Customer Value-based Management: Competitive Implications

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Abstract

Many firms today quantify the value of individual customers and serve them differentially; providing better priviliges, discounts or other inducements to high value customers. We refer to this practice as Customer Value-based Management (CVM). Previous research in this area and popular press recommend numerous prescriptions that are research-based and intuitively sound. However, firms that have adopted CVM have often met with mixed results. For example, only a third of leading U.S. retail banks indicate that they have gained a competitive advantage from CVM. One possible factor that might account for the difference between actual outcomes and anticipated results could be that real firms implement CVM in a competitive environment. Our objective is to study CVM explicitly in a competitive setting. Our results suggest that while some recommendations and prescriptions from past research continue to hold in a competitive environment, some others do not. For example, firing low-value customers decreases firm profits, and even improving their value may prove counter-productive. Also as the cost of CVM technology decreases, firms adopting CVM in a competitive environment do not necessarily benefit.

(Keywords: Competitive Games; Customer Relationship Management)

Customer Value-based Management: Competitive Implications

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1 Introduction

Increasingly, firms are recognizing and managing customers as assets. Using information technology, they identify individual customers and track their interactions. By leveraging sophisticated analytical tools, they estimate the value of each customer to the firm. Armed with this information, they tailor discounts, service levels, and other inducements to each customer according to her value. For instance, Fidelity Investments routes calls from low value customers to longer queues (Selden & Colvin 2003). Continental Airlines e-mails only their high value customers apologizing for flight delays and compensates them with frequent flier miles (CIO Insight 2006). At Harrah's, room rates range from nothing to $199 a night depending on customer value (Wall Street Journal 2004). At Cingular Wireless, customer retention incentives such as cell phone subsidies or free airtime are based on customer value (New York Times 2006). In this paper, we refer to such practices as Customer Value-based Management (CVM).

Customer base analysis often reveals that a small proportion of customers contribute to a large percentage of profits, and a substantial proportion of customers are unprofitable (e.g. Rakesh et al. 2001). It stands to reason then that if a firm treats all customers equally, not only does it waste its resources on attracting and retaining unprofitable customers, but also it under-serves profitable customers, making it more likely that these profitable customers may become dissatisfied and leave. Instead, if the firm were to simply shift resources from unprofitable to profitable customers, it should be able to increase profits without additional spending.

In fact, researchers and industry experts have proposed that firms can do even better (Blattberg et al. 2001, Gupta & Lehmann 2005, Selden & Colvin 2003, Venkatesan & Kumar 2004, Zeithaml et al. 2001). By determining why some customers are unprofitable, firms can undertake initiatives to make them profitable. For instance, Fidelity Investments launched an initiative targeted at specific unprofitable customers to teach them how to use lower cost channels such as automated phone response systems or the Internet (Selden & Colvin 2003). Further, some unprofitable customers may also be un-transformable. These so called "demon" customers (Selden & Colvin 2003) or dead-weight "lead" customers (Zeithaml et al. 2001) destroy firm profits, and it is argued that the firm is better off "firing" them. The logic here is quite compelling: if a firm has only valuable customers, this should boost its profitability and shareholder value.

Given the benefits and the compelling rationale, CVM has received unequivocal support from researchers and industry experts alike. However, it has not always led to the expected outcome. For instance, the U.S. retail banking industry, which is one of the largest adopters of CVM, has not been enthusiastic with its results in enhancing industry profitability and shareholder value, despite having invested billions of dollars in CVM (Banking Strategies 1999, US Banker 2000). As a recent survey of leading banks indicates, only a third believe that they have gained a competitive advantage from CVM (SAS Institute 2005).

One reason why actual results differ from expected outcomes could be that hitherto, researchers and industry experts have by and large looked at firms in isolation without considering competitive reactions. In this paper, we provide the first theoretical analysis of CVM practices when CVM capabilities are potentially available to all firms in the industry, and compare our results with prescriptions from research and popular press that do not consider competition explicitly. Some of the questions we seek to address are

- How does a firm benefit from CVM?

- Should a firm "fire" low value customers?

- How does increasing customer value affect firm profits?

- Are firms in an industry better off with CVM?

- Do firms in an industry benefit as CVM capabilities becomes more affordable?

To address these questions explicitly in a competitive context, we consider a duopoly where customers are of two types; high value Good customers and low value Poor customers. Firms have existing customers and can distinguish between their own and rival's customers. They compete to retain / acquire customers by offering costly inducements. We model CVM as a technology that provides a firm with private, imperfect information about customer type, is more accurate in determining the type of a firm's own customers than its rival's customers, and allows a firm to tailor inducements based on a customer's perceived type.

In this setting, we find that some of the intuition and prescriptions that are popular with practitioners continue to hold. For instance, CVM helps firms retain high value customers better. And when a firm has better CVM accuracy than its rival, it enjoys a competitive advantage as it

acquires / retains a better customer mix. But in addition, we find that a firm also benefits from CVM as it moderates competition and lowers the firm's overall spending on customers. With CVM, the firm "skims the cream" of the customer base, leaving behind those who are less attractive. As the rival does not find it worthwhile to compete as hard for these "leftover" customers, the firm can lower its customer spending. We refer to this as the "skimming" effect and find that it leads to some interesting insights.

Contrary to current wisdom, in a competitive setting, Poor customers have a valuable role to play. They are crucial to the skimming effect and discourage competition under CVM. Thus "firing" or "pruning" them may only decrease profits by motivating the rival to compete more intensely for Good customers.

Moreover, we find that not all increases in customer value have similar consequences. While increasing the value of Good customers is beneficial, increasing the value of Poor customers may actually prove counter-productive. As may be expected, we find that when CVM capabilities become more affordable in an industry, firms tend to invest more. However, if the extent to which the insights about one's own customers are useful in predicting the value of rival's customers is sufficiently high, firms do not necessarily benefit when CVM becomes more affordable.

We also examine extensions where one firm is more efficient than its rival and where firms are differentiated. We find that these firm-level advantages interfere with skimming, and can intensify competition under CVM by making Poor customers more attractive to the firm. As a result, with the advent of CVM, a cost-efficient or differentiated firm may find itself worse off when it does not have a sufficiently higher CVM accuracy than its rival.

In what follows, we review related literature in Section 2, describe our model in Section 3 and provide our analysis and results in Section 4. In Section 5, we discuss several extensions. We summarize our findings and discuss the limitations and avenues for future research in Section 6.

2   Literature Review

Our work complements prior research that addresses the ability of sellers to target customers (e.g. Chen et al. 2001, Shaffer & Zhang 1995), to treat their own customers differently from those of the rival's (e.g. Chen 1997, Shaffer & Zhang 2000) and to target advertising (e.g. Iyer et. al. 2005, Gal-Or et. al. 2006). A common feature across much of this literature is that differences

in customer value arise from heterogeneity in customer preference or loyalty for competing sellers. Loyal customers are of high value while switchers are of low value. However, it is the switchers who receive better "treatment" (lower prices or higher discounts). This is contrary to the commonly observed CVM practice of treating high value customers better. This suggests that there are instances where differences in customer value are driven by factors other than loyalty. Our model seeks to address such settings, and we find that the nature of competitive interaction is qualitatively different.

For instance, Chen et. al. (2001) also consider a model where firms face uncertainty about customer types and firms classify customers independently. Customers are heterogenous on loyalty and firms cannot perfectly distinguish their loyals from switchers. A firm may then mistarget switchers as loyals and charge a relatively high price. To the extent that the rival classifies these customers correctly as switchers, it can attract them without offering too low a price. So mistargeting moderates competition as the left over customers in this context are easy to win over. In contrast, skimming moderates competition as the left over customers are not worth competing for. Further, mistargeting is not necessary for skimming. For instance, skimming moderates competition even when one firm has perfect information and its rival has none.

Our work is also related to the research on credit market competition when lenders ration credit by screening borrowers based on their repayment ability. Closest to our work are Broecker (1990) and Banerjee (2005). Broecker (1990) restricts all lenders to have the same screening accuracy and looks at the impact of imperfect independent screening on competition. Banerjee (2005) extends this model to allow for lenders to have different screening accuracies and analyzes their incentives to adopt a superior screening technology. However, given their market context, they assume that Poor borrowers are a priori unprofitable and are always denied credit. Thus lenders compete only for perceived Good borrowers. This moderates competition as some of the borrowers who are denied credit by one lender may be classified as Good by a rival, and are easy to acquire[1]. So, unlike in skimming, lenders are not deterred from competing by the prospect of acquiring less attractive borrowers. Consequently, in contrast to our model, increasing the value of Poor borrowers always benefits lenders. Also in Banerjee (2005), an improvement in a lender's screening accuracy never benefits a rival, whereas in our model a rival may benefit if skimming sufficiently moderates

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[1] They restrict attention to the case when the expected returns from a borrower classified as Poor is negative even at the highest interest rate, whereas the expected returns from a cross-classified borrower is positive.

competition.

Furthermore, a common feature across Chen et. al. (2001), Broecker (1990) and Banerjee (2005) is that imperfectly correlated classifications moderate competition. However, we find that when one firm is more cost-efficient than the other, or customers prefer one seller over the other, competition may in fact be more intense as these firm-level advantages interfere with skimming.

3   Model

Consider two competing firms, namely Firm 1 and Firm 2. To begin with, we assume that each firm has a customer base of size s. Later, in Section 5.1, we allow for Firm 1 to have a larger customer base than Firm 2. We assume that firms offer inducements such as discounts, free products, or additional services in order to retain their customers or to attract rival's customers, while customers choose the firm that offers them the best inducement[2]. In Section 5.3, we consider that customers attach a premium to buying from their current firm. Initially, we assume that inducements only influence a customer's switching behavior, but not their consumption behavior. In some instances, this assumption is fairly realistic. For instance, a customer retention incentive such as a subsidized cell phone is likely to induce a customers to stay with the service provider, but may not cause her to use more minutes. Later, in Section 5.4, we examine the case when inducements also affect consumption behavior.

We take inducements to be variable costs that are incurred only if the customer chooses the firm. Firms are assumed to be equally efficient in offering inducements both within and across customer bases. In other words, it costs the same for both firms to offer a given level of inducement to any customer. In Section 5.2, we allow for Firm 1 to be more efficient than Firm 2 in providing inducements. We assume that inducement spending strictly increases with the level of inducement. So, without loss of generality, we can set the cost of providing an inducement of level d to be equal to d. We will use the term "inducement" to refer to the level of inducements, and the term "inducement spending" for the cost of providing the inducement.

When a customer chooses a firm offering an inducement d, let $\Pi(d)$ be the firm's profit from the customer. As the inducement costs d, we can express $\Pi(d)$ as

$$\Pi(d) = \pi - d, \tag{1}$$

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[2]If both firms offer the same inducement, the customer stays with her current firm.

where π is defined as the intrinsic value of the customer, or simply customer value. Customers may differ in their value due to a combination of factors such as the basket of products and services bought, purchase volume and frequency, product returns, customer support requests and so on. This formulation succinctly captures the idea that customer profitability is the outcome of both customer behavior and firm's actions. Since inducements do not affect consumption behavior, π is independent of d. We can interpret π as the customer profitability at some reference level of inducements, with inducements being measured relative to this reference level[3]. Alternately, in the context of Eqn. (1), π is the inducement at which customer profitability is zero.

As we will see in our analysis, it is important to distinguish between a change in π and a change in d, even though the net effect on customer profitability may be the same. A lower level of service translates to a lower d. On the other hand, if a customer's behavior changes such that she is more profitable for the same inducement level then this translates to an increase in π. Also, if both firms use a more efficient technology to deliver the same inducement at a lower cost, we can represent this as an increase in π, as the inducement at which customer profitability is zero is now higher[4].

We assume that customers may be of two types based on their value; high value Good customers and low value Poor customers. We abstract away from the details of the differences between Good and Poor customers and take their values to be π_G and π_P respectively, with $\pi_G > \pi_P$. Let $\alpha \in (0, 1)$ be the proportion of Good customers in each firm's customer base. α, π_G and π_P are taken to be common knowledge for both firms

Even when a firm does not have a CVM information system, it is still likely to have a rudimentary information system that enables it to identify its existing customers, for instance, based on purchase records or ongoing subscriptions. Consequently, we assume that firms know who their current customers are. This is a reasonable assumption in industries such as banking or telecom, but may not be as palatable when firms go through dealers or distributors. Since the ability to identify customers is a pre-requisite for CVM, this assumption is reasonable for industries that have adopted CVM.

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[3]A lower than usual service level or a new fee is then represented as a negative inducement. Note that we do not restrict inducements to be positive.

[4]Firm efficiency can be incorporated explicitly in our customer profitability equation as

$$\Pi(d) = \pi - \gamma d,$$

where γ denotes efficiency and γd is the cost of providing an inducement d. A higher γ means lower efficiency. When both firms are equally efficient, a decrease in γ can be equivalently represented as an increase in π.

In our context, it follows that a firm can also identify its rival's customers, since any customer who is not its own must belong to its rival, and it can offer different inducement levels for each customer base. This implication simplifies our analysis considerably as it allows us to analyze the competitive interaction within each customer base separately because a firm's inducement in one customer base does not affect its own or its rival's profits in the other customer base. For instance, Firm 1's inducement to Firm 2's customers neither affects Firm 1's nor Firm 2's profits from Firm 1's customers.

While our assumptions best describe mature markets dominated by two firms, the implication that firms can identify their rival's customers is likely to hold in other instances as well. As part of their regular ongoing sales efforts, firms may be able to obtain lists of rival's customers either through primary research or market intelligence agencies. For instance, in the U.S. pharmaceutical industry, market intelligence firms such as IMS and VeriSpan track the prescription activity of individual physicians by mapping them to actual retail drug sales, and sell this information to pharmaceutical companies. Also, in business-to-business settings, a firm's sales force typically knows who a potential customer's current supplier is. For instance, in the market of educational institutions, Xerox is likely to know whether a given university currently purchases copiers from Canon, Ricoh or HP. Similarly, Dell is likely to know whether the university purchases personal computers from IBM or HP.

On the other hand, the data and technology needed to estimate the value of individual customers is quite demanding. This requires extensive transaction information, a reliable activity-based accounting system and sophisticated models of customer behavior. And it typically involves several million dollars of investment as well as the adoption of new processes within the firm. So we assume that a firm cannot determine the value of its existing customers without a CVM information system[5]. With CVM, a firm can analyze transaction histories of its customers to estimate their value. So CVM provides a firm with private information that enables it to classify its customers as Good or Poor. Such classification may however be imperfect.

Moreover, to the extent that there are common customer characteristics across the two customer bases, the insights a firm gains from analyzing the behavior of its own customers may be useful in inferring the behavior of its rival's customers, even though it does not have access to

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[5]We will refer to a CVM information system as simply CVM.

their transaction histories. For instance, customer value may be correlated with easily obtainable customer characteristics such as demographics or lifestyle variables. A firm could then classify its rival's customers based on the patterns it observes in its own customer base. While this is unlikely to be as accurate as classification based on actual transaction data, nevertheless such analysis is still likely to yield some useful information. The degree to which it is useful is likely to vary with the industry and technology. So we assume that CVM provides some information about rival's customers as well.

We now introduce the required notation to characterize the nature and accuracy of CVM classification. Let g and p represent the events that the true type of a customer in Firm 1's customer base is respectively Good and Poor. Similarly, let G and P respectively represent the corresponding events in Firm 2's customer base. Let g_1 and p_1 (G_1 and P_1) represent the events that Firm 1 classifies a customer to be Good and Poor in Firm 1's (Firm 2's) customer base. Similarly, let g_2 and p_2 (G_2 and P_2) represent the events that Firm 2 classifies a customer to be Good and Poor in Firm 1's (Firm 2's) customer base. We represent compound events and conditional events in the usual manner. For instance, $g_1 p_2$ is the event $g_1 \cap p_2$ that a Firm 1's customer is classified as Good by Firm 1 and Poor by Firm 2. And, for instance, $P_1 | G_2$ is the event that Firm 2's customer is classified as Poor by Firm 1, given that Firm 2 classified her as Good. Let $\Pr(X)$ be the probability of event X. For instance, we have $\Pr(g) = \Pr(G) = \alpha$.

When CVM is imperfect, customers will be misclassified. To start with, consider the two extreme scenarios - non-informative CVM (or no CVM) and perfect CVM. Non-informative CVM will perform no better than random classification. We can expect that a random α proportion of customers are classified as Good, and the remaining $1-\alpha$ as Poor. So on an average, α proportion of Poor customers are misclassified as Good and $1-\alpha$ proportion of Good customers are misclassified as Poor. On the other hand, with perfect CVM there is no misclassification. Imperfect CVM falls between these two extremes, with less than α of Poor customers and $1-\alpha$ of Good customers misclassified. Thus CVM accuracy can be characterized based on the misclassification probabilities.

We assume that classification is consistent at the aggregate level, i.e. firms always classify α proportion of customers as Good and the remaining $1 - \alpha$ as Poor. We have

$$\Pr(g_1) = \Pr(g_2) = \Pr(g) = \alpha \text{ and } \Pr(G_1) = \Pr(G_2) = \Pr(G) = \alpha. \tag{2}$$

In this context, the probabilities of both types of misclassification are equal[6], and we need only one parameter to represent CVM accuracy[7]. We now define the CVM Accuracy Index, referred to simply as CVM accuracy, based on the misclassification probabilities as follows. If $I_1 \in [0, 1]$ is Firm 1's CVM accuracy, then the misclassification probabilities are given by[8]

$$\Pr(gp_1) = \Pr(pg_1) = \alpha(1 - \alpha)(1 - I_1). \tag{3}$$

Thus, $I_1 = 0$ represents non-informative CVM where random classification leads to a misclassification probability of $\alpha(1 - \alpha)$. On the other hand, $I_1 = 1$ represents perfect CVM with no misclassification. Similarly, let $I_2 \in [0, 1]$ be Firm 2's CVM accuracy in its own customer base. Let $k \in (0, 1)$ be the degree to which insights about one's own customers is useful in predicting the type of rival's customers, so that kI_1 and kI_2 are the CVM accuracies of Firm 1 and Firm 2 respectively in their rival's customer base.

When both firms have CVM, we assume that given the true type of the customer, the classification decisions by the firms are independent. In other words, we assume conditional independence[9]. It is worthwhile to note that conditional independence does allow for the overall classifications by the firms to be correlated. For instance, in either customer base, the correlation in classifications by the firms is the product of CVM accuracies, given by kI_1I_2, which increases when CVM accuracy of either firm increases.

We also develop notation for the expected value of customers with and without information about their perceived types. Let $\bar{\pi}$ be the average value of customers in either customer base, given by

$$\bar{\pi} = \alpha\pi_G + (1 - \alpha)\pi_P. \tag{4}$$

Let $\pi(X)$ represent the expected customer value conditional on event X. For instance, $\pi(g_1)$ is the expected value of a customer classified as Good by Firm 1 in its customer base, and $\pi(g_1g_2)$ is

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[6] For instance, for Firm 1 in its customer base we have

$$\Pr(gp_1) = \Pr(g) - \Pr(gg_1) = \Pr(g_1) - \Pr(gg_1) = \Pr(pg_1).$$

[7] This is also the approach in Chen *et al.* (2001) for parameterizing classification accuracy.

[8] This is equivalent to defining CVM accuracy as the correlation between the true and perceived customer types. For instance, the correlation between g and g_1 is given by

$$\frac{\Pr(gg_1) - \Pr(g)\Pr(g_1)}{\sqrt{\Pr(g)\Pr(p)}\sqrt{\Pr(g_1)\Pr(p_1)}} = \frac{\Pr(g) - \Pr(gp_1) - \Pr(g)\Pr(g_1)}{\sqrt{\Pr(g)\Pr(p)}\sqrt{\Pr(g_1)\Pr(p_1)}} = 1 - \frac{\Pr(gp_1)}{\alpha(1 - \alpha)} = I_1.$$

Since CVM is informative by assumption, the correlation is always positive and $I_1 \in [0, 1]$.

[9] For instance, $\Pr(g_1p_2 \mid g) = \Pr(g_1 \mid g)\Pr(p_2 \mid g)$

the expected value of a customer classified as Good by both firms in Firm 1's customer base.

We analyze a two stage game where firms first invest in CVM capabilities and then compete for customers by offering inducements. In the first stage, firms simultaneously decide on the level of investment in CVM capabilities. Their investment determines how much customer data firms collect or how sophisticated their analytical techniques are. Let $c > 0$ be the CVM investment cost parameter. If a firm invests $\frac{1}{2}cI^2$ in CVM, then it acquires a CVM accuracy of I and kI respectively about its own and its rival's customers[10]. Typically c and k would vary across industries as well as with CVM technology. We assume that both firms have access to the same technology.

In the second stage, knowing each other's CVM investment decisions, firms compete for customers by deciding on their inducements. We restrict our attention to a single period of interaction. When Firm i does not have CVM, let d_i (D_i) be its inducement to Firm 1's (Firm 2's) customers. To represent mixed strategies, we will use f_i (F_i) for the cumulative density function for d_i (D_i). When Firm i has CVM, let d_{ig} and d_{ip} (D_{iG} and D_{iP}) respectively be its inducements to perceived Good and Poor customers in Firm 1's (Firm 2's) customer base. For mixed strategies, we will use f_{iG} and f_{iP} (F_{ig} and F_{ip}) respectively for the cumulative density functions for d_{ig} and d_{ip} (D_{iG} and D_{iP}). Let λ_1 and λ_2 (Λ_1 and Λ_2) respectively represent Firm 1's and Firm 2's profits in serving Firm 1's (Firm 2's) customers. Let Π_1 and Π_2 represent Firm 1's and Firm 2's overall profits across customer bases and including the CVM investment cost, so that

$$\Pi_1 = \lambda_1 + \Lambda_1 - \frac{1}{2}cI_1{}^2 \text{ and } \Pi_2 = \lambda_2 + \Lambda_2 - \frac{1}{2}cI_2{}^2. \tag{5}$$

Table 1 summarizes our main assumptions.

Table 1: Key Model Assumptions	
1.	Two competing firms, each with customer base of size s.
2.	Customers are Good or Poor with values π_G and π_P. A proportion α are Good.
3.	Inducements affect only customer switching behavior.
4.	Firms are not differentiated and are equally efficient in offering inducements.
5.	A firm can identify its customers. A customer who is not its own, must belong to its rival.
6.	CVM classifications are independent, private and consistent at the aggregate level.
7.	Firms have access to the same CVM technology.
8.	If CVM accuracy about one's own customers is I, then it is kI about rival's customers, $k \in (0,1)$.
9.	Single period of interaction in the inducement stage.

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[10]However, we shall refer to I rather than $\frac{1}{2}cI^2$ as the CVM investment decision.

4   Analysis

We solve for the sub-game perfect Nash equilibrium of the two stage game. We start with the second stage and look at the impact of CVM on the competition for customers. We analyze three scenarios.

1. The simple scenario where neither firm has CVM, which serves as our benchmark.

2. The scenario where only one of the firms has CVM, which helps us understand the basic intuition behind how CVM works in a competitive setting.

3. The general scenario where both firms have CVM.

As firms can perfectly discriminate between their own and the rival's customers, firm profits in each customer base depend only on the inducements in that customer base. Therefore we can analyze the competitive interactions one customer base at a time. Further, the analysis of the interactions within each customer base is identical. So, while we provide the results for both customer bases, we focus explicitly only on Firm 1's customer base when analyzing these scenarios.

4.1   Equilibrium without CVM

When neither firm has CVM, they cannot differentiate between Good and Poor types. So all customers appear to be of expected value $\bar{\pi}$ to both firms. This leads to Bertrand competition. In equilibrium firms offer an inducement $\bar{\pi}$ in each customer base. They retain their existing customers, but realize no profits. Formally, the equilibrium strategies and profits are given by

$$d_1 = d_2 = \bar{\pi},\ \lambda_1 = \lambda_2 = 0, D_1 = D_2 = \bar{\pi} \text{ and } \Lambda_1 = \Lambda_2 = 0. \tag{6}$$

Thus Poor customers receive an inducement that exceeds their value and are essentially subsidized by Good customers. If a firm were to now measure the profitability of each of its customers, it would find Poor customers unprofitable and Good customers profitable. In other words, a fraction of the customer base is profitable while the remaining destroy firm value, a scenario that is often described in the popular press and has been used by researchers and industry experts to urge firms to adopt CVM. Our benchmark case represents this starting point.

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4.2 Equilibrium when One Firm has CVM

Suppose one of the firms were to adopt CVM. Say for instance Firm 1 pioneers the use of CVM in its industry. So Firm 1 has an information advantage over Firm 2. It has been argued that Firm 1 will benefit from this information advantage by selectively retaining or acquiring Good customers. While intuitively sound, this argument is incomplete as it leaves the rival out of the picture. We now examine this scenario explicitly accounting for competition.

Consider Firm 1's customer base. Ex-ante, all customers appear to be the same and of expected value $\bar{\pi}$ for Firm 2. On the other hand, Firm 1 can discriminate between customer types to a certain degree and values its perceived Good customers more than its perceived Poor customers. We have that

$$\pi(p_1) < \bar{\pi} < \pi(g_1), \tag{7}$$

where, as defined earlier, $\pi(p_1)$ and $\pi(g_1)$ are the expected value of Firm 1's perceived Poor and Good customers respectively. In other words, using CVM information, Firm 1 can "de-average" the value of its customers. Now, not only can Firm 1 offer better inducements to its perceived Good customers than to its perceived Poor customers, but also, since $\pi(g_1) > \bar{\pi}$, it can offer a higher inducement to its perceived Good customers than what Firm 2 can. Subsequently, Firm 2 is more likely to acquire Poor customers than Good customers, and will be left with a higher proportion of Poor customers than there were in the customer base to begin with. Intuitively, Firm 1 "skims the cream" of the customer base and takes away the more valuable customers. Since the "left-over" customers are of lower value, Firm 2 is discouraged from competing as intensely as in the benchmark case. Stated differently, the expected customer value conditional on Firm 2 acquiring the customer is lower than the ex-ante expected value $\bar{\pi}$. This forces Firm 2 to offer an inducement lower than $\bar{\pi}$ to avoid incurring a loss. This is similar to the winner's curse in a common value first-price auction (Milgrom & Weber 1982). Thus Firm 1 benefits from CVM not only because it retains a better customer mix, but also because its inducement spending is lower as competition is less intense.

Lemma 1 *When only Firm 1 has CVM, there is no pure strategy equilibrium. But there exists a unique mixed strategy equilibrium. In Firm 1's customer base, the equilibrium strategies are given*

by

$$f_{1g}\left(d\right) = \begin{cases} 0 & if \quad d \leq \pi(p_1); \\[2ex] \frac{(1-\alpha)(d-\pi(p_1))}{\alpha(\pi(g_1)-d)} & if \quad d \in \left(\pi(p_1), \bar{\bar{\pi}}\right); \\[2ex] 1 & if \quad d = \bar{\bar{\pi}}, \end{cases} \qquad f_2\left(d\right) = \begin{cases} 0 & if \quad d < \pi(p_1); \\[2ex] 1-\alpha & if \quad d = \pi(p_1); \\[2ex] \frac{\pi(g_1)-\bar{\bar{\pi}}}{\pi(g_1)-d} & if \quad d \in \left(\pi(p_1), \bar{\bar{\pi}}\right); \\[2ex] 1 & if \quad d = \bar{\bar{\pi}}, \end{cases}$$

and $d_{1p} = \pi(p_1)$. The equilibrium profits are given by

$$\lambda_1 = s\alpha\left(1 - \alpha\right) I_1 \left(\pi_G - \pi_P\right), \quad \lambda_2 = 0. \tag{4.1}$$

Proofs for all lemmas and propositions are provided in Appendices A and B respectively.

We find that competition ensures that firms offer an inducement of at least $\pi(p_1)$. Under pure strategies, Firm 2 will always incur a loss no matter what inducement it offers, since Firm 1 can take away the profitable customers leaving behind only the unprofitable ones. Thus there is no equilibrium in pure strategies. There is, however, a unique mixed strategy equilibrium. In equilibrium, Firm 1 offers better inducements to its perceived Good customers than its perceived Poor customers ($d_{1g} > d_{1p}$). Firm 2 offers better inducements to Firm 1's perceived Poor customers than Firm 1 ($d_2 \geq d_{1p}$), while the reverse is true for Firm 1's perceived Good customers ($f_{1g}\left(d\right)$ stochastically dominates $f_2\left(d\right)$). So Firm 1 retains a better customer mix than in the benchmark case, and also the average inducements are lower than in the benchmark case. The equilibrium mixed strategies f_{1g} and f_2 are shown in Figure 1.
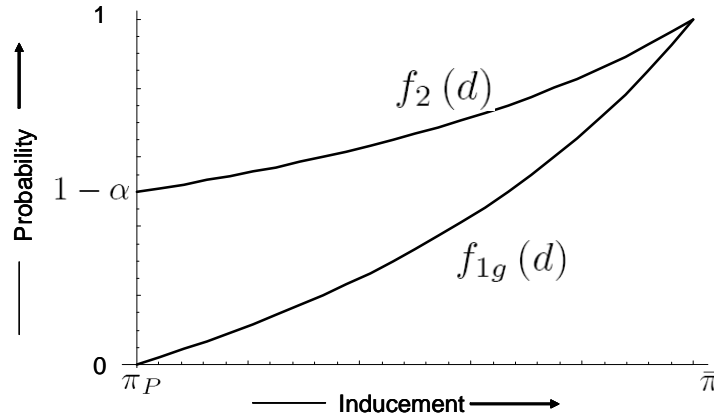

Figure 1: Mixed Strategy CDFs

Firm 1 derives no profits from perceived Poor customers as $d_{1p} = \pi(p_1)$. On the other hand,

it can profitably retain all its perceived Good customers by offering an inducement $\bar{\pi}$, since this is the highest inducement that Firm 2 can offer without incurring a loss. This in fact determines Firm 1's equilibrium profits, which are given by $s \Pr(g_1) [\pi(g_1) - \bar{\pi}]$. On the other hand, Firm 2 derives no profit.

The same analysis applies to Firm 2's customer base and equilibrium profits are given by

$$\Lambda_1 = s\alpha (1 - \alpha) k I_1 (\pi_G - \pi_P) \text{ and } \Lambda_2 = 0. \tag{9}$$

4.3 Equilibrium when Both Firms have CVM

An increasingly common situation is one where not only the firm but also its rival has imperfect CVM. This scenario has not received much attention in prior work. We now look at the impact of CVM in this setting.

Lemma 2 *When both firms have CVM, there is no pure strategy equilibrium. But there exists a unique mixed strategy equilibrium. In Firm 1's customer base, the equilibrium strategies are given by*

$$f_{1g}(d) = f_{2g}(d) = \begin{cases} 0 & \text{if } d = \pi(p_1 p_2); \\[2ex] \dfrac{\Pr(g_1 p_2)[d - \pi(p_1 p_2)]}{\Pr(g_1 g_2)[\pi(g_1 g_2) - d]} & \text{if } d \in (\pi(p_1), \hat{\pi}); \\[2ex] 1 & \text{if } d = \hat{\pi}, \end{cases}$$

where $\hat{\pi} = \Pr(g_1 \mid g_2) \pi(g_1 g_2) + \Pr(p_1 \mid g_2) \pi(p_1 p_2)$, and

$d_{1p} = d_{2p} = \pi(p_1 p_2)$. *The equilibrium profits are given by*

$\lambda_1 = s\alpha (1 - \alpha) I_1 (1 - k I_2) \dfrac{1 - \alpha(1 - k I_2)}{1 - \alpha(1 - k I_1 I_2)} (\pi_G - \pi_P)$,

$\lambda_2 = s\alpha (1 - \alpha) k I_2 (1 - I_1) \dfrac{1 - \alpha(1 - I_1)}{1 - \alpha(1 - k I_1 I_2)} (\pi_G - \pi_P)$.

Again consider Firm 1's customer base. We can expect that firms offers a higher inducement to their perceived Good customers as they are of higher value. But firms also have to consider how a given customer will be classified by their rival. Consider those customers who are classified as Poor by Firm 1. Some of them will also be classified as Poor by Firm 2, while others will be cross-classified as Good. Now, as long as $I_1 < 1$, we have that

$$\pi(p_1 p_2) < \pi(p_1) < \pi(p_1 g_2). \tag{9}$$

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That is, amongst the pool of customers perceived as Poor by Firm 1, those who are also classified as Poor by Firm 2 are relatively less attractive than those who are cross-classified as Good, provided $I_1 < 1$ so that Firm 2's classification contains some additional information. This sets the stage for Firm 2 to skim Firm 1's Poor customer pool. Since $\pi(p_1) < \pi(p_1 g_2)$, Firm 2 can always offer a higher inducement (through d_{2g}) to selectively lure away the more valuable customers in this pool[11]. Consequently, Firm 1 is more likely to retain only those perceived Poor customers who are also classified by Firm 2 as Poor. This forces it to offer an inducement lower than the ex-ante expected value $\pi(p_1)$. In fact, in equilibrium we find that Firm 1 only retains those perceived Poor customers that Firm 2 also classifies as Poor. So we have $d_{1p} = \pi(p_1 p_2)$ and Firm 1 derives no profits from perceived Poor customers. Similarly, Firm 1 can skim the pool of customers classified as Poor by Firm 2, forcing Firm 2 to offer an inducement $d_{2p} = \pi(p_1 p_2)$ that is lower than $\pi(p_2)$, and Firm 2 also derives no profits from perceived Poor customers.

Now consider those customers who are classified as Good by Firm 1. Firm 1 faces a trade-off. On the one hand, some of these customers will be classified as Good by Firm 2. This creates an incentive to compete intensely as such customers are of high value to both firms. On the other hand, the remaining will be cross-classified as Poor by Firm 2. Since Firm 1 can profitably skim Firm 2's perceived Poor customer pool, this relaxes competition. This trade-off leads to a mixed strategy for perceived Good customers in equilibrium[12].

The profit opportunity from skimming moderates the competition for perceived Good customers. Indeed, equilibrium profits are determined by skimming. As Firm 1 has to offer an inducement equal to d_{2p} $(= \pi(p_1 p_2))$ to profitably retain all cross-classified customers (of value $\pi(g_1 p_2)$), its profits are given by $s \Pr(g_1 p_2) [\pi(g_1 p_2) - \pi(p_1 p_2)]$. Similarly Firm 2 derives a profit of $s \Pr(p_1 g_2) [\pi(p_1 g_2) - \pi(p_1 p_2)]$. If however $I_1 = 1$, all of Firm 1's perceived Poor customer are truly Poor and Firm 2 no longer has an opportunity to skim. Then it derives zero profits[13].

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[11] This is true even though Firm 2 may have lower accuracy, i.e. $kI_2 < I_1$. We only require that $I_1 < 1$ so that $\pi(p_1) < \pi(p_1 g_2)$.

[12] Our assumption that classifications by both firms are consistent at the aggregate level implies that the cross-classification probabilities are equal. For instance,

$$\Pr(g_1 p_2) = \Pr(g_1) - \Pr(g_1 g_2) = \Pr(g_2) - \Pr(g_1 g_2) = \Pr(p_1 g_2)$$

As shown in the Technical Appendix, this results in both firms having identical equilibrium inducement strategies even though they have different accuracies. If cross-classification probabilities are not equal, this does not alter our analysis drastcially, and we expect qualitatively similar results.

[13] Since $k < 1$, Firm 1 always makes positive profits from its customers whenever it has non-zero accuracy.

The analysis in Firm 2's customer base is identical and equilibrium profits are given by[14]

$$\Lambda_1 \;=\; s\alpha\,(1-\alpha)\,kI_1\,(1-I_2)\,\frac{1-\alpha(1-I_2)}{1-\alpha(1-kI_1I_2)}\,(\pi_G-\pi_P)\,, \tag{10-a}$$

$$\Lambda_2 \;=\; s\alpha\,(1-\alpha)\,I_2\,(1-kI_1)\,\frac{1-\alpha(1-kI_1)}{1-\alpha(1-kI_1I_2)}\,(\pi_G-\pi_P)\,. \tag{10-b}$$

To summarize, when both firms have imperfect CVM, cross-classification allows firms to skim each other's perceived Poor customer pool, which moderates competition for both perceived Poor and Good customers. Note that the profit opportunity from skimming, for say Firm 1, depends not only on the cross-classification probability $\Pr(p_1 g_2)$ and the value of cross-classified customers $\pi(p_1 g_2)$, but also on the extent to which skimming deters Firm 2 from competing for perceived Poor customers, which is given by $\pi(p_1 p_2)$. Consequently, an exogenous increase in the value of Poor customers π_P has two effects. On the one hand, it increases the value of cross-classified customers $\pi(p_1 g_2)$. On the other hand, $\pi(p_1 p_2)$ also increases as Poor customers are more attractive, thereby decreasing the extent to which skimming deters competition. The latter always offsets the former and firm profits are lower than before.

This aspect distinguishes the nature of competitive interaction in our model from that in Broecker (1990) and in Banerjee (2005). Both of these models make the following assumptions.

1. Perceived Poor borrowers are ex-ante unprofitable, i.e. they are unprofitable at the highest possible interest rate.

2. Cross-classified borrowers (i.e. those who are classified as Poor by one lender and Good by a rival) are still profitable to serve.

Consequently, the optimal strategy for a lender is to always reject perceived Poor borrowers irrespective of how a rival might classify them, and lenders essentially compete only for perceived Good borrowers. Since lenders know that some of their perceived Good borrowers will be cross-classified as Poor by the rival and rejected, these borrowers can be acquired profitably at the highest interest rate, which moderates competition for perceived Good borrowers. Thus there is no notion of the rival being discouraged from competing because of skimming. Consequently, an increase in the value of Poor borrowers (i.e. their repayment probability) is always beneficial to firms as its only effect is to increase the value of cross-classified borrowers.

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[14]The results for Firm 2's customer base are obtained by replacing the parameters or variables specific to Firm 1's customer base with those of Firm 2's.

While both firms make profits, as may be expected it is the firm with better information in a customer base that makes higher profits since it targets Good customers with better inducements more often to obtain a better customer mix[15]. This is reflected in the difference in firm profits in a customer base, for instance $\lambda_1 - \lambda_2$, which is given by

$$\lambda_1 - \lambda_2 = s\alpha\left(1-\alpha\right)\left(I_1 - kI_2\right)\left(\pi_G - \pi_P\right). \tag{11}$$

Proposition 1 *The firm with better CVM accuracy in a customer base makes higher profits. The difference in profits increases with the difference in accuracies.*

Thus a firm's competitive advantage in a customer base is directly linked to its information advantage. A firm can strengthen its competitive position by acquiring additional customer information or improving its CVM technology.

Impact of Improvement in CVM Capability

We next look at how an improvement in a firm's CVM capability affect inducement spending, profits and customer welfare. We have already seen that CVM reduces spending on customers relative to the benchmark case by moderating competition. We would like to know whether an increase in a firm's CVM accuracy further moderates competition.

Proposition 2 *When a firm's CVM accuracy increases, competition in a customer base is moderated further if the rival's accuracy is not too high.*

We look at combined firm profits of both firms as a measure of competitive intensity. The effect of an increase in a firm's CVM accuracy will differ across customer bases since both the firm's and its rival's accuracy vary with the customer base. Figure 2 depicts the impact of an increase in Firm 1's accuracy in Firm 1's (left panel) and in Firm 2's customer base (right panel) for the case when $\alpha = \frac{4}{5}$. For a particular k, each curve represents the maximum I_2 up to which an increase in I_1 further moderates competition. As k decreases, the bound on I_2 increases[16]. In general, if Firm 2's accuracy is sufficiently high then competition intensifies as the correlation in classifications is high.

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[15] As both firms have identical equilibrium inducement strategies, they spend the same on inducements. The difference in firm profits is then driven only by the difference in customer mix.

[16] It is possible that the bound for I_2 is higher in either of the customer bases, so that competition may be moderated in one but intensified in the other. For instance in Figure 2, when $k = 0.4$, the bound for I_2 is higher in Firm 1's customer base when $I_1 < 0.826$, and is higher in Firm 2's customer base otherwise.
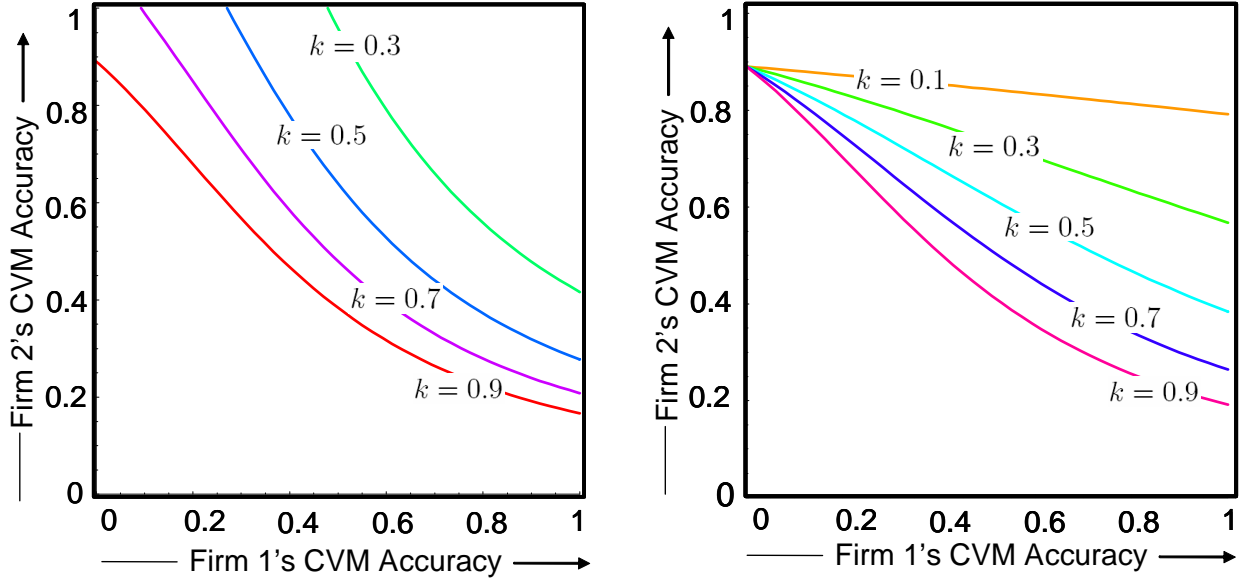
Figure 2: Competitive Intensity

When Firm 1's CVM accuracy increases, the inducement to perceived Poor customers always decreases. This can also relax the competition for perceived Good customers by increasing the profit opportunity from cross-classification. However, the extent of cross-classification decreases as the correlation in classifications kI_1I_2 increases. When the correlation is high, this can intensify competition for perceived Good customers and this may dominate the overall impact on competitive intensity. We next look at the impact on profits.

Proposition 3 *When a firm's CVM accuracy increases, its profit from customers always increases, while its rival's profit increases if $\alpha \in \left(\frac{1}{2}, 1\right)$ and CVM accuracies are not too high.*

Consider Firm 1's customer base. When Firm 1's accuracy increases, the increase in its profit opportunity $\pi(g_1p_2) - \pi(p_1p_2)$ always offsets the decrease in cross-classification probability $\Pr(g_1p_2)$. So even if competition becomes more intense (as discussed in Proposition 1), Firm 1's profits increase as this is offset by the improvement in customer mix (as discussed in Proposition 2). Similarly, Firm 1's profits always increase in Firm 2's customer base.

For Firm 2, the customer mix always worsens and in particular $\pi(g_2p_1)$ decreases. Interestingly however, Firm 2's profits may still increase. This is because the extent to which skimming deters competition for perceived Poor customer increases, or $\pi(p_1p_2)$ decreases. So Firm 2's profit oppor-

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tunity from cross-classification $\pi(g_2p_1) - \pi(p_1p_2)$ may still increase. When the CVM accuracies of both firms are not too high, the moderation in competition is sufficient to offset the worsening of customer mix and Firm 2's profits also increase. The interaction in Firm 2's customer base is similar, and we find that Firm 2's profits across both customer bases increases when CVM accuracies are not too high. Note that in Banerjee (2005), a rival's profits can never increase when a lender's screening accuracy increases. This is because screening per se has no impact on the competition for perceived Poor borrowers as they are always just rejected. We next consider how CVM affects consumer welfare.

CVM practices have often raised concerns about discrimination and unfairness since it involves "red-lining" some low value customers (e.g. *Business Week* 2000). Such customers are charged higher fees, provided poorer service or even discouraged from shopping with the firm. Firms have countered criticism by arguing that CVM enables them to serve high value customers better and that rolling back these measures would be unfair to these customers as they would be forced to subsidize others. But this assumes that the gains from reduced cross-subsidy accrue to Good customers. We find that this is not necessarily true. While CVM does reduce the extent of cross-subsidization, and on an average Good customers do receive better inducements than Poor customers, competition may be moderated to such an extent that even Good customers are worse off than before. So the benefits from reduced cross-subsidization are instead appropriated by the firms.

Proposition 4 *Relative to the benchmark case, Good customers are worse off with CVM when I_1 and I_2 are both not too high.*

Figure 3 shows the impact of CVM on the welfare of Good customers for the case when $\alpha = \frac{1}{2}$. Each curve corresponds to a particular k, and the region below each curve represents the scenarios where Good customers are worse off than before in Firm 1's customer base. When CVM accuracy increases, Good customers receive the higher inducements offered to perceived Good customers more often. However, if the correlation in classifications is not sufficiently high, competition for perceived Good customers may be moderated. As a result, when CVM accuracies of both firms are not too high, Good customers are worse off.
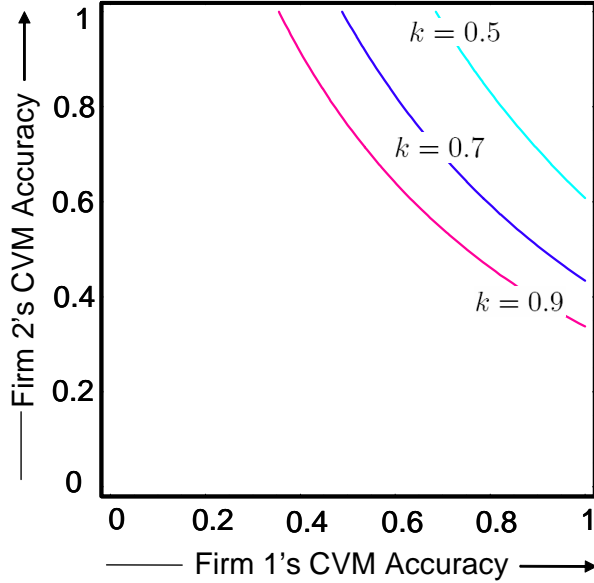
Figure 3: Welfare of Good Customers

Impact of Changes to Customer Base

We now consider the impact of changes to the customer base. A frequently mentioned benefit of CVM is that firms can take measures to improve the value of its low value customers. In fact, some advise that firms should either make low-value customers more valuable or "fire" them (e.g. Selden & Colvin 2003). Since such customers are usually unprofitable to begin with, they argue that the firm can never lose by taking such steps. However, we find that when we consider the effect of competition, such measures may prove counter productive.

With CVM, when a firm's accuracy is less than perfect, pruning perceived Poor customers has two unintended consequences. First, in the process of pruning Poor customers, the firm will also prune some Good customers as it cannot identify customer types perfectly. Second, by stripping its customer base of Poor customers, the firm would encourage the rival to compete more aggressively for its customers. Both these outcomes can reduce firm's profits. In fact, even when a firm can identify customer types perfectly, customer pruning can still be counter productive. To see this, suppose Firm 1 has perfect CVM accuracy about its customers, so that $I_1 = 1$. Its profits in its customer base are given by

$$\lambda_1 = s\alpha\left(1 - \alpha\right)\left(1 - kI_2\right)\left(\pi_G - \pi_P\right).\tag{12}$$

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Suppose Firm 1 could remove or "fire" some of its Poor customers before firms compete by offering inducements[17]. If Firm 1 fired $s\delta$ Poor customers, where $\delta \in (0, 1 - \alpha]$, then the size of the customer base decreases to $s(1 - \delta)$ while the proportion of Good customers increases to $\frac{\alpha}{1-\delta}$. Firm 1's profits λ_1' after firing Poor customers are given by

$$
\begin{aligned}
\lambda_1' &= s(1 - \delta) \frac{\alpha}{1 - \delta} \left(1 - \frac{\alpha}{1 - \delta}\right)(1 - kI_2)(\pi_G - \pi_P) \\
&< s\alpha(1 - \alpha)(1 - kI_2)(\pi_G - \pi_P) = \lambda_1.
\end{aligned}
\tag{13}
$$

Thus profits are lower as poaching becomes more attractive for Firm 2 and intensifies competition[18].

Some industry observers have cautioned against firing Poor customers on the basis that CVM systems are imperfect in identifying them (*Strategy+Business* 2002). Others have argued that firing customers would lead to bad publicity and Poor customers should be treated as the cost of doing business (*ABA Banking Journal* 2000). Our analysis reveals yet another reason such efforts can back-fire. In fact, we find that Poor customers are actually "valuable" to the firm as they determine the profits realized from Good customers.

Again suppose Firm 1 has perfect accuracy. But now, instead of firing Poor customers, suppose it increases their value, *i.e.* it increases π_P. For instance, a bank may educate its low value customers to use lower cost online channels. To the extent that its rival also offers online channels and customer behavior in using online channels is firm agnostic, we can expect that these customers are more valuable to its rival as well. So the increase in customer value is common to both firms. Now, not only is the increase in the value of Poor customers competed away, but also the effectiveness of skimming in deterring the rival decreases, thereby reducing the profits from Good customers. So Firm 1's profits always decrease. Instead, suppose Firm 1 increases the value of all Good customers, thereby increasing π_G. Now, even though Good customers become more valuable to both firms, still skimming allows Firm 1 to extract additional profits as the increase in inducements is lower than the increase in customer value. So Firm 1's profits always increase. Finally, suppose Firm 1 increases the value of some of its Poor customers to that of the Good customers, or α increases. If $\alpha \geq \frac{1}{2}$, competition always intensifies and Firm 1's profits reduce.

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[17] We assume that Firm 2 observes the changes in Firm 1's customer base before both firms compete for customers. A limitation of our approach is that it ignores the potential dynamics of the process. A more elaborate approach would be to consider a two period version of the inducement game.

[18] While it is true that Firm 1 realizes zero profits from its Poor customers in equilibrium and does not per se incur a loss, it does not follow that Firm 1 is indifferent between firing and not firing Poor customers. In fact, Eqn (13) shows that they are strictly worse off by firing them.

We summarize these results in the following proposition. Thus, not all increases in customer base value are the same, and can lead to drastically different results. Firms may be better off focusing on improving the value of their Good customers.

Proposition 5 *When a firm has perfect information about its customers*

a. *Increasing the value of Poor (Good) customers decreases (increases) the firm's profits.*

b. *Increasing the proportion of Good customers decreases the firm's profits if $\alpha \geq \frac{1}{2}$.*

c. *Reducing the number of Poor customers (by retrenching / firing) decreases the firm's profits.*

4.4 CVM Investment Decisions

We now analyze the competitive interaction in CVM investment decisions and focus on the symmetric (in investment strategies) sub-game perfect Nash equilibrium. Typically, as CVM technologies and methodologies mature, we can expect that the CVM cost declines, and firms are likely to acquire a higher level of accuracy. While firms have an incentive to improve their CVM accuracy, such improvements also affect rival's profits and the competition may become more intense.

Proposition 6 *At the CVM investment stage, there exists a unique symmetric sub-game perfect Nash equilibrium. When CVM cost $c \leq c^*$, both firms invest to the maximum extent. Whenever $c > c^*$, a decrease in c leads to an increase in CVM investment. However, firm profits decrease if $c^* < c \leq c^{**}$ and $k > k^*$.*

Figure 4 depicts these results for a particular parametric scenario[19]. As may be expected, CVM investment increases when cost decreases. However, firms may actually become worse off[20]. To understand this better, consider how firm profits from the customer bases vary with CVM accuracy when both firms have the same accuracy, i.e. consider $\lambda_1 + \Lambda_1$ when $I_1 = I_2 = I$. As shown in Figure 5[21], profits initially increase and then decrease with I. This is because when investment levels are high, the correlation in classifications is also high which leads to more intense competition

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[19] $\pi_G = 20, \pi_P = 10, \alpha = \frac{1}{2}, k = \frac{1}{2}$. The kinks in equilibrium investment and profits correspond to the transition from $c \leq c^*$ to $c > c^*$.

[20] Firms are worse off relative to their position prior to the decrease in CVM cost. They may still be better off than in the benchmark case.

[21] $\pi_G = 20, \pi_P = 10, \alpha = \frac{1}{2}$.

for perceived Good customers. In particular, this is because of the "spillover" k across customer bases[22]. As k increases, the maximum accuracy I beyond which firm profits decline also decreases.
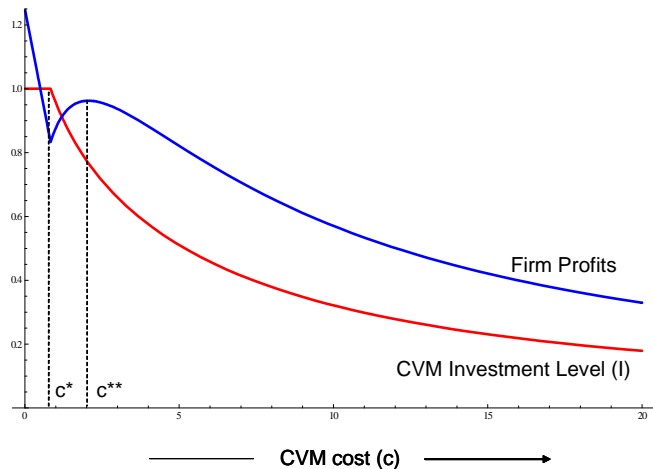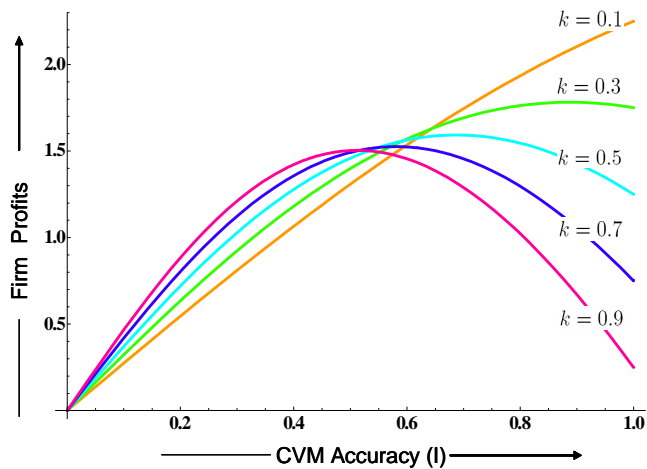

Figure 4: CVM Investment and Profits

Figure 5: Firm Profits with Equal Accuracy

Going back to Figure 4, we see that when CVM investment cost is low, equilibrium investment levels are high. Now if CVM becomes more affordable, equilibrium investments continue to increase. But a firm's gain from higher accuracy is more than offset by the loss from its rival's higher accuracy. If k is sufficiently high, this even offsets the savings from the lower investment cost. Thus firms can become worse off when CVM becomes more affordable.

This is in line with the observation in Banking Strategies (1999) that retail banks may not have benefited from CVM as it eventually led to more intense competition for high value customers. It also suggests that in regulated industries such as insurance, restrictions on the extent to which firms can discriminate between customers may prove to be a blessing in disguise. Chen et. al. (2001) also find that an increase in industry targeting accuracy eventually leads to a decrease in firm profits. They propose that this may explain why direct marketers have voluntarily adopted measures to protect customer privacy. Similarly, firms in industries adopting CVM may also find it worthwhile to self regulate their ability to obtain and use customer information.

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[22]As noted earlier the correlation in classifications in each customer base is kI_1I_2.

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5   Extensions

We analyze several extensions to our model. First, we consider that one of the firms may have a larger customer base. Next, we look at how other firm-level advantages such as cost-efficiency and firm differentiation affect the impact of CVM. Lastly, we consider that inducements affect not only customers' switching behavior but also their consumption behavior.

5.1   Customer Base Size

Suppose Firm 1 has a larger customer base than Firm 2. Let S, $1 - S$ respectively be the size of the customer bases of Firm 1 and Firm 2 respectively, where $S \in \left(\frac{1}{2}, 1\right)$. As before, in the inducement stage of the game, the interactions in one customer base are independent of those in the other. In particular the size of one customer base does not affect the interactions in the other. Thus our earlier analysis holds except for the rescaling of profits. When both firms have CVM, we have from Lemma 2

$$\lambda_1 = S\alpha\left(1 - \alpha\right)I_1\left(1 - kI_2\right)\frac{1 - \alpha(1 - kI_2)}{1 - \alpha(1 - kI_1 I_2)}\left(\pi_G - \pi_P\right),\tag{14-a}$$

$$\lambda_2 = S\alpha\left(1 - \alpha\right)kI_2\left(1 - I_1\right)\frac{1 - \alpha(1 - I_1)}{1 - \alpha(1 - kI_1 I_2)}\left(\pi_G - \pi_P\right),\tag{14-b}$$

$$\Lambda_1 = \left(1 - S\right)\alpha\left(1 - \alpha\right)kI_1\left(1 - I_2\right)\frac{1 - \alpha(1 - I_2)}{1 - \alpha(1 - kI_1 I_2)}\left(\pi_G - \pi_P\right),\tag{14-c}$$

$$\Lambda_2 = \left(1 - S\right)\alpha\left(1 - \alpha\right)I_2\left(1 - kI_1\right)\frac{1 - \alpha(1 - kI_1)}{1 - \alpha(1 - kI_1 I_2)}\left(\pi_G - \pi_P\right).\tag{14-d}$$

Propositions 1, 2, 4 and 5 are not affected as they characterize interactions within a customer base. Proposition 3, which considers firm profits across customer bases, is modified in that the bounds on CVM accuracies depend on S (refer Appendix B).

In the investment stage of the game, we find that there is always an equilibrium where Firm 1 invests more than Firm 2 (unless c is small, in which case both firms invest to the maximum). But this equilibrium is not necessarily unique. As the analysis of the general case is complicated[23], we set $\alpha = \frac{1}{2}$ and derive sufficient conditions for uniqueness. In Appendix B, we show the equilibrium is unique when k is sufficiently small and when Firm 1 is sufficiently larger than Firm 2.

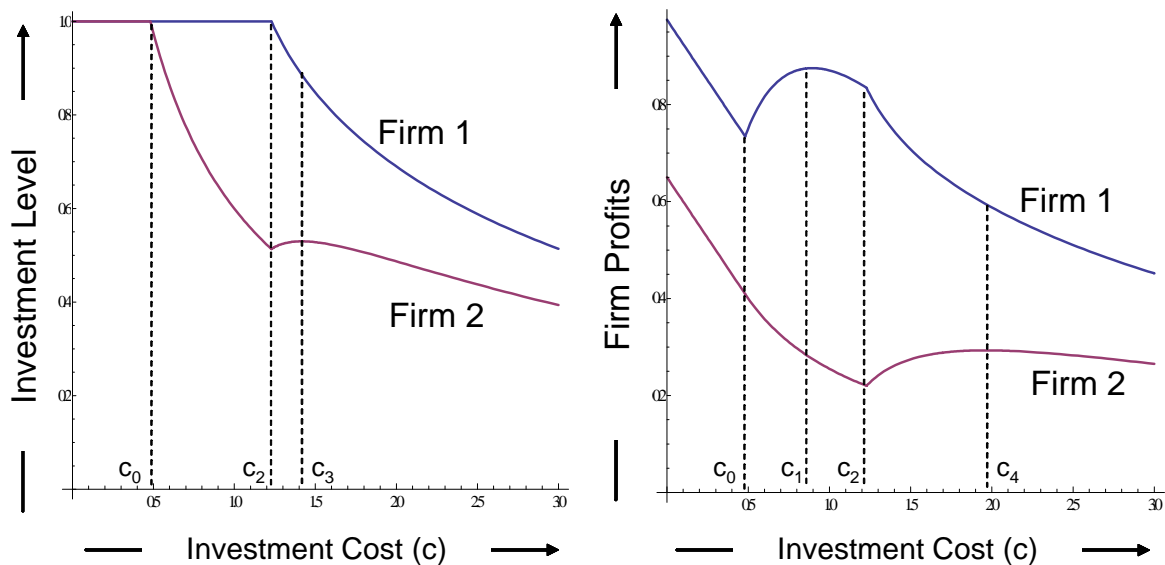[23]The equilibrium solutions are the roots of a polynomial of degree 11.

Figure 6: CVM Investment and Profits

Figure 6 shows the equilibrium investments and profits as a function of CVM investment cost in a particular parametric scenario when the equilibrium is unique[24]. We find that as CVM becomes more affordable, higher investment by Firm 1 may make it less attractive for Firm 2 to invest ($c_2 < c < c_3$ in Figure 6) and may also make Firm 2 worse off ($c_2 < c < c_4$ in Figure 6). On the other hand, if Firm 1 already has invested to the maximum extent, further decrease in CVM cost may make Firm 1 worse off since Firm 2's investment increases ($c_0 < c < c_1$ in Figure 6).

5.2 Cost Efficiency

A firm may be more efficient than its rival by virtue of its unique business processes or technologies, resulting in a lower cost structure. We look at whether CVM helps reinforce this existing source of competitive advantage. Suppose Firm 1 is more efficient than Firm 2 in the following sense: to provide an inducement of level d to a customer, it costs γd for Firm 1 and d for Firm 2, where $\gamma \in (0, 1)$ is the measure of Firm 1's efficiency[25]. A lower γ means a higher efficiency.

In the benchmark case, we again have Bertrand competition. But Firm 1 now derives positive

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[24]$\pi_G = 20, \pi_P = 10, \alpha = \frac{1}{2}, k = \frac{1}{3}, S = \frac{2}{3}$

[25]We now restrict inducements to be positive. A sufficient condition for inducements to be positive in any equilibrium is $\pi_P > 0$.

profits as it has a cost advantage. The equilibrium strategies and profits are given by[26]

$$d_1 = d_2 = \bar{\pi} \text{ and } \lambda_1 = s\,(1 - \gamma)\,\bar{\pi},\ \lambda_2 = 0, \tag{15-a}$$

$$D_1 = D_2 = \bar{\pi} \text{ and } \Lambda_1 = s\,(1 - \gamma)\,\bar{\pi},\ \Lambda_2 = 0. \tag{15-b}$$

Note that Firm 1's profit increases with the average value of customers. Thus it is also relatively more efficient in harnessing an increase in customer value.

The results and formal analysis when both firms have imperfect CVM are provided in Appendix A and the Technical Appendix respectively. We discuss the intuition here.

We saw that when both firms are equally efficient, skimming determines Firm 2's profit opportunity from perceived Good customers by discouraging Firm 1 from competing intensely for perceived Poor customers. For instance, in its own customer base, Firm 1's inducement to its perceived Poor customers is lower than their ex-ante expected value. Firm 1 retains only those customers classified as Poor by both firms, i.e. the $p_1 p_2$ customers. It does not compete to retain the cross-classified $p_1 g_2$ customers, since the additional gain from doing so is more than offset by the loss on the retained $p_1 p_2$ customers. So skimming determines Firm 2's profit opportunity from perceived Good customers, and this in turn moderates competition for customers classified as Good by both firms, i.e. the $g_1 g_2$ customers.

However, when Firm 1 is more efficient, the higher margin makes it attractive for Firm 1 to compete for the cross-classified $p_1 g_2$ customers as well. This reduces Firm 2's profit opportunity from perceived Good customers and motivates it to compete harder for $g_1 g_2$ customers. In turn, this intensifies the competition faced by Firm 1 for perceived Good customers. Thus Firm 1's higher efficiency reduces Firm 2's profit opportunity from skimming and consequently, CVM moderates competition to a lesser extent relative to the benchmark case. This has three implications.

1. For Firm 2 to derive positive profits, its CVM accuracy should be sufficiently high in order for it to be able to skim in spite of Firm 1's cost advantage. Figure 7 shows the range of I_1 and I_2 when Firm 2 makes positive profits in Firm 1's customer base[27]. Each curve corresponds to a particular γ and Firm 2 makes positive profits in the region above the curve. Higher Firm 1's efficiency, smaller the range over which Firm 2 can realize positive profits.

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[26]To ensure uniqeuness, we restrict attention to equilibria where weakly dominated actions are not employed.

[27]In Figures 7,8 and 9, $\pi_G = 20, \pi_P = 10, k = \frac{1}{2}, \alpha = \frac{1}{2}$. In Figures 8, 9 not all γ levels are labeled. The levels used are 0.1, 0.3, 0.5, 0.7 and 0.9.

Interestingly, over some range of I_2, Firm 1's CVM accuracy should neither be too high nor too low. When I_1 is low, Firm 1 competes primarily on the basis of its cost advantage and this may completely offset Firm 2's skimming profit opportunity. When I_1 is high, Firm 2's potential profit opportunity is low to begin with, as the value of the cross-classified $p_1 g_2$ is low, and hence is more easily offset by Firm 1's cost advantage. Between these extremes, Firm 2's profits initially increase and then decrease with I_1. So when Firm 1 is more efficient, Firm 2 may benefit from an improvement in Firm 1's accuracy as this encourages Firm 1 to compete more on the basis of its CVM information.
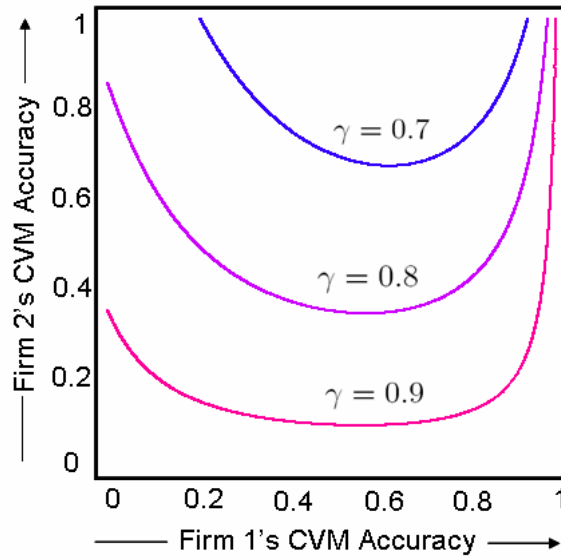

Figure 7: Positive Firm 2 Profits

2. Firm 1 is not necessarily better off than in the benchmark case, even when it has a higher accuracy than Firm 2. In Appendix B, we show that when $I_1 = I_2 = I$, Firm 1 is worse off than in the benchmark case if I is sufficiently low. We also show that when Firm 1's efficiency is sufficiently high, Firm 1 is worse off even when $I = 1$. Figure 8 shows the minimum I_1 for Firm 1 to be better off as a function of I_2. Each curve corresponds to a particular γ. When Firm 1's efficiency is high, it competes primarily on the basis of its cost-advantage to counter Firm 2's skimming, which intensifies competition and dissipates profits. As a result, if Firm 2's accuracy is sufficiently high, Firm 1 may be worse off even when $I_1 = 1$. Thus, with the advent of CVM, the more efficient firm could find its competitive position eroded even when it possesses better information than its rival, since the two sources of advantage

do not reinforce each other. If the rival's accuracy is not too high, then the efficient firm can avoid such a situation when it has a sufficiently high information advantage.
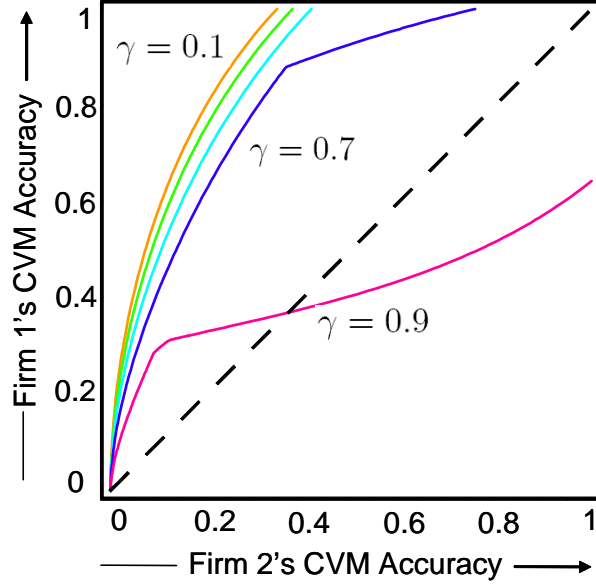

Figure 8: Minimum Accuracy for Firm 1 to be
Better Off

3. Not only does CVM moderate competition to a lesser extent but, in fact competition may be more intense than in the benchmark case. Figure 9 depicts the region of I_1 and I_2 where combined firm profits with CVM in Firm 1's customer base is lower than in the benchmark case. Each curve corresponds to a particular γ, and profits are lower in the region to the left of the curve. In general, competition is less intense if Firm 1's information level is sufficiently high or Firm 2's information level is sufficiently low. At lower levels of efficiency, competition is also less intense if Firm 2's information level is high, since Firm 1's cost advantage does not sufficiently offset Firm 2's skimming profit opportunity.

We now look at how changes by Firm 1 to its customer base affect its profits. Firm 1's profits in its customer base when it has perfect accuracy are given by

$$\lambda_1 = \frac{s\alpha(\pi_G-\pi_P)((1-\gamma k I_2)\pi_G+\gamma(2-kI_2-\gamma)\pi_P)-(1-kI_2)\alpha^2(\pi_G-\pi_P)^2}{\pi_G-\gamma\pi_P} + s\left(1-\gamma\right)\pi_P. \tag{16}$$

As before, increasing the value of Poor customers intensifies competition for Good customers, and this is reflected in the first term in Eqn (16). But Firm 1 is now also more efficient in harnessing an

increase in customer value, which is captured by the second term. When Firm 1's efficiency is not too high, its profits again decline when π_P increases (refer Appendix B). But when its efficiency is sufficiently high, the gains from efficiency more than offset the losses from intensified competition, and Firm 1 benefits from an increase in the value of Poor customers. Similarly, an increase in the proportion of Good customers is always beneficial to Firm 1 if its efficiency is sufficiently high. Irrespective of its efficiency, Firm 1 always benefits from an increase in the value of Good customers, not only because of skimming but also because of its higher efficiency. Lastly, firing Poor customers always reduces firm profits. This is not surprising, since not only is competition for Good customers more intense, but also, Firm 1 in fact derives positive profits from Poor customers when it is more efficient.
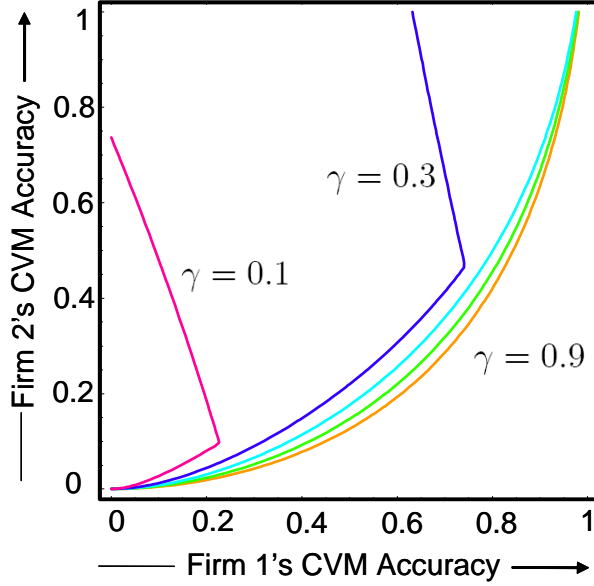

Figure 9: Competitive Intensity

Firm 2's profits in its customer base when it has perfect accuracy are given by

$$
\Lambda_2 = \begin{cases} s\left(1 - kI_1\right)\alpha\left(1 - \alpha\right)\left(\frac{\gamma - \alpha(1 - kI_1)}{\gamma(1 - \alpha(1 - kI_1))}\pi_G - \pi_P\right) & if \quad 1 > \gamma > \frac{\alpha(1 - kI_1)\pi_G}{\pi_G + (1 - \alpha(1 - kI_1))\pi_P}; \\ 0 & otherwise. \end{cases} \tag{17}
$$

We find that qualitatively similar results as in Proposition 5 hold in this case.

5.3 Differentiated Firms

Firms may be differentiated so that customers may prefer the firm they are currently buying from. Or customers may face a switching cost because of contractual obligations or the lack of familiarity with a rival seller. Let t_1 and t_2 respectively be the premium that Firm 1's and Firm 2's customers attach to their current vendors. For instance, if Firm 1 offers an inducement d to its customers, then Firm 2 must offer an inducement of $d + t_1$ to be equally attractive to these customers. So essentially each firm enjoys a cost advantage in its own customer base. While this is different from the type of cost advantage in Section 5.2 (fixed cost here vs. variable cost there), we find that the nature of interactions is qualitatively similar (refer Appendix B). We find that a differentiated firm may be worse off than in the benchmark case, even in its own customer base, if it does not have a sufficiently higher CVM accuracy than its rival. The range of rival's accuracy over which this is true increases with the firm's advantage in its own customer base. However, since firms are still equally efficient in harnessing an increase in customer value, the results of Proposition 5 continue to hold qualitatively.

5.4 Inducements Affect Switching and Consumption

When firms tailor their inducements to individual customers, this might not only affect a customer's choice of whom to buy from, but may also affect her choice of what all, how much or how frequently to buy. If customer spending increases sufficiently in response to inducements, then a firm has an additional incentive to offer higher inducements, for this not only improves acquisition / retention but also customer profitability. We incorporate such behavior in our model by allowing intrinsic customer value to change with the level of inducements. Let $\tilde{\pi}_G(d)$ and $\tilde{\pi}_P(d)$ be the intrinsic customer value of Good and Poor customer types respectively. Let $\Pi_G(d)$ and $\Pi_P(d)$ denote the profitability of Good and Poor customers respectively at inducement d, so that

$$\Pi_G(d) = \tilde{\pi}_G(d) - d, \text{ and } \Pi_P(d) = \tilde{\pi}_P(d) - d. \tag{18}$$

For the analysis to be meaningful as well as tractable, we restrict the shape of the customer profitability functions as follows. For either customer type $t \in \{G, P\}$, $\Pi_t(d)$ is strictly concave and C^1. $\Pi_t'(d) < 0$ for d sufficiently large, so that profitability does not perpetually increase with inducements. $\Pi_t(d) > 0$ for some d, so that customers are worth serving when inducements are

not too large. Lastly, $\Pi_G(d) > \Pi_P(d)$ for all d, so that Good customers are always more profitable than Poor customers.

As before, in the benchmark case, we have Bertrand competition and firms realize zero profits. To understand how the competitive interaction with CVM changes, we examine the case when CVM provides perfect information about one's own customers and no information about rival's customers, i.e. $I_1 = I_2 = 1$, $k = 0^{28}$. All of this impacts our analysis only if Good and Poor customers respond differently (in varying their consumption) to changes in inducements. For only then is there an opportunity for the firm to incorporate this additional difference between customer types when serving its customers, while its rival cannot. We formalize this notion in our analysis in Appendix B.

We find that CVM continues to moderate competition. For instance Firm 2 offers lower inducements to Firm 1's customers than in the benchmark case, since the left over customers are again less attractive. If the profitability of Good customers is not too different from that of the average customer[29], then Firm 1 has an incentive to lower its inducement to its Good customers. The nature of interaction is similar to that before and Proposition 5 holds qualitatively. On the other hand, if the the profitability of Good customers is sufficiently different from the average customer, then Firm 1 in fact finds it worthwhile to offer its Good customers higher inducements than in the benchmark case. In such cases, a firm benefits from CVM not because competition is moderated, but because it is able to optimize the profitability of its Good customers. Consequently, small changes to the value or the number of Poor customers do not impact firm profits, even though it may encourage the rival to compete more intensely[30].

6   Concluding Comments

The primary contribution of our research is to introduce a competitive perspective to CVM. Previous research on CVM and popular press offer numerous managerial prescriptions. For instance, they recommend that firms should try to make low-value customers more valuable, and firing those

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[28] The analysis readily extends to the case when $I_1 < 1$, $I_2 < 1$ and $k = 0$, if we work with the expected profitability functions for perceived Good and Poor customers for each firm in its own customer base.

[29] We require that the profitability of Good customers decreases with inducements beyond the point where average customer profitability is zero. For consumption behavior to affect the nature of interactions, we not only require that $\Pi_G(d)$ and $\Pi_P(d)$ are different, but also that there are not too many Good customers, since the average profitability depends on α.

[30] A larger change could, however, still reduce profits.

who cannot be transformed. While such prescriptions are research-based and intuitively sound, our analysis suggests that they best apply to firms that operate in an isolated or non-competitive environment. As is sometimes the case, the simple logic that works in a non-competitive context may not carry over to a competitive setting. We find that the competitive dimension provides some interesting and important insights.

1. CVM not only improves customer mix but also reduces overall spending on customers by moderating competition. Managers need to track both aspects when measuring the performance and effectiveness of CVM.

2. Increasing the value of customers can lead to drastically different outcomes depending on whose value is increased. If low-value customers are made more valuable, this can be counterproductive. Managers can instead focus on improving the value of high-value customers.

3. Even when low-value customers can be identified perfectly, firing them intensifies competition and reduces profits. So managers should be cautious when considering such measures.

4. While CVM reduces the extent to which low-value customers are subsidized, even high-value customers may be worse off if CVM moderates competition sufficiently. Hence managers should be mindful of potential customer backlash and fairness concerns.

5. With the advent of CVM, a firm with a prior advantage such as cost-efficiency or differentiation may find itself worse off unless it achieves a sufficiently superior position in CVM.

6. Firms in an industry may become worse off as CVM becomes more affordable. So they have an incentive to self-regulate their ability to collect or use customer information.

We now briefly discuss some important limitations of our model and point to possible directions for future research.

In our model, by virtue of being able to identify its own customers, a firm can identify its rival's customers. This allows the simplification that firms exactly know the rival's CVM accuracy for any customer. A more general approach would allow for uncertainty in rival's CVM accuracy. A particularly interesting case is when there are new-to-market customers about whom neither firm has any information. Then a firm cannot distinguish between rival's customers, about whom the

rival has information, and new-to-market customers, about whom the rival has no information. On the one hand, new-to-market customers may intensify competition as it reduces the number of customers about whom the rival has better information. On the other hand, the skimming effect that moderates competition for rival's customers could spill-over to the new-to-market customers as well.

We have restricted attention to a single period of interaction between the firms. It would be interesting to extend the model along the lines of Villas-Boas (1999) to multiple period of interactions, which would allow firms to learn about the customer types, and overlapping generations of customers, which would maintain uncertainty about customer types. In general, as firms learn more about a customer, their classifications become more similar, which is likely to intensify competition. But it also gives rise to non-trivial inter-temporal incentives. Firms now have to consider the heterogeneity of their future customer base and also what their rival learns about customers in each period. In addition, if customers are strategic, this adds another dimension to the dynamics of the process as they may want to exploit their private information about their type and manage what firms learn about them.

Differences in customer value may arise from differences along multiple dimensions such as cost-to-serve, basket of goods and services they buy, purchase frequency, volume and so on. While we abstract away from these differences, a richer model of customer behavior can examine the impact of these different dimensions.

Finally, we do not consider that firms may differ in the manner or type of inducements they offer. For instance, Syam and Hess (2007) consider the timing of differential rewards to "loyal club" customers to vary depending on whether the firm adopts an acquisition (early rewards) or retention (later rewards) strategy. They find that, contrary to popular notions, a retention strategy may not always be the right approach in a competitive CRM setting.

Notwithstanding these limitations, we hope that our work will help advance the understanding of CVM and motivate further research.

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