our model serves as an impetus for further theoretical and empirical research in CRM.

# Appendix

## Proof of Lemma 1 (The value of information).

First, we consider for retailer *A*. Let *z* be the first period market share, then  $\Pr[\theta_2 \le z | \theta_1 \le z] \ge \Pr[\theta_2 > z | \theta_1 \le z] \Leftrightarrow (1 - \beta) + \beta z \ge \beta(1 - z)$ . Hence,  $\Pr[\theta_2 \le z | \theta_1 \le z] - \Pr[\theta_2 > z | \theta_1 \le z] \ge 0 \Leftrightarrow \beta \le \frac{1}{2(1-z)}$ . Therefore, it always holds when  $\beta \le \frac{1}{2(1-z)}$ . In particular, when  $z \ge \frac{1}{2}$  the inequality always holds for  $\forall \beta \in (0,1]$ . Next, let  $\overline{z} = 1 - z$  be retailer *B*'s 1<sup>st</sup> period market share and substitute it into equation (2). We get the exactly same result. **Q.E.D.** 

#### Proof of Proposition 1 (Reward one's own customers).

(1) We first verify that  $p^{iL} - p^{iO} = \frac{1}{2} - \frac{(2+\beta)(1+q)}{6(q^2+1)(2-\beta)} \ge 0 \Leftrightarrow 2(3q^2 - q + 2) \ge (3q^2 + q + 4)\beta$ . It is obvious that  $(3q^2 + q + 4)\beta \le (3q^2 + q + 4)$  and  $2(3q^2 - q + 2) > (3q^2 + q + 4) \Leftrightarrow 3q(q-1) \ge 0$ . Therefore,  $p^{iL} \ge p^{iO}$  for all  $\beta \in [0,1]$  and  $q \ge 1$ .

Next, we only need to show that  $p^{iO} \le p^{iH} \Leftrightarrow \frac{(2+\beta)(1+q)}{3(q^2+1)(2-\beta)} \le \frac{1}{q}$ . The (LHS) is monotonically increasing in  $\beta \in [0,1]$  since the derivative of (LHS) with respect to  $\beta$  is  $\frac{4(1+q)}{3(1+q^2)(2-\beta)^2} > 0$ . Also, note that  $\beta = \frac{2(3-q+2q^2)}{3+q+4q^2}$  is the unique cut-off value of  $\beta$  such that  $p_2^{iH} = p_2^{iO}$ . Hence, for all  $\beta \le \frac{2(3-q+2q^2)}{3+q+4q^2}$ ,  $\frac{(2+\beta)(1+q)}{3(q^2+1)(2-\beta)}$  is decreasing as  $\beta$  approaches zero while (RHS) is constant, i.e.,  $\frac{(2+\beta)(1+q)}{3(q^2+1)(2-\beta)} \le \frac{1}{q} \Leftrightarrow p^{iO} \le p^{iH}$ .

(2) First, we notice that  $1 > \chi(q) = \frac{2q^2 - q - 6 + \sqrt{4q^4 - 4q^3 + 25q^2 + 24q}}{4q^2 + q - 3} > \frac{2q^2 - q - 15}{4q^2 + q - 3} = \frac{2q + 5}{4q + 1} > \frac{1}{2}$  for all  $q \ge 1$ . We have  $p_2^{iO} \le p_2^{iL} \Leftrightarrow \frac{(2+\beta)(1+q)}{12+6(q^2-1)\beta} \le \frac{1}{2} \Leftrightarrow 2(1+q) - 6 \le (3q+1)(q-4)\beta$ . The inequality always satisfies for all  $q \ge 1$  when  $\beta = \frac{1}{2}$ . Hence, the inequality always satisfies for all  $\beta \ge \chi(q)$  since the RHS of this inequality is monotonically increasing in  $\beta$  and  $\chi(q) > \frac{1}{2}$ .

Next, we have  $p_2^{iH} \leq p_2^{iO} \Leftrightarrow \frac{2-\beta}{2q\beta} \leq \frac{(2+\beta)(1+q)}{12+6(q^2-1)\beta}$ . Note that  $\chi(q)$  is the unique cut-off value of  $\beta \in [0,1]$  such that  $p_2^{iH} = p_2^{iO}$ . Also, the derivative of (LHS) with respect to  $\beta$  is  $-\frac{1}{q\beta^2} < 0$  and the derivative of (RHS) with respect to  $\beta$  is  $-\frac{(1+q)(q^2-2)}{3(2+(q^2-1)\beta)^2} < 0$  for q > 1. Hence, both  $p_2^{iH}$ ,  $p_2^{iO}$  are monotonically decreasing in  $\beta$ . Moreover, when  $\beta = 1$ ,  $p_2^{iH} \leq p_2^{iO} \Leftrightarrow \frac{1}{q} \leq \frac{(1+q)}{2+(q^2-1)} \Leftrightarrow 1 \leq q$ . By monotonicity and the fact that  $p_2^{iH} \leq p_2^{iO}$  at  $\beta = 1$ , we know that when q > 1 and  $\beta \in [\chi(q), 1]$ ,  $p_2^{iH} \leq p_2^{iO}$ . Note that when q = 1, the inequality does not hold for all  $\beta \in [0,1]$ . However, the equality  $p_2^{iH} = p_2^{iO}$  only holds when  $\beta = 1$  in this case. This proves that  $p_2^{iH} \leq p_2^{iO} \leq p_2^{iL}$  when  $\beta \in [\chi(q), 1]$  and q > 1. Q.E.D.

#### Proof of Lemma 2.

Define the implicit functions from equation (9) as follows:

$$F^{L}(p_{1}^{A},\tilde{\theta}_{1}^{L},\tilde{\theta}_{1}^{H}) = 2\tilde{\theta}_{1}^{L} - \left\{1 + p_{1}^{B} - p_{1}^{A} + \delta\left(E^{AL}(\tilde{\theta}_{1}^{L},\tilde{\theta}_{1}^{H}) - E^{BL}(\tilde{\theta}_{1}^{L},\tilde{\theta}_{1}^{H})\right)\right\} = 0,$$

and 
$$F^{H}(p_{1}^{A}, \tilde{\theta}_{1}^{L}, \tilde{\theta}_{1}^{H}) = 2\tilde{\theta}_{1}^{H} - \left\{1 + qp_{1}^{B} - qp_{1}^{A} + \delta\left(E^{AH}(\tilde{\theta}_{1}^{L}, \tilde{\theta}_{1}^{H}) - E^{BH}(\tilde{\theta}_{1}^{L}, \tilde{\theta}_{1}^{H})\right)\right\} = 0$$

We differentiate both equations and rearrange them as follows:

$$\frac{d\tilde{\theta}_{1}^{L}}{dp_{1}^{A}} = -\frac{\left(\frac{\partial F^{L}}{\partial p_{1}^{A}} + \frac{\partial F^{L}}{\partial \tilde{\theta}_{1}^{H}} \cdot \frac{d\tilde{\theta}_{1}^{H}}{dp_{1}^{A}}\right)}{\frac{\partial F^{L}}{\partial \tilde{\theta}_{1}^{L}}}, \text{ and } \frac{d\tilde{\theta}_{1}^{H}}{dp_{1}^{A}} = -\frac{\left(\frac{\partial F^{H}}{\partial p_{1}^{A}} + \frac{\partial F^{H}}{\partial \tilde{\theta}_{1}^{L}} \cdot \frac{d\tilde{\theta}_{1}^{L}}{dp_{1}^{A}}\right)}{\frac{\partial F^{H}}{\partial \tilde{\theta}_{1}^{H}}}.$$

Solving these two equations simultaneously, we have the following results:

$$\frac{d\tilde{\theta}_{1}^{L}}{dp_{1}^{A}} = -\frac{\left(\frac{F_{p}^{L} - \frac{F_{\partial H}^{T}}{F_{p}^{H}}, F_{p}^{H}}{\left(F_{\partial L}^{L} - \frac{F_{\partial H}^{L}, F_{p}^{H}}{F_{\partial H}^{H}}\right)} = -\frac{F_{\partial H}^{H}F_{p}^{L} - F_{\partial H}^{L}, F_{p}^{H}}{F_{\partial H}^{H}F_{oL}^{L} - F_{\partial H}^{L}, F_{oL}^{H}} \text{ and } \frac{d\tilde{\theta}_{1}^{H}}{dp_{1}^{A}} = -\frac{\left(\frac{F_{p}^{H} - \frac{F_{\partial L}^{H}}{F_{oL}^{H}}, F_{p}^{L}}{\left(F_{\partial H}^{H} - \frac{F_{D}^{H}}{F_{oL}^{H}}, F_{OH}^{H}\right)} = -\frac{F_{\partial L}^{L}F_{p}^{H} - F_{\partial L}^{H}, F_{p}^{L}}{F_{\partial L}^{L}} = -\frac{F_{\partial L}^{L}F_{p}^{H} - F_{\partial L}^{L}, F_{p}^{L}}{\left(F_{\partial H}^{H} - \frac{F_{D}^{H}}{F_{oL}^{H}}, F_{OH}^{H}, F_{OL}^{H}, F_{OL}^{$$

Using that  $F_p^L = \frac{\partial F^L}{\partial p_1^A} = 1, F_p^H = \frac{\partial F^H}{\partial p_1^A} = q$ , we have the result, where  $F_{\theta L}^L = \frac{\partial F^L}{\partial \tilde{\theta}_1^L} = 2 - \delta \left( \frac{\partial E^{AL}}{\partial \tilde{\theta}_1^L} - \frac{\partial E^{BL}}{\partial \tilde{\theta}_1^L} \right)$ ,  $F_{\theta L}^H = \frac{\partial F^H}{\partial \tilde{\theta}_1^L} = -\delta \left( \frac{\partial E^{AH}}{\partial \tilde{\theta}_1^L} - \frac{\partial E^{BH}}{\partial \tilde{\theta}_1^L} \right)$ ,  $F_{\theta H}^L = \frac{\partial F^L}{\partial \tilde{\theta}_1^H} = -\delta \left( \frac{\partial E^{AL}}{\partial \tilde{\theta}_1^H} - \frac{\partial E^{BL}}{\partial \tilde{\theta}_1^H} \right)$ , and  $F_{\theta H}^H = \frac{\partial F^H}{\partial \tilde{\theta}_1^H} = 2 - \delta \left( \frac{\partial E^{AH}}{\partial \tilde{\theta}_1^H} - \frac{\partial E^{BH}}{\partial \tilde{\theta}_1^H} \right)$ . Q.E.D.

#### **Derivation of first period price.**

We followed Fudenberg and Tirole (2000)'s proof strategy based on the envelope theorem. First, it is convenient to rewrite equation (11) for firm *A*'s overall profits using the functions  $\pi_2^{AA}$ ,  $\pi_2^{AB}$  to represent retailer *A*'s second-period profit from its own previous customers and from retailer *B*'s previous customers, respectively.

$$\pi^{A} = (p_{1}^{A} - c) \cdot \left\{ q \tilde{\theta}_{1}^{H} + \tilde{\theta}_{1}^{L} \right\} + \delta \left\{ \pi_{2}^{AA} \left( p_{2}^{Ai} (p_{1}^{A}, p_{1}^{B}), p_{2}^{Bi} (p_{1}^{A}, p_{1}^{B}), \tilde{\theta}_{1}^{L} (p_{1}^{A}, p_{1}^{B}), \tilde{\theta}_{1}^{H} (p_{1}^{A}, p_{1}^{B}) \right) \right\},$$
(A-10)  

$$+ \pi_{2}^{AB} \left( p_{2}^{Ai} (p_{1}^{A}, p_{1}^{B}), p_{2}^{Bi} (p_{1}^{A}, p_{1}^{B}), \tilde{\theta}_{1}^{L} (p_{1}^{A}, p_{1}^{B}), \tilde{\theta}_{1}^{H} (p_{1}^{A}, p_{1}^{B}) \right) \right\},$$
(A-10)  
where  $\pi_{2}^{AA} \left( p_{2}^{Ai}, p_{2}^{Bi}, \tilde{\theta}_{1}^{L}, \tilde{\theta}_{1}^{H} \right) = (p_{2}^{AH}) q \tilde{\theta}_{1}^{H} \operatorname{Pr}^{AH} \left( p_{2}^{AH}, p_{2}^{BO}, \tilde{\theta}_{1}^{H} \right) + (p_{2}^{AL}) \tilde{\theta}_{1}^{L} \operatorname{Pr}^{AL} \left( p_{2}^{AL}, p_{2}^{BO}, \tilde{\theta}_{1}^{L} \right),$   

$$\pi_{2}^{AB} \left( p_{2}^{Ai}, p_{2}^{Bi}, \tilde{\theta}_{1}^{L}, \tilde{\theta}_{1}^{H} \right) = (p_{2}^{AO}) \left\{ q (1 - \tilde{\theta}_{1}^{H}) \left( 1 - \operatorname{Pr}^{BH} \left( p_{2}^{AH}, p_{2}^{BO}, \tilde{\theta}_{1}^{H} \right) \right) + (1 - \tilde{\theta}_{1}^{L}) \left( 1 - \operatorname{Pr}^{BL} \left( p_{2}^{AL}, p_{2}^{BO}, \tilde{\theta}_{1}^{L} \right) \right) \right\}.$$
Note  
e that  $\operatorname{Pr}^{AH} = \operatorname{Pr}[\theta_{2} \leq \frac{\left[ 1 + q (p_{2}^{BO} - p_{2}^{AH}) \right]}{2} \left| \theta_{1} \leq \tilde{\theta}_{1}^{H} \right|$  and  $\operatorname{Pr}^{BH} = \operatorname{Pr}[\theta_{2} > \frac{\left[ 1 + q (p_{2}^{BH} - p_{2}^{AO}) \right]}{2} \left| \theta_{1} > \tilde{\theta}_{1}^{H} \right|$  are functions of  

$$p_{2}^{AH}, p_{2}^{BO}, \tilde{\theta}_{1}^{H} \text{ and } \operatorname{Pr}^{AL} = \operatorname{Pr}[\theta_{2} \leq \frac{\left[ 1 + (p_{2}^{BO} - p_{2}^{AL}) \right]}{2} \left| \theta_{1} \leq \tilde{\theta}_{1}^{L} \right|$$
 and  $\operatorname{Pr}[\theta_{2} > \frac{\left[ 1 + (q_{2}^{BH} - p_{2}^{AO}) \right]}{2} \left| \theta_{1} > \tilde{\theta}_{1}^{H} \right|$  are functions of functions of  $p_{2}^{AH}, p_{2}^{BO}, \tilde{\theta}_{1}^{H}$  and  $\operatorname{Pr}^{AL} = \operatorname{Pr}[\theta_{2} \leq \frac{\left[ 1 + (p_{2}^{BO} - p_{2}^{AL}) \right]}{2} \left| \theta_{1} \leq \tilde{\theta}_{1}^{L} \right|$  and  $\operatorname{Pr}[\theta_{2} > \frac{\left[ 1 + (q_{2}^{BH} - p_{2}^{AO}) \right]}{2} \left| \theta_{1} > \tilde{\theta}_{1}^{H} \right|$  are

functions of  $p_2^{AL}, p_2^{BO}, \tilde{\theta}_1^L$ .

Since retailer *A*'s own second –period prices are set to maximize *A*'s second period profit, we can use the envelope theorem  $\left(\frac{\partial \pi_2^{AA}}{\partial p_2^{AI}} = 0, \frac{\partial \pi_2^{AB}}{\partial p_2^{AO}} = 0\right)$  to write the first-order conditions for this maximization as

$$\left(q\tilde{\theta}_{1}^{H}+\tilde{\theta}_{1}^{L}\right)+\left(p_{1}^{A}\right)\left(q\frac{\partial\tilde{\theta}_{1}^{H}}{\partial p_{1}^{A}}+\frac{\partial\tilde{\theta}_{1}^{L}}{\partial p_{1}^{A}}\right)$$

$$+\delta\left[\left\{\frac{\partial\pi_{2}^{AA}}{\partial p_{2}^{BO}}\frac{dp_{2}^{BO}}{d\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial p_{2}^{BL}}\frac{dp_{2}^{BL}}{d\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial p_{2}^{BH}}\frac{dp_{2}^{BH}}{d\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{H}}\right\}\frac{\partial\tilde{\theta}_{1}^{H}}{\partial p_{1}^{A}}$$

$$+\left\{\frac{\partial\pi_{2}^{AA}}{\partial p_{2}^{BO}}\frac{dp_{2}^{BO}}{d\tilde{\theta}_{1}^{L}}+\frac{\partial\pi_{2}^{AB}}{\partial p_{2}^{BL}}\frac{dp_{2}^{BL}}{d\tilde{\theta}_{1}^{L}}+\frac{\partial\pi_{2}^{AB}}{\partial p_{2}^{BH}}\frac{dp_{2}^{BH}}{d\tilde{\theta}_{1}^{L}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{L}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{L}}+\frac{\partial\pi_{2}^{AB}}{\partial\tilde{\theta}_{1}^{L}}\right\}\frac{\partial\tilde{\theta}_{1}^{L}}{\partial p_{1}^{A}}\right]=0.$$

Then, the first order condition equation (12) at  $\tilde{\theta}_1^H = \tilde{\theta}_1^L = \frac{1}{2}$  simplifies to

$$p_1^A = p_1^B = \frac{(1+q)-2\delta\left(\Omega^H\left(-\frac{\partial\tilde{\theta}_1^H}{\partial p_1^A}\right) + \Omega^H\left(-\frac{\partial\tilde{\theta}_1^L}{\partial p_1^A}\right)\right)}{2\left(q\left(-\frac{\partial\tilde{\theta}_1^H}{\partial p_1^A}\right) + \left(-\frac{\partial\tilde{\theta}_1^L}{\partial p_1^A}\right)\right)},$$
(12)

where  $\Omega_L = \frac{\partial \pi_2^{AA}}{\partial p_2^{BO}} \frac{dp_2^{BC}}{d\tilde{\theta}_1^L} + \frac{\partial \pi_2^{AB}}{\partial p_2^{BL}} \frac{dp_2^{BL}}{d\tilde{\theta}_1^L} + \frac{\partial \pi_2^{AB}}{\partial p_2^{BL}} \frac{dp_2^{BL}}{d\tilde{\theta}_1^L} + \frac{\partial \pi_2^{AB}}{\partial \tilde{\theta}_1^L} + \frac{\partial \pi_2^{AB}}{\partial \tilde{\theta}_1^L} + \frac{\partial \pi_2^{AB}}{\partial \tilde{\theta}_1^L} , \ \Omega_H = \frac{\partial \pi_2^{AA}}{\partial p_2^{BO}} \frac{dp_2^{BO}}{d\tilde{\theta}_1^H} + \frac{\partial \pi_2^{AB}}{\partial p_2^{BL}} \frac{dp_2^{BL}}{d\tilde{\theta}_1^H} + \frac{\partial \pi_2^{AB}}{\partial \tilde{\theta}_1^H} +$ 

#### **Proof of Proposition 2.**

We apply the case of acquisition strategy since  $\beta = 0 < \underline{\chi}(q)$  for all q > 1. Therefore, the equation (3) now can be rewritten as follows:

$$\pi_{2}^{A} = (p_{2}^{AH})q\left(\frac{1+q(p_{2}^{BO}-p_{2}^{AH})}{2}\right) + (p_{2}^{AL})\left(\frac{1+p_{2}^{BO}-p_{2}^{AL}}{2}\right) + (p_{2}^{AO})\left\{q\left(\frac{1+q(p_{2}^{BH}-p_{2}^{AO})}{2} - \tilde{\theta}_{1}^{H}\right) + \left(\frac{1+p_{2}^{BL}-p_{2}^{AO}}{2} - \tilde{\theta}_{1}^{L}\right)\right\},$$

$$\pi_{2}^{B} = (p_{2}^{BH})q\left(\frac{1-q(p_{2}^{AO}-p_{2}^{BH})}{2}\right) + (p_{2}^{AL})\left(\frac{1-p_{2}^{AO}+p_{2}^{BL}}{2}\right) + (p_{2}^{BO})\left\{q\left(\tilde{\theta}_{1}^{H} - \frac{1+q(p_{2}^{BO}-p_{2}^{AH})}{2}\right) + \left(\tilde{\theta}_{1}^{L} - \frac{1+p_{2}^{BO}-p_{2}^{AL}}{2}\right)\right\}.$$
(A-15)

The first-order conditions for retailers' maximization yield  $p_2^{AH} = \frac{3+q(2q-1)+4q\bar{\theta}_1}{6q(1+q^2)}$ ,  $p_2^{AL} = \frac{2+q(3q-1)+4\bar{\theta}_1}{6(1+q^2)}$ ,  $p_2^{AO} = \frac{3(1+q)-4\bar{\theta}_1}{3(1+q^2)}$ ,  $p_2^{BH} = \frac{3(q-1)+6(1+q^2)-4q\bar{\theta}_1}{6q(1+q^2)}$ ,  $p_2^{BL} = \frac{3(1+q)+3(1+q^2)-4\bar{\theta}_1}{6(1+q^2)}$ , and  $p_2^{BO} = \frac{4\bar{\theta}_1-(1+q)}{3(1+q^2)}$ , where  $\bar{\theta}_1 = q\bar{\theta}_1^H + \bar{\theta}_1^L$ .

Firm A and B's overall profit functions are now can be rewritten as

$$\pi^{A} = (p_{1}^{A} - c) \cdot \left\{ q \tilde{\theta}_{1}^{H} + \tilde{\theta}_{1}^{L} \right\} + \delta \left[ \frac{49}{72} + \frac{62q + 80\bar{\theta}_{1}(\bar{\theta}_{1} - (1+q))}{72(1+q^{2})} \right],$$

$$\pi^{B} = (p_{1}^{B} - c) \cdot \left\{ q(1 - \tilde{\theta}_{1}^{H}) + (1 - \tilde{\theta}_{1}^{L}) \right\} + \delta \left[ \frac{49}{72} + \frac{62q + 80\bar{\theta}_{1}(\bar{\theta}_{1} - (1+q))}{72(1+q^{2})} \right].$$
(A-17)

By using Lemma 1 and equation (12), we get the result that  $p_1^A = p_1^B = \frac{(3+\delta)(1+q)}{3(1+q^2)}$ . We get the profit result directly from plugging the prices into equation,  $\pi^A - \pi^s = \frac{41\delta}{72} + \frac{36(1+q)^2 + 46q\delta}{72(1+q^2)} - \frac{(1+q)^2(1+\delta)}{2(1+q^2)} = \frac{(q-5)(5q-1)\delta}{72(1+q^2)} > 0$  if q > 5. **Q.E.D.** 

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