Research Note: Price Discrimination as an Adverse Signal: Why an Offer to Spread Payments May Hurt Demand

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Abstract

Firms often search enthusiastically for distinguishing traits that they may use to price discriminate between segments. Yet there are occasions in which firms forgo the opportunity to price discriminate and instead charge a single price. Traditional explanations for why retailers forgo the opportunity to price discriminate focus on the cost of discriminating, including operational costs, explicit discrimination costs, and implicit discrimination costs. In this paper we identify an additional reason for why firms may forgo an opportunity to price discriminate. By revealing that a product is being sold to a broad range of segments, a retailer implicitly claims that the product is suitable for each segment. However, claiming that a premium-quality product is suitable for price-sensitive consumers undermines the credibility of a retailer's quality claim.

The signaling explanation was motivated by extensive discussions over more than a year with a major catalog retailer that sells premium-quality jewelry and gifts. Discussions with managers revealed that they were reluctant to use any price-discrimination mechanism that signals their products are targeted at price-sensitive customers. For example, the catalog does not include sale or clearance sections and does not target more price-sensitive customers by using separate items. However, management was under some pressure to consider installment-billing offers, which allow customers to pay over a series of periods rather than in a lump sum. Management feared that offering installment billing may adversely affect customers' quality perceptions and demand.

To investigate this issue, we develop a general game-theoretic model, illustrate how the model extends to installment billing, and conduct a large-scale field test. The general model illustrates how selling to multiple segments may lead to an adverse quality signal. We illustrate how the model extends to installment-billing offers in a direct-mail catalog. Installment-billing offers allow customers to spread the total payment over a series of payments. All customers have the option of using installment billing, and customers who use the plan receive an economic benefit (an interest-free loan).

We would normally expect this type of offer to increase demand or, at a minimum, leave demand unchanged. However, because installment-billing offers target credit-constrained customers, we predicted that the introduction of installment billing would prompt an unfavorable quality inference and reduce demand among quality-sensitive customers.

We empirically investigated this prediction in a large-scale field test with a catalog that offers premium-quality jewelry and gifts. Two versions of the catalog were created: a test version that contained an installment-billing offer, and a control version in which installment billing was not offered. Importantly, the prices in both the test version and control version were identical. Approximately 240,000 catalogs were mailed, and customers were randomly assigned to either the test version or control version. Results show that the installment-billing offer (test version) was associated with both a reduction in the number of orders received and a reduction in aggregate revenue. Offering installment billing resulted in approximately $15,000 in lost revenue. The only plausible explanation for this counterintuitive finding appears to be the signaling theory.

To investigate the long-term effects, the catalog agreed to survey their customers to measure how an offer of installment billing affects their customers' quality perceptions. Similar to the field test, two versions of a catalog were created, and customers were randomly mailed a catalog, along with a short survey. Respondents were asked to browse through the catalog and return their responses in a reply-paid envelope. The findings are consistent with customer beliefs in the signaling model: Offering installment billing lowers the perceived quality of the items in the catalog.

The field test and survey findings were both statistically significant and managerially relevant. Together, the results convinced the catalog not to include installment-billing offers in future catalogs.

(*Signaling; Price Discrimination; Installment Billing; Promotions; Quality Perceptions; Retailing*)

1. Introduction

Firms often search enthusiastically for distinguishing traits that they may use to price discriminate between segments, yet there are occasions in which firms forgo the opportunity to price discriminate and instead charge a single price. Fashion garments provide a useful example. Although department stores often anticipate that demand for a style will vary across colors, they generally charge the same price for all colors, even if this requires ordering different quantities to accommodate demand differences. Compact discs offer a similar example. Retailers selling compact discs often group their titles into a small number of price categories and charge the same price within each category, despite variance in anticipated demand within the categories.

Traditional explanations for why retailers forgo the opportunity to price discriminate focus on the cost of discriminating, including operational costs, explicit discrimination costs, and implicit discrimination costs. The operational costs of charging different prices in advertising and at the point of sale may help to explain why retailers do not vary the prices of different-colored clothing. Explicit discrimination costs include the costs of ascertaining which segment customers are in and preventing arbitrage following purchase. For example, the Yankees may decide not to offer discounts to out-of-state fans because of the difficulty of confirming eligibility and preventing subsequent resale. Implicit discrimination costs arise due to the distortion of one or more marketing variables to facilitate self-selection and prevent arbitrage between segments. Examples include manufacturers increasing prices or altering packaging in foreign markets to discourage transshipping and resale in the United States.

In this paper we identify an additional reason for why firms may forgo an opportunity to price discriminate. By revealing that a product is being sold to a broad range of segments, a retailer implicitly claims that the product is suitable for each segment. However, claiming that a premium-quality product is suitable for price-sensitive consumers undermines the credibility of a retailer's quality claim. This signaling explanation was motivated by extensive discussions over more than a year with a major catalog retailer. The retailer operates 12 different catalog businesses with aggregate revenue exceeding $600 million. Each catalog business has different brands and independent marketing and management teams, comprising employees with extensive experience in the retail industry. Several of the company's catalogs were considering offering ''installment billing'' in response to favorable experiences reported in the trade press (see, for example, Chevan 1995 and *Business and Management Practices* 1998). Installment billing is perhaps best described by the following offer, which represents the actual wording used in the field test reported in §3 of this paper:

> At your request, [we] will divide any order containing an item denoted by [icon] into five equal payments charged monthly to your VISA, Mastercard, American Express, Diners Club or NOVUS Cards. There is never a finance charge for this service, and your total cost remains the same, regardless of the payment method you prefer. When you request extended payment, your total will be divided into five equal monthly payments. Shipping and handling, plus any surcharges or sales tax, will be added to your first installment.

Despite the favorable reports in the trade press, one of the company's catalogs resisted the introduction of installment billing. The managers of this catalog, which competes with firms like Tiffany's in selling premium-quality jewelry and gifts, were concerned that offering installment billing may adversely affect their customers' quality perceptions. This reluctance was not limited to installment billing. In discussions, these managers revealed that they were reluctant to use any price-discrimination mechanism that signals their products are targeted at price-sensitive customers. The catalog does not include sale or clearance sections and does not target more price-sensitive customers by using separate items.

Prior to our study, corporate management and other catalog managers were skeptical about this concern. The empirical findings reported in this paper confirm that the concern is well founded and highlight the importance of the issue. The findings are also surprising. Customers had the option of not using installment billing, and customers who used the

plan received an economic benefit (an interest-free loan). We would normally expect this type of offer to increase demand or, at a minimum, leave demand unchanged. Yet, the outcome was a reduction in demand that was both statistically significant and managerially relevant. Subsequent survey findings confirmed that the installment-billing offer was also associated with a reduction in customers' quality perceptions.

This signaling argument may help to explain why Tiffany's, Cartier, Louis Vuitton, and other retailers selling premium-quality products generally forgo use of price-discriminating mechanisms such as installment billing or temporal discounts. However, the argument can also explain the absence of price discrimination in other markets. In the case of fashion clothing, discounting less fashionable colors may implicitly reveal retailers' private information about which colors are less fashionable.

The argument relates to a well-established literature on snob appeal. Pesendorfer (1995) argues that customers in fashion markets prefer to signal membership of one segment and to distance themselves from others (see also Navon et al. 1995, Wernerfelt 1990, and Leibenstein 1950). As we shall show, the argument we present does not require this type of customer behavior to deter retailers from price discriminating, although these dependencies in customers' preferences will accentuate the adverse effect that results. In particular, price discrimination may deter quality-sensitive customers, due to both concerns about the true quality of the product and because these customers prefer not to purchase the same items as more price-sensitive customers.

We formally illustrate the signaling argument using two models. We first show in §2 that the argument requires few assumptions to support existence and uniqueness. The transparency of this first model enables us to claim that the result is a strong one, which can be easily adapted to different price-discrimination mechanisms, such as brand extensions and hi-low pricing. In particular, in §3 we extend the finding to installment billing, and then test the argument by illustrating how the introduction of installment billing affected demand in the premium-quality catalog. The paper concludes in §4.

2. Model

We contemplate a single-period model in which a monopolist retailer sells a single product in a market with two customer segments. The customer segments include a mass of X customers who are quality sensitive and a mass of Y customers who are relatively insensitive to quality. For ease of exposition we characterize customers in these two segments as *high types* (high preference for quality) and *low types* (low preference for quality). The consumer surplus function for both customer segments is given by $U = \theta q - p$, where θ denotes the customers' quality sensitivity, and q and p denote the quality and price of the product, respectively. We use $j \in \{X, Y\}$ to denote each segment and assume that $\theta = \theta_j$, where $\theta_X > \theta_Y$. The product sold by the retailer may be high or low quality, such that $q \in \{q_L, q_H\}$, where $q_H - q_L = \Delta > 0$. The quality difference is known by the retailer and is reflected in the marginal cost, $c \in \{c_L, c_H\}$, where $c_L < c_H$. Customers are, at least initially, unaware of the quality of the product, and believe with probability α that quality is high and with probability $1 - \alpha$ that quality is low.

We assume that the cost of a high-quality product exceeds what low-type customers are willing to pay ($\theta_Y q_H < c_H$), so that it is not profitable to sell to these customers if quality is high. In contrast, $\theta_Y q_L > c_L$, so that it may be profitable to sell to low-type customers when quality is low. Together these assumptions imply that when customers observe retailers selling to low types they can conclude that the product is low quality. The game proceeds with the retailer setting prices, which are observed by the customers. Customers decide whether to purchase, and trade occurs. We assume that arbitrage is not possible and the quality of the product sold by the retailer is exogenous, so that the retailer's strategy space is limited to designing a menu of prices. We also initially assume that quality sensitivities covary with an observable customer trait and that it is legal to price discriminate on this trait. Examples might include charging different prices in different locations and distribution channels or offering discounts to customers who are senior citizens, students, and/or members of the military. In §3 we show that this assumption is not

restrictive by using the model to explain retailers' use of installment billing. In that application, customers' quality sensitivities are not observable. Instead, customers reveal their sensitivities by self-selecting from the options of purchasing with or without installment billing.

It is helpful to first consider the retailer's pricing strategies under complete information, when customers know the quality of the product. There is a unique equilibrium, with the retailer maximizing its profits by selling only to high types at a price of $p = \theta_X q_H$. In the low-quality condition the retailer will price discriminate, charging $\theta_X q_L$ and $\theta_Y q_L$ to the high and low types, respectively.

Signaling

When customers do not know the quality of the retailer's product, two different types of equilibria are possible: a *pooling equilibrium* and a *separating equilibrium.* We begin by focusing on a separating equilibrium, in which the prices are identical to the full information case. Three types of deviations are possible: (1) deviations in which either retailer type price discriminates, (2) deviations in which a low-quality retailer charges $\theta_X q_H$ to mimic a high-quality retailer, and (3) deviations in which either retailer type charges a single price other than $\theta_X q_H$. To confirm the existence of the separating equilibrium we need to rule out all three alternatives. Consider first deviations in which a retailer price discriminates. By assumption, a high-quality retailer can never profit from deviating from $\theta_X q_H$ and selling to low-type customers. For this reason, customers can reasonably conclude that retailers who price discriminate offer low quality.[1] Under these beliefs, a low-quality firm earns more when charging $\theta_X q_L$ and $\theta_Y q_L$ than charging any other discriminating prices.

Second, if a retailer with a low-quality product mimics a high-quality retailer by charging $\theta_X q_H$, it

sells to high-type customers at $\theta_X q_H$ but forgoes sales to the low types who are unwilling to pay this price. We introduce an equilibrium condition describing when a retailer with a low-quality product prefers to price discriminate and reveal its true quality rather than mimic a high-quality retailer:

Condition I

$$X(\theta_X q_L - c_L) + Y(\theta_Y q_L - c_L) \geq X(\theta_X q_H - c_L). \quad \text{(I)}$$

Third, a retailer may also deviate by charging a single price other than $\theta_X q_H$. A high-quality retailer earns its full information profits in equilibrium, and hence can do no better. Given this, charging a single price other than $\theta_X q_H$ reveals that the retailer is low quality, in which case the retailer can do no better than its equilibrium profits. We conclude that when Condition (I) is satisfied, there exists a separating equilibrium in which the retailer charges $\theta_X q_H$ if quality is high and charges the discriminating prices $\theta_X q_L$ and $\theta_Y q_L$ when quality is low. The equilibrium is supported by customer beliefs that quality is low when the retailer either price discriminates or charges a single price other than $\theta_X q_H$.

If Condition (I) is not satisfied, a low-quality retailer prefers to mimic a high-quality retailer by charging $\theta_X q_H$. In these situations an alternative separating equilibrium may exist in which a low-quality retailer charges $\theta_X q_L$ and $\theta_Y q_L$ and a high-quality retailer lowers its price to a level that will not be mimicked. This level, which we label p^*, is defined as follows:

$$X(\theta_X q_L - c_L) + Y(\theta_Y q_L - c_L) = X(p^* - c_L). \quad \text{(1)}$$

The left-hand side of Equation (1) is the low-quality retailer's equilibrium profits, and the right-hand side is the profit that this retailer earns when it mimics a high-quality retailer by charging p^*.

The same three categories of deviations are possible, and the first two are ruled out using analogous logic. For the third category, deviations to a single price other than p^*, several deviating price ranges are relevant. Charging a price above $\theta_X q_H$ yields zero demand under any customer beliefs, and so neither firm can profit from a deviation in this range. For deviations below p^*, a high-quality retailer cannot earn more than its equilibrium profits. Therefore, charging

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[1] This is consistent with the intuitive criterion (Cho and Kreps 1987), which requires that customers believe a deviating firm is type θ_j only if this type profits from an observed deviating when customers believe that product quality is high (the most favorable customer beliefs). A retailer can benefit only from deviations that involve price discrimination if product quality is low (and then only under the most favorable beliefs).

a price in this region reveals that the retailer is low quality, in which case the retailer can do no better than its equilibrium profits. Finally, for deviations in the range $(p^*, \theta_X q_H)$, both retailer types would prefer to deviate given the most favorable beliefs (the product is high quality). When customers observe prices in this range they revert back to their prior beliefs. Therefore, to prevent deviations the equilibrium requires that high-type customers will not pay more than p^*, given their prior beliefs. Define $p^P = \alpha\theta_X q_H + (1 - \alpha)\theta_X q_L$ as the maximum price that high-type customers will pay given their prior beliefs (α). We assume that $p^P > c_H$, so that a high-quality retailer charging this price earns positive profits. The equilibrium requires that $p^* \geq p^P$.

If $p^* < p^P$ both retailer types would prefer to deviate to p^P, raising the possibility of a pooling equilibrium. In a pooling equilibrium both retailer types charge the same price, and so the price does not allow customers to infer retailer quality. Instead, customers must rely on their prior beliefs. We earlier defined p^P as the maximum price that high types will pay given their prior beliefs. We first identify conditions under which p^P is an equilibrium pooling price, and then show that this is the only pooling equilibrium.

We must consider two types of deviations: (1) deviations in which either type of retailer price discriminates, and (2) deviations in which either retailer type charges a single price other than p^P. First consider deviations in which a retailer price discriminates. Recall that a high-quality retailer will never price discriminate, and so customers can reasonably conclude that retailers who do so offer low quality. Under these beliefs, a low-quality firm earns more when charging $\theta_X q_L$ and $\theta_Y q_L$ than at any other discriminating prices. We introduce an equilibrium condition to ensure that a low-quality entrant prefers to charge p^P and disguise its type rather than charge $\theta_X q_L$ and $\theta_Y q_L$:
Condition II

$$X(p^P - c_L) \geq X(\theta_X q_L - c_L) + Y(\theta_Y q_L - c_L). \quad (II)$$

Given satisfaction of this condition, deviations involving a single price are also unprofitable. Recall that charging a price above $\theta_X q_H$ yields zero demand under any customer beliefs, and so neither firm can

profit from a deviation in this range. For deviations to a price below c_H, only the low-quality firm could profit, and so customers can reasonably infer that quality is low. Under these beliefs the retailer would strictly prefer to price discriminate by charging $\theta_X q_L$ and $\theta_Y q_L$, and Condition (II) ensures that such deviations are unprofitable. For deviations to a price in the range $[c_H, \theta_X q_H]$, both firms have the same incentive to deviate from p^P, and so customers must rely on their prior beliefs. Under these beliefs p^P is the profit-maximizing price.

We conclude that if Condition (II) is satisfied, a pooling equilibrium exists in which the firm charges p^P irrespective of its type. We can also show that this is the only pooling price. In a pooling equilibrium, the price does not contain any information that customers can use to infer quality, and so in equilibrium customers rely on their prior beliefs. Prices higher than p^P cannot be equilibrium-pooling prices, as they would yield zero demand. For prices lower than p^P, both retailer types have the same incentive to deviate to p^P, and so customers retain their prior beliefs when observing p^P. Therefore, p^P is a profitable deviation for any equilibrium-pooling price below p^P.

Uniqueness
Because high-type customers will pay more when they know that quality is high ($\theta_X q_H > p^P$), Conditions (I) and (II) cannot both be satisfied. This implies that the pooling equilibrium cannot coexist with a separating equilibrium in which a high-quality retailer charges $\theta_X q_H$. It is also not possible for the pooling equilibrium to coexist with a separating equilibrium in which the retailer charges p^* when quality is high. If $p^* \geq p^P$, a retailer with a low-quality product will prefer to price discriminate rather than pool (Condition (II) fails), and if $p^* < p^P$ a retailer with a high-quality product will prefer to deviate from the separating equilibrium. We conclude that within the class of pure-strategy equilibria, all three equilibria are unique in their respective parameter regions.

Extensions and Applications
The three signaling equilibria share common features (Table 1). When quality is high, the retailer targets

Table 1   Summary of Equilibria

Equilibrium Type	Equilibrium Prices		Equilibrium Condition
	High Quality	Low Quality	
Full information	$\theta_X q_H$	$\theta_X q_L,\ \theta_Y q_L$	Full information
Separating	$\theta_X q_H$	$\theta_X q_L,\ \theta_Y q_L$	Condition (I)
Separating	p^*	$\theta_X q_L,\ \theta_Y q_L$	$p^* \geq p^P$
Pooling	p^P	p^P	Condition (II)

only customers who are sensitive to quality. Therefore, when customers observe the retailer price discriminating, they infer that quality is low. For this reason, a retailer who price discriminates can expect diminished demand from its quality-sensitive customers. To support existence and uniqueness we have made two important assumptions. First, to satisfy incentive compatibility we assumed that quality sensitivity covaried with an observable trait. Second, we assumed that a high-quality retailer sells to only high-type customers. In the next section we will show that incentive compatibility may be endogenous. In other applications the second assumption could also be satisfied endogenously.

From this transparent beginning the model can easily be extended to incorporate other market features. For example, competition could be introduced so that the customers' outside option is defined by a competitor's price rather than by the alternative of not purchasing at all, although the model would have to account for competitive responses. The model may also be applied to describe different price-discrimination mechanisms. Examples might include hi-low pricing, in which a retailer charging a high price sells to impatient high-type customers and then drops its price briefly to sell to more patient low-type customers. If this strategy is optimal only when quality is low, the model predicts that hi-low pricing will also result in an adverse-quality signal.

Alternatively, a retailer may price discriminate through brand extensions by introducing a second product to target more price-sensitive customers. Conventional wisdom in marketing advises against extending brand names of high-quality products to lower-quality products because of brand dilution

problems.[2] This model provides a rational-actor explanation for this wisdom. If customers believe brand extensions are not profitable for a high-quality retailer, introducing a brand extension could diminish quality perceptions for all products. For example, if Tiffany's introduced a new product line, customers might reasonably question the quality of all of its products. More generally, by introducing a second product in one category, the retailer also risks adversely influencing customers' quality perceptions for products in other categories and for service levels that are common to all products.

Installment billing offers another price-discrimination mechanism, and in the next section we explicitly extend the model to this application. The resulting prediction that installment-billing offers may adversely affect quality perceptions is then tested through a large-scale field test in a mail-order catalog.

3.   Installment Billing

Installment-billing offers are common among retailers selling high-priced items such as jewelry, furniture, and electronics. Customers are generally invited to pay in equal monthly installments spread out over up to 5 months through charges to a designated credit card.[3] The prevalence of retailers' installment-billing offers is somewhat surprising. Other firms that have invested in sophisticated credit approval and delinquency procedures are generally better placed than retailers to offer credit. We might expect these other firms to offer credit terms that are at least as favorable as those offered by retailers, yet installment-billing offers invoke neither a credit check nor a finance charge.[4] Interpreting installment billing as a price-discrimination device helps to resolve this apparent dilemma. Installment billing enables customers with tight budget constraints to loosen these con-

[2]We thank an anonymous reviewer for this application.
[3]By limiting the plan to five months retailers avoid regulations governing offers of consumer finance.
[4]Although it may be profitable to bundle product and credit offers, we would expect retailers to outsource the credit portion. Consistent with this argument, Crate and Barrel (and many other retailers) outsource their store charge card operations to Citibank.

straints and enjoy an implicit discount by reducing reliance on more costly forms of credit. In contrast, customers who face fewer budget constraints place less value on the provision of free credit. These customers, who are also less price sensitive, reject the installment-billing offer and do not receive the same implicit discount.

We extend the model presented in §2 to illustrate this application by introducing the possibility that payment can be delayed, and assuming that customers vary in their desire to do so. In particular, we assume that the customer segments discount payments between periods by δ_X and δ_Y, respectively, where $1 \geq \delta_X > \delta_Y$. For analytical convenience we assume that the retailer's discount rate (δ_R) is the same as the high-type customer's ($\delta_R = \delta_X$), but note that the findings do not depend on this assumption. We also relax the assumption that the retailer knows a priori which segment each customer is in. Instead, the retailer can price discriminate by offering an installment-billing scheme under which customers pay some proportion (β) of the purchase price immediately and the remainder in a subsequent period. In equilibrium, customers reveal their relative preference for quality when self-selecting from the menu of purchasing with or without installment billing.

To avoid the regulations governing consumer finance, the price that the retailer charges to customers who choose the installment-billing option cannot exceed the price charged to other customers. However, the firm's options under this model are directly analogous to the options under the previous model. An installment-billing offer, denoted by (p, β), is equivalent to charging different prices to the different segments. By varying the parameter β, the firm can vary the effective price paid by low-type customers independently of the price paid by high-type customers.

A surprising feature of installment-billing plans is that not all customers take advantage of them. For example, the manager of a bedding catalog revealed in discussions that on average only 22% of his customers take advantage of an installment-billing offer when it is available. Customers who choose not to use the plan forgo an interest-free loan, suggesting that there are either other costs associated with choosing

an installment-billing option, or that there is no perceived benefit of delaying payments of this magnitude. We could model the absence of perceived benefits by setting $\delta_X = 1$ (the results would not change substantively). Instead, we introduce an implicit cost of adopting the installment-billing offer, reflecting the inconvenience of tracking multiple payments or managing future liabilities. We denote this cost by F and, for simplicity, assume that it is the same for all customers (allowing this cost to vary between customer types would not contribute any additional insights). There is published evidence supporting this interpretation. Prelec and Loewenstein (1998) argue that the act of paying often undermines the pleasure derived from consumption, and offer the example of a clicking taxi meter reducing the pleasure of the ride. Contrary to the standard prediction that people will finance purchases to minimize the present value of payments, their model predicts that customers will prefer to prepay for consumption.

We continue to assume that the cost of a high-quality product exceeds what the low-type customers are willing to pay ($\theta_Y q_H < c_H$). However, this is now no longer sufficient to ensure that the retailer does not sell to low-type customers when quality is high. The difference between the discount factors of the low-type customers and the retailer introduces a theoretical opportunity for the retailer to generate surplus by lending money to the low-type customers. This technical possibility can yield very unusual outcomes, including the possibility that a high-quality retailer may still sell to low-type customers even when $\theta_Y q_H < c_H$. As we discussed, other firms are generally better placed than retailers to offer credit, and we do not believe that these types of outcomes reflect what occurs in practice. Therefore, we introduce an additional condition to rule out this outcome. If quality is high, the maximum discounted revenue that the retailer can earn from the low-type customers is $\delta_R(\theta_Y q_H - F)/\delta_Y$, which we assume is less than c_H.

Our interpretation of installment billing as a price-discrimination mechanism is best illustrated in the full information context. Under reasonable conditions there is a unique equilibrium. When quality is high, the retailer charges a price of $p = \theta_X q_H$ without offer-

ing installment billing, and only the high-type customers purchase. If quality is low, the retailer charges $\theta_X q_L$ and offers an installment-billing plan where β is given by

$$\theta_Y q_L = \beta^* \theta_X q_L + \delta_Y (1 - \beta^*) \theta_X q_L + F. \qquad (2)$$

Several conditions are required to ensure that this is a dominant strategy. First, we assume that there exists a $\beta^* \geq 0$ that satisfies Equation (2).[5] Second, we assume that the high-type customers prefer to purchase immediately, rather than adopt the installment-billing offer: $\delta_X \theta_X q_L + F > \theta_X q_L$. Recall that all customers incur a fixed cost when adopting installment billing, while high-type customers do not value delaying the payment as much as the low-type customers ($\delta_X > \delta_Y$). Third, we assume that a low-quality firm prefers to offer installment billing to low-type customers rather than not sell to them, $X(\theta_X q_L - c_L) \leq \pi^*$, or insist they pay immediately, $(X + Y)(\theta_Y q_L - c_L) \leq \pi^*$, where π^* is the retailer's profit under the ($\theta_X q_L, \beta^*$) offer. Fourth, to act as a bank and arbitrage the difference between δ_R and δ_Y, the firm could increase its price and offer to delay a greater proportion of the price until the second period. High-type customers would either purchase under the installment plan or not purchase at all. As we discussed, we do not believe that these types of outcomes reflect what occurs in practice. A sufficient condition to rule them out is $(X + Y)(p_Y - c_L) < \pi^*$, where p_Y is the maximum discounted revenue that the retailer can earn from the low-type customers, $\delta_R(\theta_Y q_L - F)/\delta_Y$.

All other deviations are ruled out by implication. For example, lowering the price and offering to delay a smaller proportion of the payment would reduce the profit earned from both customer segments, and so cannot be a profitable deviation. We conclude that given these conditions, the dominant strategy for a low-quality firm facing fully informed customers is to charge $\theta_X q_L$ and offer to delay $1 - \beta^*$ proportion of the payments until the next period. Although this analysis highlights the need for additional conditions to support our interpretation of installment billing as

a price-discrimination mechanism, it is straightforward to show that there exist parameter regions in which these conditions are all satisfied.[6] Extending the argument that price discrimination may yield an adverse-quality signal to this application does not require any additional assumptions.

Signaling

The signaling equilibria are substantively unchanged from the earlier model, although the equilibrium conditions need to be modified. The analog to Condition (I), which supports the first separating equilibrium, ensures that a low-quality retailer prefers to offer installment billing and charge $\theta_X q_L$ rather than charge $\theta_X q_H$ and not offer installment billing (mimicking a high-quality retailer):

Condition Ia

$$X(\theta_X q_L - c_L) + Ym \geq X(\theta_X q_H - c_L). \qquad (Ia)$$

In this expression $m = \theta_X q_L(\beta^* + \delta_R(1 - \beta^*)) - c_L$ is the equilibrium-separating profit that a low-quality retailer earns from a low-type customer who accepts the installment plan. When Condition (I) is not satisfied, we showed that an alternative separating equilibrium may exist in which a high-quality retailer lowers its price to a level that will not be mimicked. In the modified model this level, which we label p^*, is defined by

$$X(\theta_X q_L - c_L) + Ym = X(p^* - c_L). \qquad (3)$$

To prevent deviations, the equilibrium requires that $p^* \geq p^P$, where $p^P = \alpha\theta_X q_H + (1 - \alpha)\theta_X q_L$ is the maximum price that high-type customers will pay, given their prior beliefs (α). This condition remains unchanged in the modified model and ensures that neither firm type prefers to deviate to p^P. If $p^* < p^P$, a pooling equilibrium may exist in which both retailer types charge p^P without offering installment billing. This condition is supported by Condition (II), the analog of which ensures that a low-quality entrant prefers the pooling strategy rather than offering installment billing and charging $\theta_X q_L$:

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[5]Values of $\beta^* < 0$ imply a loan in the first period and a price paid in the second period that exceeds $\theta_X q_L$. To avoid lending regulations the retailer would have to reduce the purchase price below $\theta_X q_L$.

[6]For example, $F = 0.35$, $\theta_X = 2.2$, $\theta_Y = 1.7$, $q_H = 1.1$, $q_L = 1$, $\delta_X = \delta_R = 0.9$, $\delta_Y = 0.6$, $X = 2$, $Y = 2$, $c_H = 2.3$, $c_L = 1$, $\alpha = 0.5$. This example yields $\theta_X q_L = 2.42$ and $\beta^* = 0.03$.

Table 2   Summary of Equilibria

| | Prices and Installment Billing Offers in Equilibrium | | | |
| | High Quality | | Low Quality | |
Equilibrium Type	Price	β	Price	β
Full information	$\theta_X q_H$	No offer	$\theta_X q_L$	β^*
Separating	$\theta_X q_H$	No offer	$\theta_X q_L$	β^*
Separating	p^*	No offer	$\theta_X q_L$	β^*
Pooling	p^P	No offer	p^P	No offer

Condition IIa

$$X(p^P - c_L) \geq X(\theta_X q_L - c_L) + Ym. \qquad \text{(IIa)}$$

We summarize the three pure-strategy equilibria outcomes in Table 2. The equilibria are supported by customer beliefs that quality is low when the retailer offers an installment-billing plan. In the previous section we showed that the three pure-strategy signaling equilibria are all unique within their respective parameter regions. The same uniqueness feature also applies to the installment-billing model. Inspection of the new equilibrium conditions reveals that installment billing is more likely to be offered when the retailer has a lower cost of credit (δ_R is higher). Both increases in δ_R and decreases in δ_Y improve the net efficiency of installment billing by increasing the benefit of delaying payment for low-type customers relative to the cost to the retailer.

This is consistent with anecdotal evidence from the industry. In a review of installment-billing programs offered by different catalog retailers, Chevan (1995) observes that the adverse effect on cash flow limits installment-billing offers to companies with financial depth. ''All the companies offering or interested in [installment billing] have one thing in common— their sales, or those of their parent company, exceed $50 million'' (Chevan 1995, p. 7). Installment billing is also more likely when low types more heavily discount future payments (δ_Y is low). If future payments are more heavily discounted, the retailer can increase the proportion of the purchase price that low types pay immediately (β^* is larger), which reduces the implicit discount that the retailer must offer these customers to induce a purchase.

A further implication of the equilibrium conditions

is that we are less likely to observe a firm offering installment billing when the proportion of high-type customers in the market increases. A high-quality firm never offers installment billing, while a low-quality firm will find it less attractive to do so if there are relatively few low-type customers in the market. In terms of the equilibrium conditions, the conditions supporting the separating equilibria (Condition (Ia) and $p^* \geq p^P$) are both less likely to hold as X increases relative to Y, while the condition supporting the pooling equilibrium (Condition (IIa)) is more likely to hold.[7]

Testable Hypothesis

The three signaling equilibria share common features. A retailer who offers installment billing can expect diminished demand from its quality-sensitive customers. To sell to these customers, a firm offering installment billing must reduce its price to compensate for the adverse-quality signal. This leads to the following prediction:

HYPOTHESIS 1. *Offering installment billing while holding prices constant will reduce the number of orders received from quality-sensitive customers.*

The hypothesis holds irrespective of whether the firm offers high- or low-quality products. However, holding the prices constant is important. When offering installment billing, a catalog can continue to sell to quality-sensitive customers by lowering its price (from $\theta_X q_H$ to $\theta_X q_L$) to compensate for the adverse-quality signal. Therefore, Hypothesis 1 may not hold if an installment-billing offer is accompanied by a price reduction. By holding the prices constant we also ensure that any differences in response are attributable to the installment-billing offer. This prediction is quite counterintuitive. Because customers are not required to use the installment-billing plan, the option of using the plan might be expected to weakly dominate not having this option. The restriction to

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[7]For example, holding constant the values of the other parameters in Footnote 5, the separating equilibrium supported by Condition (Ia) holds when $X = 2$, the separating equilibrium supported by $p^* \geq p^P$ holds when $X = 10$, and the pooling equilibrium holds when $X = 20$.

quality-sensitive customers is also important. For low-type customers the adverse-quality signal is offset by the opportunity to delay payment, and so there is no clear prediction of how an installment-billing option will impact their demand when holding prices constant. The outcome for these customers depends on the extent to which they care about quality versus the opportunity to delay payment.

Field Test

We test Hypothesis 1 by investigating how the introduction of installment billing affects demand in a mail-order catalog that targets customers who purchase high-quality products. For confidentiality reasons we cannot identify the name of the catalog—we will call it Alison's. The catalog sells expensive gift and jewelry items and competes with such retailers as Tiffany's. Most of the products either carry the catalog's own brand or are unbranded, and so customers must infer quality from the photographs and descriptions of the products, together with their overall perceptions of the catalog. As we discuss later, field testing places some limits on the complexity of the experimental design. However, measuring the purchasing behavior of real customers offers greater external validity than laboratory experiments and overcomes the potential endogeneity issues that arise when using historical data.

Two versions of the catalog were created: a test version that contained an installment-billing offer, and a control version in which installment billing was not offered. The offer in the test version was introduced at the start of the catalog and explained in detail on the order form. The actual wording was the same as the offer described in the introduction to this paper. The offer was made (an icon appeared) on all items for which the purchase price exceeded $150. On these items, which included the majority of the items in the catalog, the price description included the installment-billing icon with an explicit calculation of the monthly payment, presented as ''Payments of $X.'' The control version of the catalog contained no reference to installment billing, either at the start of the catalog, on the order form, or on any of the products. When calling to place an order, the version of the catalog from which the customer was ordering was identified by a code printed on the back page of the catalog. The installment-billing option was available only to customers who received the test version. The catalogs and the ordering process were otherwise identical (their prices were equivalent).

Composition of the Sample

The two versions of the catalog were distributed to separate randomly chosen customer samples of different sizes, with 189,629 customers receiving the control version and 50,553 customers receiving the test version. The difference in these sample sizes reflects our prediction that demand would be lower for the test version. The customers had all purchased from the catalog within the previous 12 months, revealing their preference for premium-quality products. This sample was chosen under the guidance of the catalog merchants and management who agreed that it was dominated by customers who are sensitive to quality and relatively insensitive to price.

Recall that Hypothesis 1 holds only for quality-sensitive customers, and so the composition of the sample is important. If the sample does include some low-type customers this would bias against the hypothesis; Any support for Hypothesis 1 occurs despite, not because of, this possibility. It also means that it is not possible to make predictions regarding the *average* order size. Installment billing is likely to lead to a higher proportion of purchases from low-type customers. The change in average order size depends upon the difference in order size between the customer segments and the impact of the offer on the demand of low-type customers.

The focus on past customers will tend to result in more certainty about quality than if a sample of new or prospective customers was used. The model does not require that customers have no prior information about quality (their priors are specified by α), and it could be modified to include a segment of fully informed customers. In practice, we expect that most of the field-test customers had strong priors that quality is high, but some uncertainty remained. For most of the products, quality

Table 3   Test Results

	Control Version (No Installment Offer)	Test Version (Includes Installment Offer)
Standardized numbers		
Number of orders	100	87.0
Aggregate revenue	100	95.5
Raw numbers		
Response rate	4.15%	3.61%
Aggregate revenue (scaled)	$331,094	$316,126

Notes. The standardized numbers are standardized to 100 in the control version after controlling for the differences in the samples sizes. The response rate reflects the number of responses received as a percentage of customers mailed. The raw aggregate revenue in the control version is rescaled to reflect a sample size of 50,553 customers.

is difficult to evaluate prior to purchase, and in some cases, even postpurchase (e.g., the purity of the gold and the strength of the jewelers' welds). The possibility that there is no quality uncertainty makes the empirical test more conservative.

Results

We received aggregate data describing the number of orders received in each condition, as well as with total revenue. These data allow us to test the null hypothesis that offering installment billing does not affect the number of orders received. The data are summarized in Table 3, where we facilitate comparison by indexing aggregate demand in the control version to 100. We report demand in the test version as a percentage of demand in the control version after first multiplying by the (inverse) ratio of the sample sizes to adjust for the difference in sample size. We also report the response rate, representing the number of orders received as a percentage of books mailed and aggregate revenue in both conditions (aggregate revenue in the control version is rescaled to adjust for the larger sample size of that version).

The data are consistent with Hypothesis 1 and allow us to reject the null hypothesis that there was no effect. The installment-billing offer was associated with both a reduction in the number of orders

received and a reduction in aggregate revenue. Offering installment billing resulted in approximately $15,000 in lost revenue. The sample sizes are very large, and so the difference in the number of orders received between the test and control versions is statistically significant ($p < 0.01$). It is not possible to calculate significance tests for the aggregate revenue measure. However, the changes are economically significant, influencing the decision to include installment-billing offers in future catalogs (see later discussion).

A customer sample dominated by customers who are sensitive to quality translates in the model to a market with high values of X relative to Y. The model predicts that a high-quality firm will not offer installment billing in this context. Therefore, the split sample design of the test may also be interpreted as a comparison of equilibrium and deviating strategies, with the model predicting higher profits in the equilibrium (control) condition. Unfortunately, the catalog company would not provide details of the profits earned in each condition. However, under the assumption that gross profits increase monotonically with revenue, the aggregate revenue findings are also consistent with the model's predictions. The assumption that gross profits increase monotonically with revenue is consistent with our own analysis of the firm's price and cost data, which reveals the widespread use of constant percentage markups to set the retail price. We caution that even if this assumption is accurate, the findings do not allow us to claim that all deviating strategies are unprofitable.

We did not receive any detailed information about how many customers used the installment plan, although the company estimated that the participation rate was less than 50% among customers who ordered. The company was also unable to provide data describing demand for individual products or customers. Undertaking the programming required to report these data would have required additional programming prior to implementation, and the catalog managers were unwilling to undertake this task.

Quality Perceptions

The measures in Table 3 reflect only the short-term effect of the installment-billing offer. The offer may also erode subsequent demand. To investigate the long-term effects, the catalog agreed to survey their customers to measure how an offer of installment billing affects their customers' quality perceptions. A sample of customers who had purchased in the last 12 months was mailed one of the catalog versions, with a short survey. The two catalogs were very similar to the field-test catalogs, with a test version that contained an installment-billing offer and a control version in which installment billing was not offered. However, the catalog management made two changes to the test version in an effort to mitigate any adverse-quality signal. First, installment billing was only offered on items with a purchase price over $500. Second, installment-billing icons that had been used in the field test were omitted. Because the installment-billing offer was less obtrusive, we would expect differences in quality perceptions between these catalogs to be smaller than the differences for the field-test catalogs.

Respondents were asked to browse through the catalog and return their responses in a reply-paid envelope. A cover letter assured respondents that their decision to respond and their answers would be kept confidential. The response forms did not identify who the respondent was, although an unobtrusive code identified which of the catalog versions the respondent saw. The survey asked respondents to indicate the extent to which they agreed or disagreed with the following statements regarding the quality of the items in the catalog:

1. I would be concerned about product quality when buying from [Alison's].
2. I would buy more from [Alison's] if it had more premium-quality products.

Agreement with each statement was measured separately using a 7-point semantic differential scale anchored at 1 by *strongly disagree* and at 7 by *strongly agree.* A *don't know* option was also included. Pretesting confirmed that the questions were unambiguous. The survey and catalog stimuli were mailed to ap-

Table 4   Survey Results

	Control Version (No Installment Offer)	Test Version (Includes Installment Offer)
I would be concerned about product quality when buying from [Alison's].	2.2	2.8*
I would buy more from [Alison's] if it had more premium quality products.	2.5	2.8

Notes: Data in the table describe the average responses to each question on a 7-point agreement scale anchored by *strongly disagree* (1) and *strongly agree* (7).
*Average significantly different in the two conditions ($p < 0.05$).

proximately 400 randomly selected customers in each condition, although the catalog could not confirm that the same number of people received each version of the catalog. None of these customers participated (received catalogs) in the field test. A total of 97 responses were received from the test version and 68 from the control version. The results are summarized in Table 4.

The findings are consistent with the customer beliefs in the model: Offering installment billing lowers the perceived quality of the items in the catalog. Respondents in the test version were on average significantly ($p < 0.05$) more concerned about product quality when buying from Alison's than respondents in the control version. They also indicated that they would buy more from Alison's if it offered more premium-quality products, although this difference was not significant. The survey did not ask respondents to explain their answers. However, one respondent in the test version offered the following remarks: ''My reaction to this catalog is that people must be cutting back or not as rich as [Alison's] thought because suddenly everything is installment plan. It makes [Alison's] look tacky to have installment plans—kind of like Franklin Mint dolls.'' These survey findings and the results of the field test convinced the catalog not to include installment-billing offers in future catalogs.

4.   Conclusions

We have proposed a signaling explanation for why firms may forgo an opportunity to price discriminate.

To test this argument, we investigated how the introduction of installment billing affects demand in a mail-order catalog that targets customers who purchase premium-quality products. Installment-billing plans offer retailers the opportunity to discriminate between customers who face a high cost of capital and other customers who are less credit constrained and less price sensitive. We argued that introduction of installment billing may prompt an unfavorable inference that quality is low and reduce demand among quality-sensitive customers. The results are consistent with the prediction. Demand is lower when the option of installment billing is introduced, even though customers are at least weakly better off when given this option.

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