Managing Dissatisfaction

How to Decrease Customer Opportunism by Partial Refunds

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Previous research emphasizes the benefits of generous refunds as part of overall complaint management service policy, yet recent empirical evidence suggests that many retailers have concerns about abusive returns and hesitate to fully compensate dissatisfied customers. We present an analysis of three refund policies—no questions asked, no refunds, and verifiable problems only—and show that no questions asked is the most efficient way to handle consumer opportunism.

DISSATISFACTION AND REFUNDS

Many researchers and business consultants have emphasized the importance of defensive marketing in recent years. As opposed to offensive marketing, which is aimed at attracting new customers, defensive marketing is aimed at keeping existing customers satisfied and preventing them from defecting to competitors (Hauser and Shugan 1983; Schmidt and Kernan 1985; Westbrook 1981; Woodruff, Cadotte, and Jenkins 1983). To keep existing customers satisfied, companies have different policies and systems to handle complaints by dissatisfied customers. Manufacturers who sell durable goods typically offer product warranties for limited time periods that cover repairs of products in case of performance failure (Corville and Hausman 1979; Kendall and Russ 1975; Lutz 1989; Menezes and Currim 1992; Welling 1989; Padmanabhan and Rao 1993). Manufacturers of expensive, frequently purchased products and retailers of consumer goods have compensation polices in which they promise to give dissatisfied customers their money back (Davis, Gerstner, and Hagerty 1995; Mann and Wissink 1990; Moorthy and Srinivasan 1995). Some service companies offer compensation to customers who complain of service failure (Hart 1988). Examples of such compensation include free fruit baskets in hotels, discount coupons on future flights by airlines, and free appetizers or desserts by restaurants. An important issue facing managers in this arena is how generous they should be with their compensation or refund policies.

Hart (1988, 1993) also emphasizes the advantage of attracting customers with unconditional and generous satisfaction guarantee policies as part of providing extraordinary service. He points out that a construction sup-

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ply company had an annual sales growth of 7.5% at the time when housing starts were falling 9% by promising, "If we have to backorder even one stock item [of the 22,000 we stock] to complete your job, that item is FREE—GUARANTEED!" That is, the company offered to let the buyers keep the item and receive 100% of their money back to compensate for delays in shipment.

Retailers such as Nordstrom gained reputations for offering very generous satisfaction guarantee policies under which customers can return products for a full refund without any time limits. Embassy Suites and Hampton Inn promise refunds to dissatisfied guests for any reason, no questions asked. Hart (1988) reports that a Miami-based company called "Bugs" Burger Bug Killer promises to exterminate insect pests on the client's premises. If the company fails, it will refund the customer's last 12 monthly payments and will pay for 1 year's service by another exterminator of the customer's choice. The company charges up to 10 times more than its competitors but has a disproportionately high market share in its operating areas.

Fornell and Wernerfelt (1987, 1988) were the first to examine this issue theoretically. From their analysis, they recommend that companies have a generous refund policy as part of their complaint management policy because it will increase loyalty, generate positive word of mouth, and lead to greater long-term profits. They also recommend that in a competitive environment, companies should not only give generous refunds but also *encourage* customers to complain.

Although this recommendation of extremely generous refunds may be appealing from a theoretical point of view, we find that in practice, many sellers hesitate to provide generous refunds that compensate customers for all their costs involved in purchasing an unsatisfactory product or service. Consider the following situations in which only partial refunds are offered.

Restocking Fees

Prior to the 1998 Super Bowl between the Denver Broncos and the Green Bay (Wisconsin) Packers, Best Buy electronic stores in Denver and the entire state of Wisconsin cautioned customers that large-screen televisions purchased the week prior to the Super Bowl will be subject to a 15% "restocking fee" if they were returned (Pressey 1998).

Such restocking fees are routinely charged on returns by computer components stores (see Table 1). The data were collected from 20 mail-order computer dealers, drawn randomly from the October 1996 issue of *Computer Buying Guide and Handbook.* As can be seen, 60% of the dealers have restocking fees, which means that they are

TABLE 1
Restocking Fees and Partial Refunds

Restocking Fee (%)	*Partial Refund*[a] *(%)*	*Number of Companies*[b]
0	100	8
10	90	1
15	85	8
20	80	3
Mean = 9.5	Mean = 90.5	Total = 20

a. The partial refund percentage is actually lower because the retailers do not refund shipping and handling charges, as discussed.
b. The following companies were included in the survey: Anson, Arbor Computer, Astra Technology, Computer Palace, Dee One Systems, Elek-Tek, Envision One Systems, Envision, Insight Computers, Magic PC, Micro X Press, Micron Electronics, MMI Corporation, O.S. Computers, PC's Complete, Price Pointe, Renegade Systems, Technology Distribution, Top Data, US Computer, and Wonderex.

only providing partial refunds. These partial refunds do not take into account nonrefundable shipping and handling charges, as considered next.

Nonrefundable Shipping and Handling Charges

Many retailers do not refund shipping and handling charges (see Davis, Gerstner, and Hagerty 1995; Hess, Chu, and Gerstner 1996; Hess and Mayhew 1997). Therefore, the partial refunds for computers as a percentage of the total expenditure are actually smaller than those reported in Table 1. To see the impact of shipping and handling charges on partial refund, consider apparel catalogers. We requested a catalog from all mail-order clothing retailers identified in the October issue of *Consumer Reports* ("Mail-Order Shopping" 1994), and 27 responded. A total of 24 of the catalogs listed shipping and handling charges as a function of the order value, and the other 3 determined the shipping charge by weight.

Table 2 gives the percentages of companies that refund shipping and handling and the percentage of those refunding return costs (reshipping expenses). Roughly 90% of the apparel catalogers do not refund shipping and handling, 70% do not compensate for return costs, and more than two thirds of the sellers refund neither shipping and handling charges nor return costs. A true, full money-back policy in which all the consumer out-of-pocket costs are refunded constitutes only 7% of the sample (see upper left cell of Table 2).

Computers and clothing are examples of products that are often sold by mail order. We find that many mail-order sellers use a partial refund policy, implemented either in the form of nonrefundable shipping and handling charges or restocking fees. Unlike mail-order companies, tradi-

TABLE 2
Refund Policies of Apparel Mail-Order Sellers

	Is Shipping and Handling Charge Refunded?		
	Yes	*No*	*Row Sums*
Is Return Cost Refunded?			
Yes	2 (7)	6 (22)	8 (29)
No	1 (4)	18 (67)	19 (71)
Column sums	3 (11)	24 (89)	27 (100)

NOTE: Cell entries are the number of sellers. Numbers in parentheses are percentages.

TABLE 3
Cases of Abusive Returns

Products	*Abusive Returns*
Radar and video cameras	Bought for vacation trips
Evening wear	Bought for proms and class reunions
Patio furniture, air conditioners	Bought for the summer season
Laptop computers	Bought by students before finals
Hiking boots, camping equipment	Bought for a camping trip
Snow blowers	Bought for the winter season
Compact discs	Recorded and returned

tional stores do not charge nonrefundable shipping and handling fees and may be more vulnerable to abusive returns. Perhaps this is why their complaints about excessive returns are heard louder (Longo 1995; Neuborne 1996).

It seems that a crucial obstacle to liberal compensation policies is opportunistic behavior by consumers. This is acknowledged by Fornell and Wernerfelt, who wrote in the conclusion of their 1987 article, "A possible limitation of our model is that it does not consider the possibility of customer abuse (e.g., generous compensations could generate "false" complaints)." Although they claim that consumer abuse is probably not a serious problem, we will show that generous returns actually encourage an otherwise nonopportunistic consumer into acting opportunistically, because the rewards from opportunism are greater.

Recent empirical evidence also suggests that such abuse behavior is of great concern to retailers (Fenvessy 1992; Hess and Mayhew 1997; Longo 1995). The resulting losses to retailers have been estimated to be in the magnitude of $1 billion annually (Neuborne 1996). To stop consumers from borrowing products—sellers sometimes refer to using an item and then returning it for a refund as "boomerang buying"—retailers are seeking ways to crack down on excessive returns. Table 3 provides examples of abusive returns by consumers who buy products with the intention of using them for a limited time and then returning them for a refund (Longo 1995; Neuborne 1996).

This article investigates the impact of such abusive returns on a seller's optimal compensation policy. Our model builds on Fornell and Wernerfelt (1987) in the following ways. First, and most important, we explicitly consider the possibility of abusive returns (opportunistic behavior) by consumers as an endogenous part of the model. That is, consumers decide whether to become opportunistic depending on the incentives provided by the seller. Second, we assume that the consumer's claim of dissatisfaction is purely subjective and that a seller cannot verify whether the claim is justified or not. We find that even without competition, a seller may find it optimal to offer a no-questions-asked refund policy. Third, the refund offered may only be partial or extremely generous, depending on a few key parameters.

Intuitively, a generous refund raises consumers' willingness to pay for the product, but it also encourages consumers to become opportunistic. On the other hand, returns are more costly to consumers when complaining costs are high, and they are more costly to sellers when salvage values of returned products are low. The optimal refund must balance this tradeoff. We show that partial compensation policies are more likely to be offered under the following conditions: (a) The probability of dissatisfaction is low, (b) usage rate during product trial is high (that is, there is a serious threat of opportunistic behavior), (c) consumers' cost of complaining is low, and (d) seller's salvage value is low.

Before presenting the formal model of dissatisfaction management, it is useful to compare the type of opportunistic consumer behavior described in our model with the economic literature on warranties. It has been shown that warranties can provide insurance against the risk of product failure (Heal 1977), can be used as signals to consumers that a product is of high quality (Boulding and Kirmani 1993; Grossman 1981; Lutz 1989; Priest 1981), or can be used to screen heterogeneous customers and extract more surplus through price discrimination (Mann and Wissink 1989). The moral-hazard behavior on the part of consumers is that they may take advantage of such warranties by using the product intensively or without care during the warranty period (Cooper and Ross 1985).

The opportunistic behavior addressed in our model is more "threatening" because the seller does not require proof of product or service failure to compensate dissatisfied consumers. A dissatisfied consumer can claim compensation for any reason, no questions asked. For many products, such a refund policy is necessary because the cause of consumer satisfaction is subjective. For example, often the return of a clothing item is not due to a failure in the workmanship such as a tear in the garment but due to the fact that the consumer does not like it after taking it home. Another example is a person who is dissatisfied with a rental car company because the agent was unfriendly and did not explain the rental policy carefully. In these cases, in which satisfaction is in the eye of the beholder, it is easy for truly satisfied consumers to *claim* dissatisfaction just so that they can receive a refund. In the next section, we present a model that studies the characteristics of refund policies when such opportunistic behavior exists.

ELEMENTS OF THE MODEL

Consider a seller who offers a product or service at price P. The product may or may not satisfy a particular consumer. This uncertainty is modeled with a random variable. If satisfied with the product, the consumer derives a value v; if the consumer is dissatisfied, the consumer gets 0. Let d denote the probability of the consumer being dissatisfied. We assume that v is uniformly distributed within the consumer population from 0 to V, but the probability of being dissatisfied, d, is identical for all consumers and known by the seller. The market size is normalized to 1.

This article focuses on a policy that allows the product to be returned, no questions asked. That is, the judgment of whether the consumer is satisfied or not is purely subjective. Consumers may behave in an opportunistic fashion, in which they may claim dissatisfaction even when they are not dissatisfied to receive some form of reparation. If the consumer claims dissatisfaction, the seller offers the consumer a refund of rP, where r is the proportion of the price refunded (r could be any value greater than 0). The inequality $r \geq 1$ will imply a generous compensation, whereas $r < 1$ will imply a partial one (examples of partial refunds are the restocking fees and nonrefundable shipping and handling charges discussed above). Consumers also incur a cost of claiming dissatisfaction, C, that could capture the psychological cost of complaining, as well as the time, effort, and reshipping expenses in cases in which the product needs to be returned.

The salvage value of the returned product is represented as S. We assume that the seller has an advantage over the buyer in reselling or otherwise salvaging the returned merchandise. To make this act of salvaging economically efficient, we will assume that

$$S > C. \quad (1)$$

This condition is critical for many of the results that follow. If Condition 1 is violated then the retailer prefers that the customer costlessly dispose of the product rather than return it for a refund. The condition is reasonable for product categories in which the salvage value is large. For example, a preowned dress might fetch \$10 or more in a used market, but it may cost the customer only \$1 or \$2 in postage to return. In many cases, retailers can themselves return to manufacturers unsold or returned merchandise or they have outlet stores to resell them.

Condition 1 may be inappropriate for a restaurant meal, intimate apparel, or seasonal items that cannot be easily resold, so the model is not universally applicable. In between these extremes are services such as a room for a weekend at a hotel or a seat on an airplane, which may or may not have salvage value depending on occupancy. If a customer holds a reservation for a week at a sold-out hotel but leaves after a day, the room can sometimes be rented to travelers who make last-minute requests, salvaging part of the lost revenue.

To retain a customer-oriented model and avoid confounding the analysis with another motive for partial refunds, we assume that the seller incurs no costs of picking, packing, and shipping the product to the consumer. This is reasonable if the product is purchased during a store visit by the consumer but unrealistic if the seller is a direct marketer. In the concluding section, we will discuss how the findings would change in a more general model. The cost of handling returned merchandise is already incorporated in the salvage value. The manufacturing costs are irrelevant for the analysis and are assumed to be zero without loss of generality.

After ordering the product, a consumer tries it to discover if it matches his or her needs. A proportion, t, of the value is extracted during a trial period, giving the consumer a utility tv if the consumer is satisfied and 0 if the consumer is dissatisfied. The consumption value remaining after product trial is therefore $(1 - t)v$ for a satisfied consumer and 0 for a dissatisfied one. When $t = 0$, the period is too short for the consumer to gain any utility during the trial, and when $t = 1$, the consumer can obtain full utility from the product during the trial period. An example of a product with a low t might be a pay-per-view movie through cable television where the buyer is allowed to sample the first 5 minutes free of charge. On the other hand, a wedding gown will have a high t, because it is used for a once-in-a-lifetime occasion. The value of t is a consumer/product characteristic not a refund policy variable selected by the seller (like "60-day" refunds).

This completes the specification of the ingredients of the model. Mnemonic notation is given in Table 4. Consumers make decisions to maximize their surplus (the difference between expected value of using the product and all costs involved), whereas the optimal refund policy consists of the product's price and refund rate that maximize profit from all consumer segments, as explained next.

TABLE 4
Mathematical Notation

P	Price of the product
v	Satisfied customer's value of product (uniformly distributed on $[0, V]$)
d	Probability of the consumer being dissatisfied
C	Complaining costs of consumer
S	Salvage value of the returned product to seller
r	Proportion of the price refunded to dissatisfied customer
t	Proportion of the value the customer extracts during the trial period

OPTIMAL PRICE AND REFUND POLICIES

Dissatisfaction management will be analyzed by first exploring the outcome when the seller refuses to grant refunds ($r = 0$) to dissatisfied customers no matter what their reason for complaint. Once this simple no-refunds policy has been analyzed, we next address the less restrictive no-questions-asked refund policy, which is considerably more complex to understand because it induces consumer opportunism. Finally, a refund policy that is less restrictive than no refunds but more restrictive than no questions asked is a policy that makes refunds only when there is a verifiable problem with the product. In the context of our model, a verifiable problem is an observable mismatch between product and consumer. The verifiable-problem-only refund policy eliminates opportunism without frustrating truly dissatisfied customers. It will be analyzed last, because it is a slight variation of the no-questions-asked model.

No-Refund Policy

Consider the case in which the seller does not accept returns, $r = 0$. A typical customer would then expect a surplus of $d \cdot 0 + (1 - d)v - P$, because there is a probability d that the product is worthless, a probability $(1 - d)$ that the product is satisfactory (value v), and the price must be paid without hope of refund. Only customers who expect a positive surplus will place an order for the product; set surplus equal to 0 and solve for v, and this corresponds to those people whose value v exceeds $P/(1 - d)$. This cutoff exceeds the price because the customers, having bought caveat emptor, are taking a risk that the product will not satisfy their needs. Because v is distributed within the population uniformly from 0 to V, the number of orders placed when no refunds are possible is $O(P) = 1 - \frac{P}{(1-d)V}$ (see Figure 1).

Because there are no refunds, the seller keeps all the revenue from orders placed and has a profit of $\pi(P) = O(P)P$. Given the restriction that $r = 0$, the seller chooses the price to maximize profits; this price can be found by setting the derivative of profits equal to 0 and solving for P. The solution P_{NR} and resulting maximum profits are found in Table 5.

The optimal price, $(1 - d)V/2$, equals the expected value of product for the typical customer, because the mean of the uniform distribution from 0 to V equals $V/2$, and the probability of a satisfactory match to the customers needs is $1 - d$. Without refunds, precisely half of the customers order the product, and those who do expect a surplus of $(1 - d)v - (1 - d)V/2$. Total consumers' surplus, CS_{NR}, is the integral of these surpluses where v varies from $V/2$ to V. This outcome forms a benchmark that can be used to compare a less restrictive refund policy that permits merchandise returns no questions asked, as will be analyzed next.

FIGURE 1
Segmentation of Consumers

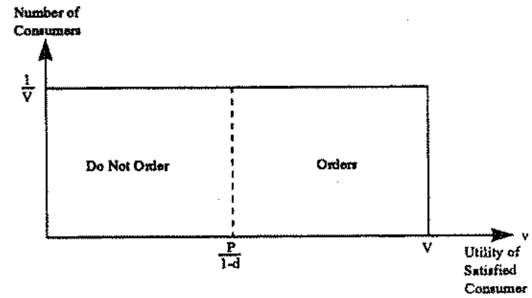


TABLE 5
Optimal Price for No-Refund Policy

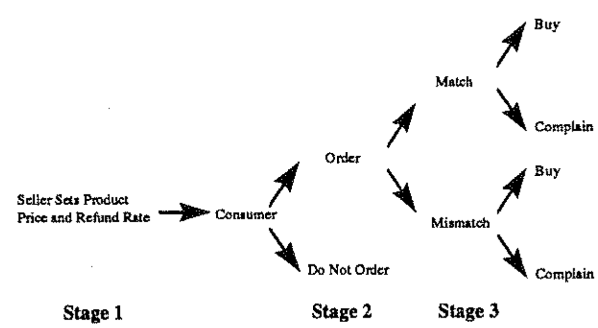
Variable	*Optimal Value*
Price, P_{NR}	$(1-d)\frac{V}{2}$
Orders, O_{NR}	$\frac{1}{2}$
Profit, π_{NR}	$\frac{1-d}{V}\left[\frac{V}{2}\right]^2$
Consumers' surplus, CS_{NR}	$(1-d)\frac{V}{8}$

NOTE: The subscript *NR* denotes *no refund.*

No-Questions-Asked Refund Policy

Unlike the no-refund policy, this case is more complicated because customers can return the products or not, creating a sequence of possible events (see Figure 2). First, the seller sets both purchase price and no-questions-asked refund rate taking into account predicted subsequent customer behavior. Second, consumers decide whether to order the product. Third, after receiving and inspecting the product, consumers decide whether to buy it (keep the product) or return it for a refund (claim dissatisfaction). We will first analyze the third stage of the game given that consumers have already ordered the product. Then, we will analyze the decision to order of the second stage given the price and refund rate. Finally, we will analyze the seller's decisions on profit maximizing price and refund rate of the first stage.

FIGURE 2
Sequence of Decisions



STAGE 3: BUYERS' DECISION TO CLAIM DISSATISFACTION

The seller faces two types of dissatisfaction claims: legitimate complaints (those coming from unfortunate consumers who are genuinely dissatisfied with a product because of a mismatch between the product and their needs) and opportunistic complaints (those coming from consumers who claim dissatisfaction even when they are satisfied).

Legitimate complaints. The product is of no value to the consumer because of a mismatch between the product and the consumers' needs. The gain from claiming dissatisfaction equals the refund, rP, less complaining costs, C. Therefore, a dissatisfied consumer will return the product if $rP > C$. We later show that this is satisfied for the optimal price.

Opportunistic complaints. When a match between the product and the consumers' needs occurs after product trial, the residual value is $(1 - t)v$. The gain from claiming dissatisfaction equals the refund, rP, less complaining cost, C. Therefore, a satisfied consumer will return the product if and only if $rP - C \geq (1 - t)v$ or

$$v \leq (rP - C)/(1 - t) \equiv v^{oo}, \quad (2)$$

where v^{oo} is the valuation of the customer who is indifferent between being opportunistic or not.

Because customers can return for any reason, the seller will not be able to directly distinguish legitimate and opportunistic complaints. Recall that t is a characteristic of consumers and should be interpreted as the time it takes for a consumer to actually diagnose that the product matches needs or not. Opportunistic consumers might want to continue using the product beyond this point if there is a good match, extracting more than tv units of satisfaction, before returning the product for a refund. However, this behavior would reveal their opportunism so we assume that all consumers return the product at time t. The seller will be able to control the size of the segments by understanding the consumers' behavior, as analyzed next.

STAGE 2: THE DECISION TO ORDER THE PRODUCT

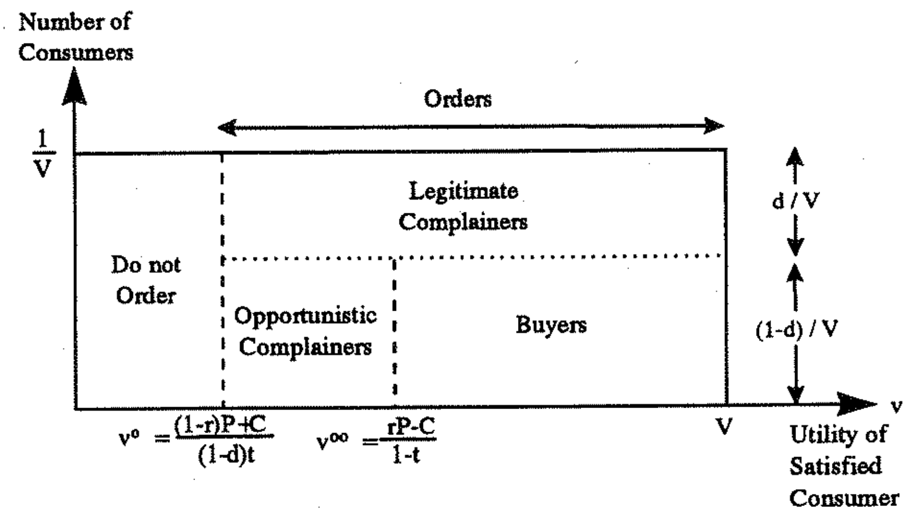
Now consider the consumer's ordering decision in Stage 2. The consumer makes the ordering decision based on expected surplus. Knowing their own valuation if satisfied, v, each consumer knows their own intention to claim dissatisfaction on purchasing the product. Let v^o denote the value of the boundary person who is just indifferent between ordering the product or not. All consumers with a v exceeding v^o will order the product (although some may later claim dissatisfaction and return it). We will examine the interesting case in which the boundary person complains opportunistically. The complement of this case in which the boundary person does not complain will lead to an equilibrium where there is no opportunistic behavior.

Let us identify the boundary opportunistic consumer who just barely benefits from ordering the product. The expected surplus of the boundary consumer, $EU[v^o]$, is obtained as follows. When satisfied, the boundary person gains a value of tv^o by using the product during trial but loses a portion of price, $(1 - r)P$, and complaining cost, C, when returning it to the seller. When dissatisfied, the boundary person also complains, incurring a cost of $(1 - r)P + C$ with no benefit. Therefore, the expected surplus of the boundary consumer is

$$EU[v^0] = (1 - d)[tv^0 - (1 - r)P - C] - d[(1 - r)P + C]. \quad (3)$$

Because the boundary person is the one indifferent between ordering or not, this customer will get 0 surplus. Setting $EU[v^o] = 0$ and solving for v^o, we get

FIGURE 3
Segmentation of Consumers



$$v^{\circ} = [(1 - r)P + C]/(1 - d)t. \quad (4)$$

From Equation 4, we can identify the demand for orders, and from Inequality 2, the number of opportunistic complaints as a function of the seller's price and refund rate.

Expected number of orders. A consumer will order the product if $v \geq v^{\circ}$. Given the uniform distribution of v, the number of products ordered, $O(P,r)$, is the area to the right of v° in Figure 3:

$$\text{Orders} = O(P,r) = 1 - \frac{(1-r)P + C}{(1-d)tV}. \quad (5)$$

The number of orders is a decreasing function of the amount that is not refunded to those who claim dissatisfaction, $(1 - r)P$, and the complaining cost, C.

Expected legitimate and opportunistic complainers. Two types of complaints occur in our model: legitimate complaints, those that occur when the consumer is dissatisfied, and opportunistic complaints, those that occur even when the consumer is satisfied. We first examine legitimate complaints. The expected number of legitimate complainers, $LC(P,r)$, is the probability of dissatisfaction, d, times the number of orders. Using Equation 5, we obtain,

$$\text{Legitimate Complaints} = LC(P,r) = \left[1 - \frac{(1-r)P + C}{(1-d)tV}\right]d. \quad (6)$$

We now examine opportunistic complaints. In this case, a consumer will complain if satisfied and Condition 2 above holds. The probability of being satisfied is $1 - d$, and the number of consumers who value the product enough to order ($v \geq v^{\circ}$) but not enough to keep it (Inequality 2) leads to the expected number of opportunistic complaints:

$$\text{Opportunistic Complaints} = OC(P,r) = (1-d)\left[\frac{rP - C}{1-t} - \frac{(1-r)P + C}{(1-d)t}\right]\frac{1}{V}. \quad (7)$$

Because total complaints equals legitimate and opportunistic complaints, we have the following equation for total complaints, $TC(P,r)$:

$$\text{Total Complaints} = TC(P,r) = LC(P,r) + OC(P,r) = 1 - \frac{(1-r)P + C}{(1-d)tV} - (1-d)\left(1 - \frac{rP - C}{(1-t)V}\right). \quad (8)$$

Expected number of buyers. The expected number of buyers equals number of orders less total complaints. Using Equations 5 and 8, we obtain

$$\text{Expected Buyers} = B(P,r) = O(P,r) - TC(P,r) = (1-d)\left(1 - \frac{rP - C}{(1-t)V}\right). \quad (9)$$

The expected demand of buyers is an inverse function of the refund amount, rP, and an increasing function of complaining costs, C. Notice that buyers decrease as $rP - C$ increases (it becomes more attractive to complain opportunistically) even though orders increase. This highlights the difference between someone who orders a product and someone who buys it (orders it and does not return it).

TABLE 6
Optimal Price and Refund Rate for No-Questions-Asked Policy

Variable	*Optimal Value*
Price, P^*	$(1-dt)V/2$
Refund rate, r^*	$\frac{(1-t)V+C+S}{(1-dt)V}$
Orders, O^*	$\frac{1}{2}+\frac{S-C}{2(1-d)tV}$
Buyers, B^*	$(1-d)\left[\frac{1}{2}-\frac{S-C}{2(1-t)V}\right]$
Total complaints, TC^*	$\frac{1}{2}\left[d+\frac{S-C}{V}\left(\frac{1}{(1-d)t}+\frac{1-d}{1-t}\right)\right]$
Opportunistic complaints, OC^*	$(S-C)\frac{1-dt}{2t(1-t)V}$
Opportunistic complaints per buyer, OC^*/B^*	$\frac{\frac{1-t}{t}\frac{1}{1-d}+1}{\frac{(1-t)V}{S-C}-1}$
Profit, π^*	$\frac{1-d}{V}\left\{(1-t)\left[\frac{V}{2}-\frac{S-C}{2(1-t)}\right]^2+t\left[\frac{V}{2}+\frac{S-C}{2(1-d)t}\right]^2\right\}$
Consumers' surplus, CS^*	$(1-d)\frac{V}{8}+d\frac{S-C}{4}+\frac{1-2dt+d^2t}{t(1-t)(1-d)}\frac{(S-C)^2}{8V}$

STAGE 1: SETTING PRICE AND REFUND RATE

At Stage 1 of the game, the seller chooses price and refund rate, P and r, to maximize expected profit. The expected profits can be expressed as expected profit from buyers plus expected profit from complainers. Expected profit from buyers is the number of buyers, $B(P,r)$, multiplied by the price P, and expected profit from complainers is total complaints, $TC(P,r)$, multiplied by $(1-r)P$ plus salvage value, S. Therefore, expected profit as a function of P and r is

$$\text{Expected Profit} = \pi(P,r) = B(P,r)P + TC(P,r)[(1-r)P + S] = \tag{10}$$
$$(1-d)\left[1-\frac{rP-C}{(1-t)V}\right](rP-S)+\left[1-\frac{(1-r)P+C}{(1-d)tV}\right]((1-r)P+S).$$

The seller optimizes the refund policy by choosing the price and refund rate to maximize the expected profit function (Equation 10). Straightforward calculus yields the optimal values (P^*, r^*) reported in Table 6 (note that $r^*P^* > C$ as required at Stage 3). The equilibrium values of orders, total returns, buyers, and profit were obtained by substituting (P^*, r^*) into Equations 5 through 10. To ensure that the solution is sensible (orders do not exceed the population, etc.), some limitations on the parameters are required; see Appendix A.

TABLE 7
Optimal Price and Refund Rate for Verifiable-Problem-Only Policy

Variable	*Optimal Value*
Expected non-refunded price, $\overline{P}^* = (1-dr)P$	$(1-d)V - d(S+C)/2$
Orders, $\overline{O}^*$	$\frac{1}{2}+\frac{d}{1-d}\frac{S-C}{2V}$
Profit, $\overline{\pi}^*$	$\frac{1-d}{V}\left[\frac{V}{2}+\frac{d}{1-d}\frac{S-C}{2}\right]^2$
Consumers' surplus, $\overline{CS}^*$	$(1-d)\frac{V}{8}+d\frac{S-C}{4}+\frac{d^2}{1-d}\frac{(S-C)^2}{8V}$

Only consumers who place an order expect to benefit from the transaction. For opportunists (value v is in the interval $[v^{o}, v^{oo}]$), the expected consumer surplus equals $(1-d)tv-(1-r^*)P^*-C$, whereas for nonopportunists (v is in the interval $[v^{oo}, V]$), the expected consumer surplus is $(1-d)v-(1-dr^*)P^*-dC$. Aggregating these across the population with density $1/V$ gives the total consumers' surplus, CS^*, reported in Table 6.

Intermediate between these restrictive and liberal policies is a refund policy that restricts refunds to only situations in which the product genuinely does not match the consumer's needs. This refund policy is analyzed next.

Verifiable-Problems-Only Refund Policy

Consider a situation in which there is no opportunism because the unsatisfactory match between product and consumer is directly observable. In this case, refunds are granted only to those consumers who are truly dissatisfied. This could correspond to product defects or observable mismatches between the product and the customer, such as wrong size, incompatibility with complementary goods, and so forth. In practice, it may be costly to verify such a mismatch, but to maintain comparability with the other refund policies, let us assume that opportunism is prevented at no cost.

A typical consumer has expected surplus

$$\begin{aligned} EU[v] &= (1-d)[v-P] - d[(1-r)P + C] \\ &= (1-d)v - (1-dr)P - dC. \end{aligned} \tag{11}$$

This depends on the expected non-refunded price,

$$\overline{P} \equiv (1-dr)P. \tag{12}$$

The seller's expected unit profit margin, $(1-dr)P + dS$, is also dependent on the expected nonrefunded price. As a result, any combination of r and P that produces the same value of $\overline{P}$ will be equally attractive to all parties concerned, reducing the dimensionality of the analysis from two variables to one. The details of the derivation are found in Appendix B, and the solution is given in Table 7.

We are now ready to compare the three most common refund policies that managers might choose: no refunds, verifiable problems only, and no questions asked. These progressively less restrictive refund policies will be contrasted next.

COMPARISON OF REFUND POLICIES

A manager seeking the highest level of service commitment might consider an unconditional return policy that allows customers to decide for themselves whether to receive a refund. This no-questions-asked refund strategy, however, invites customers to opportunistically order the product for trial use when they have no intention of keeping it. The manager must therefore consider the costs and benefits of extraordinary service by contrasting this refund policy with more conservative strategies, such as accepting no returns or paying refunds only when there is an observable defect in the product. Naturally, the comparison requires that all other aspects of the marketing program be chosen optimally given the refund policy. The above models allow us to make such a comparison.

In making the comparisons, the reader should keep in mind Condition 1, which says that the salvage value of the returned merchandise exceeds the buyer's costs of return. This implies that the seller wants the merchandise returned rather than disposed of by the consumer.

No Questions Asked Versus No Refunds

A refund policy is efficient if it generates higher profits without reducing the consumer surplus. Efficiency can be established by contrasting Tables 5 and 6.

> *Result 1:* A no-questions-asked refund policy is a more efficient way to handle consumer opportunism than a no-refund policy if the salvage value of the product exceeds the cost of complaining.

Intuition. With no refunds, the seller eliminates opportunism but at the cost of prohibiting truly dissatisfied customers from returning it for a refund. This has a price implication. If the seller refuses to grant refunds, the optimal price must be lower to partially compensate the customers for the risk they are taking when they buy a product with uncertain benefits. That is, straightforward algebra verifies that $P_{NR} < P^*$. If the price was not reduced when refunds are not given, too many customers would drop out of the market.

The no-refund policy reduces service costs because the seller does not have to return money to customers who complain, but the net impact on profits is negative, $\pi_{NR} < \pi^*$ if $S > C$. This is because a seller who guarantees satisfaction to potential customers can charge a higher price for all customers, even those who find the product perfectly acceptable and do not ask for a refund. The fact that the returned merchandise can be salvaged for S means that the high-quality service strategy is not as costly as it appears. The parameter S captures the net salvage value, incorporating any costs of labor to handle the returned merchandise. Even if these handling costs are significant, as long as the net value of the returned merchandise exceeds the customer's cost of making a complaint (which includes reshipping costs as mentioned above), the firm is better off accepting some customer opportunism than leaving customers dissatisfied.

Finally, although the customers are partially compensated by the reduced price for no refunds, the total consumers' surplus is reduced, $CS_{NR} < CS^*$, and fewer customers place orders for the product, $O_{NR} < O^*$. In fact, it is possible to show that every customer is worse off when refunds are not offered, not just for the average consumer.

No-Questions-Asked Versus Verifiable-Problems-Only Refunds

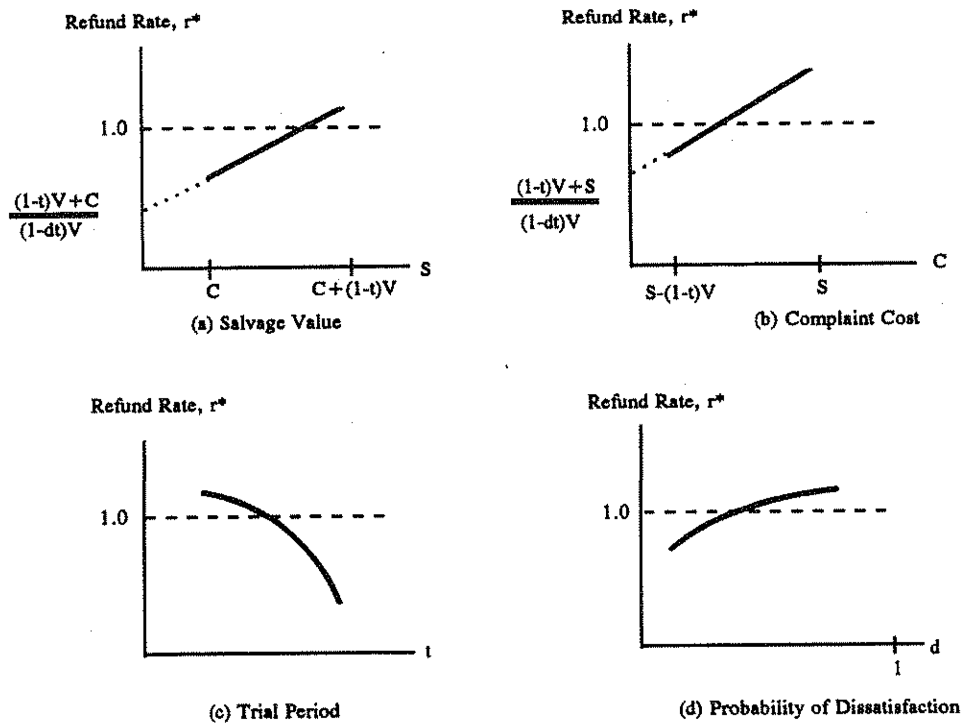
Opportunism can be eliminated with a lighter touch than no refunds by requiring that the customers demonstrate that the product does not match their needs. We call this the verifiable-problems-only refund policy. This policy, too, is less efficient than no questions asked in the sense that it produces lower profits for the seller while not increasing the consumer surplus, as can be established by comparing Tables 6 and 7.

> *Result 2:* A no-questions-asked refund policy is a more efficient way to handle consumer opportunism than a verifiable-problems-only refund policy if the salvage value of the product exceeds the cost of complaining.

Intuition. Surprisingly, eliminating opportunism reduces the seller's profits (see Appendix C). This seems illogical at first blush. Preventing a customer from acting opportunistically increases the seller's expected revenue by $(1 - d)(r^*P^* - S)$ because there are fewer abusive returns. Why do profits fall? Eliminating abusive returns forces some opportunistic customers out of the market, each of whom contributed $(1 - r^*)P^* + S$ to profit. This second effect on profits dominates the first.

Comparing the consumers' surplus with the two refund policies (from Tables 6 and 7), it is not surprising to see that total consumers' surplus is reduced when opportunism is eliminated with a verifiable-defects-only policy. Recall that the optimal seller behavior when switching from

FIGURE 4
Analysis of Optimal Refund Rate



no questions asked to verifiable problems only is to leave the price and refund rate unchanged, yet the consumers' option to act opportunistically has been removed. This forces some customers (whose valuations are below $\bar{v}^*$ but above $v^{o} = \frac{V}{2} - \frac{S-C}{2(1-d)t})$ out of the market. The customers who stay in the market but cannot act opportunistically (whose valuations are above $\bar{v}^*$ but below $v^{oo} = \frac{V}{2} + \frac{S-C}{2(1-t)})$ see a drop in their surplus because they cannot send the product back for a refund after trial use. Legitimate consumers' (valuations above v^{oo}) surpluses are unchanged.

Summary of Comparisons

Offering to refund price (perhaps partially) to a customer, no questions asked, and granting the consumer complete freedom to choose when to complain is a surprisingly desirable service policy. It is both profitable and socially efficient compared to dealing with abusive returns by either refusing to refund at all or by refunding only when there is a verifiable problem. Accepting no returns is heavy handed and results in such a dramatic drop in initial sales that it is not surprising that a lighter touch is better. Even if verifying problems is costless, so long as the salvage value of the product exceeds the cost of returning the product, a no-questions-asked refund policy not only makes more profits for the seller, but it generates more consumer surplus. The problem of consumer opportunism is better controlled by a partial refund rate than by verification of product problems. Furthermore, contrary to our assumption, such verification is costly and, therefore, the use of partial refunds with a no-questions-asked policy is even more attractive.

Given the desirability of an unrestricted, no-questions-asked refund policy, it is useful to ask, "How does the optimal no-questions-asked refund depend on the parameters of the marketing environment?" This question will now be addressed.

FACTORS AFFECTING OPTIMAL REFUND RATE

Examination of the optimal refund rate with no questions asked in Table 6 allows us to study how the optimal refund rate is affected by the salvage value of the product, the consumer's cost of complaining, the amount of product usage during the trial period, and the probability of dissatisfaction (see Figure 4). The following results can be obtained by differentiating the optimal refund rate with respect to the relevant parameters (proofs are in Appendix D, but intuition is given below each result).

Result 3: The refund rate will be higher when the salvage value is higher, as in Figure 4(a).

Intuition. A higher salvage value makes product returns less damaging so the seller will have a greater incentive to provide a higher refund rate, thereby increasing the compensation rate offered at the time of initial purchase.

Result 4: The refund rate will be higher when the cost of complaining is higher, as in Figure 4(b).

Intuition. When the cost of complaining is higher, returning a product is more costly, and, therefore, the return policy is less attractive to consumers. This would result in a decrease in orders. To counteract this effect, the seller provides a more generous compensation rate.

Result 5: The refund rate will be lower when the usage rate during the trial period is higher, as in Figure 4(c).

Intuition. When the usage rate during trial is high, there is a strong temptation for the consumers to be opportunistic. To counteract this, the seller must offer a lower rate of refund, or else there will be excessive complaints, most of which are not legitimate. This situation is consistent with Fornell and Wernerfelt (1987), who espouse a generous return policy when opportunistic behavior is small, but they also do not consider trial use as a source of opportunism.

Result 6: When the probability of dissatisfaction is higher, the refund rate is higher, as in Figure 4(d).

Intuition. When the probability of dissatisfaction is large, there will be a higher proportion of legitimate complainers (there is relatively less opportunism). Thus, a seller would want to encourage complaints to stimulate orders by providing a generous refund. This result is in contrast to Fornell and Wernerfelt (1987, 1988), who espouse a high refund rate when probability of dissatisfaction is low. It might be argued that for services, there is greater variability in "quality" as measured by probability of dissatisfaction than for goods. If this is the case, the model predicts greater refund rates for services than for goods.

Notice from Table 6 that if the probability of dissatisfaction, d, increases the optimal price decreases. This is surprising, given Result 6. It might appear intuitive that if the retailer is giving better service in the form of a more generous refund, it could be exploited by raising price. However, a more generous refund reduces the seller's incentive to raise the price because higher prices encourage opportunistic returns.

FIGURE 5
Generous Versus Partial Refunds

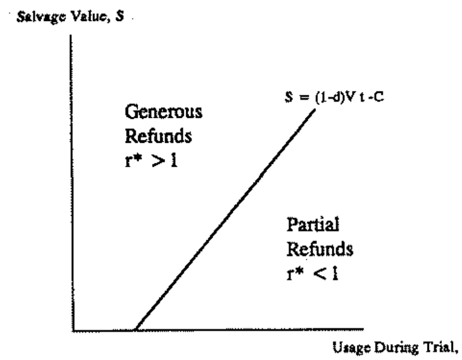


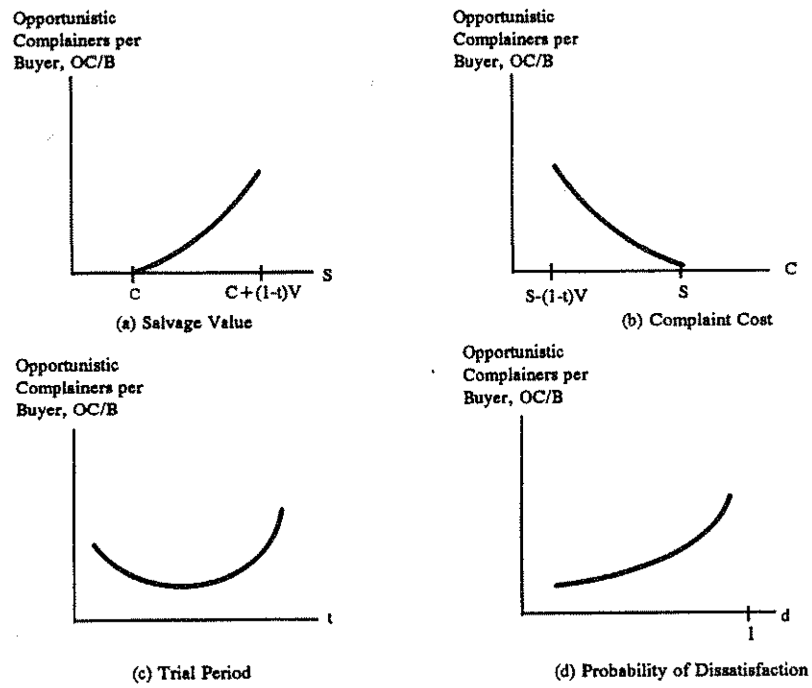
Figure 4 indicates that for some parameter values, the optimal refund rate is very generous (greater than 100% of the price is returned when a complaint is registered), whereas for many other situations the refund is a partial refund. In Figure 5, we focus on the usage rate during trial, t, and the salvage value of the product when it is returned to the seller, S. Setting the formula for r^* in Table 6 equal to 1 and solving for S in terms of t gives a combination of parameters that divides the world into situations in which refunds are generous (above the line) and situations in which refunds are partial. Naturally, the larger the amount is that the seller can salvage from returned merchandise, the more generous the seller can be in refunding dissatisfied (or opportunistic) customers.

The empirical evidence presented earlier indicates that partial refunds are more common than generous refunds, at least for computers and apparel. The rationale here is that opportunistic consumers must be controlled or profits will be diminished by illegitimate complaints. Heal (1977) provides another explanation for partial refunds by arguing that this is a risk-sharing arrangement between buyers and sellers that are both risk averse.

FACTORS AFFECTING OPPORTUNISTIC COMPLAINTS

Sellers are not only interested in the optimal refund rate for a no-questions-asked policy but also in the prevalence of opportunism for their product. In particular, sellers

FIGURE 6
Analysis of Opportunistic Complaints per Buyer, *OC/B*



would like to control the proportion of orders that are eventually returned and the percentage of returns that are opportunistic. To examine this, we conduct an analysis of the number of opportunistic complaints for every buyer as a function of the product's salvage value, the consumer's cost of complaining, the amount of use during product trial, and the probability of dissatisfaction. The following results are obtained by differentiating the optimal ratio of opportunistic complaints to expected number of buyers (*OC/B* from Table 6) with respect to the relevant parameters (see Figure 6).

Result 7: Opportunistic complaints per buyer will be higher when the salvage value is higher, as in Figure 6(a).

Intuition. When salvage value is higher, the seller provides a more generous refund, and this encourages would-be buyers to become opportunistic complainers.

Result 8: Opportunistic complaints per buyer will be lower when the cost of complaining is higher, as in Figure 6(b).

Intuition. From Figure 3, we see that the direct effect of an increase in complaining cost is to lower the number of complaints, including opportunistic complaints. The indirect effect of a higher cost of complaining is that it will lead to a higher equilibrium refund rate (see Figure 4[b]), which would increase complaints. Our results show that the direct effect dominates the indirect effect. Therefore, in equilibrium, an increase in the cost of complaining decreases opportunistic complaints per buyer.

Result 9: Opportunistic complaints per buyer will be first lower then higher as the usage rate during the trial period increases, as in Figure 6(c).

Intuition. The effect of usage rate during the trial period on opportunistic complaints per buyer is indeterminate. When the usage rate during the trial period is higher, opportunistic complaints increase because more would-be buyers become opportunistic complainers. On the other hand, this tendency to become opportunistic may be counteracted by a decrease in the refund rate (see Figure 4[c]). Therefore, as usage rate during trial increases, opportunistic complaining behavior per buyer first falls and then rises.

Result 10: Opportunistic complaints per buyer will be higher when the probability of dissatisfaction is higher, as in Figure 6(d).

Intuition. When the probability of dissatisfaction is high, the optimal refund rate will be higher (see Figure 4[d]). This encourages would-be buyers to become opportunistic complainers.

CONCLUSION

Theoretical research in marketing emphasizes the benefits of generous and unrestricted refunds as part of overall complaint management policy, but retailers have concerns that this policy encourages excessive returns by opportunistic consumers who use products for a limited time and then easily return them for a full refund. Generous and unrestricted refunds can also encourage otherwise truthful consumers to act opportunistically because the rewards from opportunism are greater. Cases of opportunistic behavior are observed in such diverse products as evening dresses, laptop computers, video camcorders, and camping equipment.

The empirical evidence presented above suggests that even though many retailers claim to offer generous refunds in the form of 100% money-back guarantees, many offer only partial refunds. The partial refunds come in the form of restocking fees and nonrefundable shipping and handling fees (often above and beyond the actual cost of shipping and handling).

These findings are consistent with the theoretical thrust of this article. A no-questions-asked refund policy dominates either a policy of no refunds or verifiable problems only. Under these more restrictive policies, too many customers risk dissatisfaction, and as a result, orders will drop. When there is considerable consumer opportunism, a partial refund is preferable. Extraordinary refunds that exceed the price will be offered only when the complaining costs of consumers are high, the usage rate during the trial period is low, the probability of dissatisfaction is high, and the salvage value of the product is high. This turns out to be more costly than paying partial refunds to a few unscrupulous customers.

Aside from the salvage value advantage of the seller, the other factors that influence the optimal refund rate relate to consumer opportunism. Higher complaining cost will lower opportunistic complaining behavior because the net benefit from opportunism is now lower. If the usage rate during trial (utility gained during the trial period) is low, the net benefit from using the product and then returning it opportunistically will be lower. Also, when the probability of actual dissatisfaction (as opposed to "claimed dissatisfaction") is high, more complaints are likely to be legitimate, which implies that there is lower danger of opportunism. In these instances, we replicate Fornell and Wernerfelt's (1987, 1988) recommendation to have a generous unrestricted refund. However, when the opposite is true, we show that a partial refund is optimal because it mitigates the problem of opportunistic abusive returns.

Consider some of the model's assumptions and limitations. We assumed that production unit cost and shipping and handling costs are zero and that consumers' willingness to pay for the product is uniformly distributed across consumers. We believe that relaxing these assumptions will not change the nature of our results for many retail scenarios. Production costs and shipping and handling costs in our model can increase the optimal price and decrease the optimal refund rate, but the seller's decision of whether to offer money-back guarantees depends on the size of the salvage value relative to the reshipping costs and not on unit costs. Also, as shown by Fornell and Wernerfelt (1987, 1988), the extension of our model to a duopoly model, although more complicated, is not likely to change our results qualitatively. However, one departure in a duopoly model could be that one seller may offer a generous refund, whereas another seller may not offer any refunds at all (a form of maximum differentiation), if consumers are heterogeneous with regard to their prior probability of being dissatisfied (Fruchter and Gerstner, 1998).

It is interesting to observe that although both restocking fees and shipping and handling fees are forms of partial refunds, restocking fees are much less common. One explanation is that shipping charges are a more subtle way to reduce the refund rate than the more transparent restocking fees. Consumers may think that shipping charges are designed to cover legitimate shipping and handling costs, whereas actual restocking fees are a penalty that is levied for returning the merchandise.

Finally, the empirical evidence presented above does not provide a formal test of the theory. To do so would require a variety of values of the model's parameters and resulting refund rates. Additional empirical research is called for with data from many product categories.

APPENDIX A

For the solution in Table 6 to be an interior solution, we need some parameter restrictions. It would also be reasonable if the parameters permit a reasonable variety of solutions; for example, we would not want to limit parameter values only to those that lead to generous refunds. We have already assumed that $S > C$, $0 < d < 1$, and $0 < t < 1$, for example. Generally speaking, if we have V sufficiently large, d bounded away from 1, and t bounded away from both 0 and 1, we are assured of an interior solution. We believe that the parameter restrictions are not limiting for our model. First, V sufficiently large is needed so that the seller can potentially get more from selling the product than salvaging the product directly. Second, it is reasonable to assume that most products do not have a dissatisfaction rate approaching 1. Also, because we assume some danger of consumer moral hazard in our model, we have t bounded away from 0. If this was not true, we would be back to the zero moral hazard model of Fornell and Wernerfelt (1988). Last, it is reasonable to assume that the majority of products do not have a t approaching 1.

More specifically,

(a) For $P^* > S$, we need $V > 2S/(1 - dt)$;
(b) for it to be possible that r^* is either greater than or less than 1, we need $V > (C + S)/t$, $V > (C + S)/(1 - d)$, and $C + S > 0$. If the first inequality is not true, then no matter what value d takes on, it can never be that $r^* < 1$. Similarly, if the second inequality is not true, then no matter what value t takes on, $r^* < 1$. Finally, if the third inequality is not true, then no matter what values d or t take on, it can never be that $r^* > 1$.
(c) for 0 < Orders < 1, we need $V > (S - C)/[(1 - d)t]$;
(d) for 0 < Buyers < 1, we need $V > (S - C)/(1 - t)$;
(e) for Opportunistic Complaints < 1, we need $V > (1 - dt)(S - C)/[2t(1 - t)]$; and
(f) for Total Complaints < 1, we need $V > \dfrac{(1-2dt+d^2t)(S-C)}{t(1-d)(2-d)(1-t)}$.

These parameters restrictions can be simplified as

$$V > \max\left\{\frac{2S}{1-dt}, \frac{S+C}{t}, \frac{S+C}{1-d}, \frac{S-C}{(1-d)t}, \frac{S-C}{1-t}, \frac{(1-2dt+d^2t)(S-C)}{t(1-d)(2-d)(1-t)}, \frac{(1-dt)(S-C)}{2t(1-t)}\right\}.$$

APPENDIX B

To solve for the optimal verifiable-problems-only policy, begin by setting Equation 11 equal to zero to find the boundary consumer who will just barely benefit from the product has valuation, $\bar{v}$, where

$$\bar{v} = \frac{(1-dr)P + dC}{1-d}. \quad \text{(B1)}$$

The number of consumers whose valuation exceeds this level equals

$$\text{Orders} = O(P, r) = 1 - \frac{(1-dr)P + dC}{(1-d)V}. \quad \text{(B2)}$$

The expected unit profit margin, $(1 - dr)P + dS$, is the sum of the expected nonrefunded price and the expected salvage value. This implies that the seller's profit,

$$\pi = \left(1 - \frac{(1-dr)P + dC}{(1-d)V}\right)[(1-dr)P + dS] = \left(1 - \frac{\bar{P} + dC}{(1-d)V}\right)[\bar{P} + dS], \quad \text{(B3)}$$

depends on price and refund rate only through $\bar{P}$, as defined in Equation 12. Inspecting Equations 11 and B3, it is evident that any combination of r and P that produces the same value of $\bar{P}$ will be equally attractive to all parties concerned.

The optimal value of expected nonrefunded price, $\bar{P}^*$, is found by maximizing profit B3 with respect to $\bar{P}$ and equals

$$\bar{P}^* = [(1 - d)V - d(S + C)]/2. \quad \text{(B4)}$$

It is easy to check that substituting price and refund rate with no questions asked (r^* and P^* from Table 6) into $(1 - dr^*)P^*$ produces a value that equals the expected nonrefunded price, $\bar{P}^*$, with verifiable-problems-only refunds found in Table 7. That is, if opportunism is eliminated, it is optimal to leave the price and refund rate unchanged (there are other optimal choices besides this).

The corresponding maximized profit when no opportunism occurs is

$$\bar{\pi}^* = \frac{1-d}{V}\left[\frac{V}{2} + \frac{d}{1-d}\frac{S-C}{2}\right]^2. \quad \text{(B5)}$$

Substituting into Equation B1, the customers who order the product have valuations that exceed

$$\bar{v}^* = \frac{V}{2} - \frac{d}{1-d}\frac{S-C}{2}. \quad \text{(B6)}$$

The total consumers' surplus is the aggregate of expected surplus (Equation 11) over all v in the interval $[\bar{v}^*, V]$ with density $1/V$:

$$\overline{CS}^* = (1-d)\frac{V}{8} + d\frac{S-C}{4} + \frac{d^2}{1-d}\frac{(S-C)^2}{8V}. \quad \text{(B7)}$$

All these results are recorded in Table 7.

APPENDIX C

The objective of this appendix is to show that profits are higher with no-questions-asked refunds than for verifiable-problems-only refunds. The maximum profits for no questions asked is found in Table 6 and reproduced here:

$$\pi^* = \frac{1-d}{V}\left\{(1-t)\left[\frac{V}{2} - \frac{S-C}{2(1-t)}\right]^2 + t\left[\frac{V}{2} + \frac{S-C}{2(1-t)t}\right]^2\right\}. \quad \text{(C1)}$$

The maximum profits for verifiable problems only is found in Table 7 and reproduced here:

$$\bar{\pi}^* = \frac{1-d}{V}\left[\frac{V}{2}+\frac{d}{1-d}\frac{S-C}{2}\right]^2. \qquad \text{(C2)}$$

Letting $x_1 = \frac{V}{2} - \frac{S-C}{2(1-t)}$ and $x_2 = \frac{V}{2} + \frac{S-C}{2(1-t)t}$, we see $\pi^* = [(1-d)/V][(1-t)x_1^2 + tx_2^2]$ and $\bar{\pi}^* = [(1-d)/V]\,[(1-t)x_1 + tx_2]^2$. Because "square" is a convex function, it is obvious that $\pi^* > \bar{\pi}^*$.

APPENDIX D

Proof of Result 3.

By direct observation of r^* in Table 6, we can see that r^* is increasing in S.

Proof of Result 4.

By direct observation of r^* in Table 6, we can see that r^* is increasing in C.

Proof of Result 5.

Suppose the result is not true. From Table 6, we can calculate the derivative $\frac{dr^*}{dt} = -\frac{(1-d)V-(S+C)d}{(1-dt)^2 V}$, which should be positive for some t, if $(1-d)V < d(S+C)$. Because $d < 1$, $(1-d)V < S+C$. But this contradicts the parameter restriction (b) of Appendix A, so the supposition is false: the result is true.

Proof of Result 6.

$$\frac{dr^*}{dd} = \frac{[(1-t)V+S+C]t}{(1-dt)^2 V} > 0.$$

Proof of Result 7.

$$\frac{d(OC/B)}{dS} = \frac{(1-t)(1-dt)V}{t(1-d)[(1-t)V-(S-C)]^2} > 0.$$

Proof of Result 8.

$$\frac{d(OC/B)}{dC} = -\frac{(1-t)(1-dt)V}{t(1-d)[(1-t)V-(S-C)]^2} < 0.$$

Proof of Result 9.

$$\frac{d(OC/B)}{dt} = -\frac{(S-C)[(1-2t+dt^2)V-(S-C)]}{t^2(1-d)[(1-t)V-(S-C)]^2}.$$

Letting $x = (1-2t+dt^2)V-(S-C)$, we have

$$x > 0 \text{ when } 0 < t < \frac{1}{d}\left[1-\sqrt{\frac{(1-d)V+d(S-C)}{V}}\right] \text{ and}$$

$$x \le 0 \text{ when } \frac{1}{d}\left[1-\sqrt{\frac{(1-d)V+d(S-C)}{V}}\right] \le t < 1.$$

Proof of Result 10.

$$\frac{d(OC/B)}{dd} = \frac{(1-t)(S-C)}{t(1-d)^2[(1-t)V-(S-C)]} > 0.$$

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