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Service Escape: Profiting from Customer Cancellations

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This paper explores the benefits of letting customers escape from prepurchased service contracts by offering refunds for cancellations. We show that such a policy creates opportunities for *multiple selling* in a capacity-constrained service—i.e., collecting cancellation fees from advance buyers who cancel, and then reselling the freed slots. The better the alternative that motivates a cancellation, the more profitable is a refund-for-cancellations policy compared with a no-refund policy that "locks in" customers. In contrast to previous research on money-back guarantees for durable goods, we show that offering refunds for service cancellations can be profitable (1) without charging a higher price compared with a no-refund policy, and (2) even when advance buyers would be willing to abandon the service for no refund. Also, service providers should decrease rather than increase the customer hassle cost of cancellations. Our research also suggests a new profit advantage of advance selling, i.e., capturing some of the consumer-added surplus created when customers find new alternatives (and are therefore willing to pay a fee to terminate the prepurchased contract). Finally, yield-management research typically assumes exogenous "no shows" by advance buyers. We suggest that offering refunds for cancellation reduces the need to reserve capacity for high-paying customers and improves capacity utilization.

Key words: cancellations; refund; pricing; yield management; advance selling; service marketing; capacity constraints; money-back guarantees
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1. Introduction

Many service providers, such as airlines, hotels, tour organizers, performing arts organizations, and educational institutions, sell their services well before their delivery date (Dana 1998, Xie and Shugan 2001, Moe and Fader 2002, Shugan and Xie 2004). For example, tickets to popular Broadway shows or opera festivals (i.e., Richard Wagner's *Festspiele* in Bayreuth, Germany) are presold years in advance, and services such as local parks, training courses, and organized tours require payment well before the service delivery dates. As their circumstances change, customers may want to cancel their advance purchases before the service delivery date. Should a service provider encourage these customers to escape from the purchased service by offering a partial refund for cancellation, or should the provider aim to lock in advance buyers using a no-refund policy?

Previous research on money-back guarantees has shown that offering refunds for *product* returns can be profitable. Product returns are often caused by low quality or poor fit. Offering a refund for product returns signals sellers' confidence in product quality (e.g., Moorthy and Srinivasan 1995, Shieh 1996) or reduces the perceived risk of a poor fit between the product and the customer's needs (e.g., Mann and Wissink 1988). Refunds for returns provide insurance against dissatisfaction, thus allowing firms to charge higher prices and earn higher profits (Fruchter and Gerstner 1999). Unlike product returns, however, service cancellations typically occur *before* the service is delivered (e.g., cancellation of a cruise before the ship departs, returning a ticket prior to a scheduled performance). Many services offer refunds only on cancellations made well in advance of the service delivery date (see some examples in Table 1). Clearly, low service quality or a poor fit cannot explain service cancellations that occur before the service is delivered. Hence, it is important to explore when service cancellations can increase profits and to examine the impact of refund policies on sellers and buyers.

Sellers frequently have concerns about offering refunds for service cancellations. First, it is commonly expected that offering refunds for service cancellations can be profitable only if the seller charges a higher price than the price under a no-refund policy.

Table 1 Examples of Refunds for Service Cancellations

Service	Refund (price—cancellation Fee)	Cancellation deadline (days prior to service delivery)
Cycling Idaho and Ireland (http://spuds.cyclevents.com/)	Price – $100	>61
Painting composition course (http://www.creativesouth.co.nz/about.htm)	Price – $20	>14
Whitewater rafting trips (http://www.lotustravel.com/policy.pdf)	50% of price	>14
Golf school packages (http://www.johnnymiller.com/about.htm)	Less than 75% of price	>14
Tours by Lotus International Tours of Huntington Beach (http://www.lotustravel.com/policy.pdf)	Price – $100	>16
Conference (http://www.ot2004.org/RefundsAndCancellations.html)	Less than 90% of price	>14
Language course (http://www.language.cqu.edu.au/courses/geninfo.htm)	Price – $250	>28

Some service providers may have concerns about the negative effect that such high prices would have on their image and on customer satisfaction. Second, some service providers fear that technology (e.g., the Internet and e-commerce) makes service cancellations too easy, which may result in excessive cancellations and greatly reduced profits. Third, and most important, service providers worry that it may be hard to resell cancelled units at the initial selling price. Should these concerns prevent sellers from offering refunds for service cancellations?

In this paper we show that, under limited capacity, offering refunds for service cancellations should be viewed not as a costly option but as a potential profit source. Allowing customers who find other alternatives to cancel the purchased service and receive a partial refund creates opportunities to resell the capacity-constrained service. Such refunds can be profitable even if (1) the cancelled unit has to be resold at a lower price, (2) advance buyers would be willing to abandon the service for no refund (i.e., they will not show up to claim the service), and (3) the same price is charged as that under a no-refund policy. The better the consumer alternative that motivates a cancellation and the lower the customer hassle cost of cancelling, the more advantageous the refund policy is. Compared with a no-refund policy that locks customers into a purchase from the service provider, refunds for cancellations can lead to a win-win situation: Customers are motivated to pursue and benefit from alternative opportunities because they can obtain partial refunds on notifying the seller of their intent to cancel, and service providers profit from retaining the portion of the price that is not refunded (equivalent to a cancellation fee) and from reselling the cancelled service.

This paper adds to the existing literature in several ways. First, in contrast with the literature about money-back guarantees, we show that the profit advantage of refunds for service cancellations is driven by the opportunity to sell service units under limited capacity multiple times, and not necessarily by the opportunity to charge a price premium under the refund policy. Moreover, unlike product returns, service cancellations occur before (not after) the time of consumption. Therefore, our research shows that partial refunds are not intended to reduce opportunistic returns by consumers who buy and use products with the intention of returning them for a refund (Davis et al. 1995, 1998; Chu et al. 1998). Instead, they are intended to capture the added surplus (by retaining the nonrefundable portion of the price) that is created when customers find new opportunities and cancel the service. As a result, sellers benefit from reducing customer hassle cost of service cancellations rather than increasing it, as suggested by research on product returns (Davis et al. 1988).

Second, our paper complements the research by Biyalogorsky et al. (1999), which shows that service providers can increase profit by overselling capacity and then offering compensation to low-paying customers who agree to cancel if high-paying customers show up at the last minute. In our model, profitable refunds for service cancellations do not rely on "upselling" opportunities that are contingent on finding late-arriving customers who agree to pay a significantly higher price than that paid by early-arriving customers (Biyalogorsky and Gerstner 2004). Instead, we intentionally model a situation where late arrivals value the service *less* than the early arrivals. We show that refunds for service cancellations can be profitable even under a "down-selling" cancellation policy, in which the service is resold to late customers at a lower price than that paid by early-arriving customers. Although our results do *not* depend on the opportunity of selling to higher valuation customers who may arrive later, as in Biyalogorsky et al. (1999) and Biyalogorsky and Gerstner (2004), our model can apply to situations where the seller does have such opportunities (see §3).

Third, recent research on advance selling (Shugan and Xie 2000, 2005; Xie and Shugan 2001) suggests that selling a service well in advance of consumption can increase profit relative to spot selling, because the service providers have information disadvantages about consumers' valuations at the consumption period (i.e., both the buyer and the seller are uncertain about valuations well before the consumption period, but only the buyer knows his or her valuation immediately prior to consumption). Our work complements this recent research by suggesting a new profit advantage of advance selling: Advance selling with refunds for cancellation provides an opportunity for sellers to capture some of the consumer-added surplus that is created when customers find new alternatives (i.e., when finding other alternatives, customers are willing to pay a fee to terminate the prepurchased contract)—a profit potential that is not possible under a spot-selling strategy. By focusing on the economics of refunds for service cancellations, we show that such refunds can alter advance selling from a less to a more profitable strategy, compared with spot selling.

Fourth, research on yield management focuses on optimal capacity allocation, while assuming *exogenous* "no-shows" by advance buyers that occur when customers fail to claim the service they booked (Weatherford and Bodily 1992, Chatwin 2000, Subramanian et al. 1999, Desiraju and Shugan 1999). Some service providers, such as hotels and airlines, estimate the distribution of no shows and overbook capacity accordingly. However, inefficiencies occur when overbooked units exceed no shows (and customers must be "bumped" or compensated) or when the realized no shows exceed overbooked units and capacity remain unsold. In contrast, we model customer cancellations as *endogenous* and focus on the economics of offering refunds for service cancellation. Our work contributes to the literature of yield management because offering refunds for service cancellations motivates potential no shows to notify service providers about cancellations, which will reduce the number of no shows and the resulting inefficiencies.

This paper is organized as follows: §2 presents our model and main results; §3 ties the issue of cancellation policy with refunds to the yield-management literature; and §4 discusses conclusions, managerial implications, and future research.

2. The Model

2.1. Assumptions

We first consider a service provider that has one service unit for sale (i.e., there is a fixed capacity of one unit). We then extend our model to a more general setting under capacity constraint in §2.4. The cost of serving the unit is c ($c \geq 0$). There are two periods ($t = 1, 2$) in which the seller has an opportunity to sell the unit. For simplification, we assume that the discount factor is one.

2.1.1. Customer Behavior. We consider two types of customers: (1) an advance shopper who enters the market in period 1 with a service valuation of V_1 and (2) a late shopper who enters in period 2 with a valuation of V_2. To highlight the profit opportunity of offering refunds for service cancellations, we deliberately assume a less favorable situation for offering refunds for service cancellations—the late shopper has a lower valuation, $V_1 > V_2$. This can occur in markets where late shoppers are bargain hunters who look for last-minute deals and, hence, intentionally come to the market closer to the consumption time.[1] (In §3, we examine the impact of a cancellation policy on yield management in markets where high-valuation shoppers, such as business travelers, come to the market later than low-valuation shoppers, such as leisure travelers.) The advance shopper can choose to buy in period 1 or wait. Waiting allows the customer to seek a better alternative, but this creates uncertainty for obtaining capacity in period 2 because of capacity constraints. Let $0 < \lambda < 1$ denote the customer's probability of obtaining capacity in period 2 if he or she waits. This probability depends on the number of customers, capacity, and prices. The advance shopper makes a purchase decision in period 1 based on the expected price in period 2. Following the literature of advance selling (e.g., Xie and Shugan 2001), we assume that the expected price in period 2 is the seller's optimal price in period 2 (i.e., the expectation is rational).

If the service provider offers a refund, R, for a cancellation, the advance shopper who bought in period 1 has to decide whether to cancel the purchase and notify the seller if an alternative comes along prior to the cancellation deadline (period 2). The surplus from the alternative (if found) is U. The probability that this alternative will be available is q, and the customer's hassle cost of notifying the seller about a cancellation is H.

2.1.2. Seller's Behavior. The seller can sell the unit at either period and considers three strategies:

(I) *Advance Selling, No Refunds* (selling in period 1 under a no-refund policy).

(II) *Advance Selling with Refunds* (selling at the beginning of period 1, offering a refund if receiving a cancellation notification prior to period 2, and reselling the cancelled unit in period 2).

(III) *Spot Selling* (selling in period 2 only).

Strategies (I) and (III) are one-stage decision problems. Strategy (II) is a three-stage decision problem. First, the seller sets the advance price and sells the service at the beginning of period 1. Second, the seller sets the refund to the advance buyer on receiving

[1] New developments in information technology and e-commerce have significantly reduced buyers' information search and transaction costs (Tyagi 2004), making it easier than previously to find last-minute deals by visiting websites such as www.lastminute.com, www.go-today.com, and www.priceline.com.

a cancellation notification prior to period 2. Third, the seller sets the resale price and resells the unit in period 2.

For the rest of this section, we proceed as follows: In §2.2, we compare the two advance-selling strategies. In §2.3, we compare advance-selling strategies with the spot-selling strategy. In §2.4, we extend our model to a more general setting of capacity constraint.

2.2. Refunds vs. No-Refunds Policy

2.2.1. Advance Selling, No Refund. Because no refunds for cancellations are offered ($R = 0$), the advance buyer has no incentive to notify the seller about cancellation, and reselling is impossible.[2] The advance shopper's choice is to buy in period 1 or wait. Waiting may lead to finding a better alternative or to a *chance* of buying in period 2 (the service is not guaranteed under the capacity constraint). The buyer's optimal decision depends on the attractiveness of the alternative, the probability of obtaining the capacity in period 2, and the prices in different periods.

Let ESA_{NR} and ESW_{NR} denote the advance shopper's expected surplus from advance purchasing and waiting, respectively. If the shopper buys in period 1, his or her expected surplus, ESA_{NR}, depends on whether $U \leq V_1$ or $U > V_1$. This is because he or she will pursue the alternative when it is found if $U > V_1$ (i.e., if the alternative is more attractive than the customer's service valuation) but consume the purchased service if $U \leq V_1$ (i.e., if the alternative is less attractive). Let P_{iNR} denote the price in period i, $i = 1, 2$. Hence,

$$ESA_{NR} = \begin{cases} V_1 - P_{iNR} & \text{if } U \leq V_1 \\ (1-q)V_1 + qU - P_{iNR} & \text{if } U > V_1. \end{cases} \tag{1}$$

To induce advance purchase, the advanced price, P_{iNR}, needs to be sufficiently low to satisfy $ESA_{NR} \geq ESW_{NR}$. The seller maximizes profit by increasing P_{iNR} until $ESA_{NR} = ESW_{NR}$. The optimal period 1 price, P^*_{iNR}, is given in (2):

$$P^*_{iNR} = \begin{cases} V_1 - ESW_{NR} & \text{if } U \leq V_1 \\ (1-q)V_1 + qU - ESW_{NR} & \text{if } U > V_1. \end{cases} \tag{2}$$

Note that ESW_{NR} depends on the probability of finding a suitable alternative, the surplus of the alternative if found, the price in period 2, and the probability of finding the capacity in period 2. For example, when the surplus from the alternative is sufficiently large that the shopper pursues the alternative if found, the advance shopper's surplus from waiting is $ESW_{NR} = qU + (1-q)\lambda(V_1 - P_{2NR})$, where λ is affected by period 2 price.[3] The seller's profit under the no-refund policy is given in (3):

$$\pi^*_{NR} = P^*_{iNR} - c + \begin{cases} 0 & \text{if } U \leq V_1 \\ qc & \text{if } U > V_1. \end{cases} \tag{3}$$

Define $\delta = 0$ if $U \leq V_1$ and $\delta = 1$, otherwise. The price given in (2) and the profit function given in (3) can be expressed as follows:

$$\begin{cases} P^*_{iNR} = V_1 + q(U - V_1)\delta - ESW_{NR} \\ \pi^*_{NR} = P^*_{iNR} - c + qc\delta. \end{cases} \tag{4}$$

2.2.2. Advance Selling with Refund. A refund, R, is offered for cancellation if the seller receives a cancellation notice prior to period 2. We derive the optimal strategy using backward induction.

Stage 3: The seller offers the cancelled unit for sale (if the advance buyer finds the alternative) at the optimal resale price, P^*_{RS}.

Stage 2: The seller offers a refund, R, to the advance buyer if a request for such is received prior to period 2. When $U \leq V_1$, the refund must be high enough that, when finding an alternative, the advance buyer is motivated to cancel the service rather than consuming it: $U + R - H \geq V_1$. When $U > V_1$, the advance buyer will not consume the service regardless of the level of refund, but will find it optimal to notify the seller about the cancellation if the refund is sufficient to compensate the hassle cost of cancelling, $R \geq H$ (without notification, the seller is unable to resell the service). The optimal refund is lowered until these two constraints hold with equalities as follows:

$$R^* = \begin{cases} H + V_1 - U & \text{if } U \leq V_1 \\ H & \text{if } U > V_1. \end{cases} \tag{5}$$

Stage 1: Let ESA_R and ESW_R denote the expected surplus under the refund policy from advance purchasing and waiting, respectively. Let P_{iR} denote the price in period i, $i = 1, 2$, respectively. If the advance shopper buys in period 1, he or she receives the refund when finding an alternative (and notifying the seller) and consumes the service otherwise. The

[2] A no-refund policy can be credible for services that are consumed repeatedly by the same customer (e.g., airlines, hotels, performance arts, spots, educational classes). In addition, recent developments in technology are making consumer online communication (Dellarocas 2003) and third-party reviews (Chen and Xie 2005) increasingly popular, which can help the seller establish credibility exogenously.

[3] For example, if period 2 price is high ($P_{2NR} = V_1$), then $\lambda = 1$ because the low valuation shopper will be priced out of the market. If the price in period 2 is low ($P_{2NR} = V_2$), then $\lambda = 1/(2-q)$ because both high and low valuation customers will be interested in buying in that period, and therefore the expected demand in period 2 is $(2-q)$.

Table 2 Comparisons of Three Strategies—Three Examples

Variable	Spot selling	Advance no refund	Advance with refund	Profit comparison	
Example 1: Reselling price is lower than advance price ($P_{RS}^* < P_{1R}^*$). $V_2 = 32$, $H = 2$, $V_1 = 74$, $U = 50$, $q = 0.57$, $c = 0$					
Period 1 price	N/A	32.9	32.9	Refund vs. no-refund	$(\pi_R^* - \pi_{NR}^*)/\pi_{NR}^* = 10.40\%$
Period 2 price	32	N/A	32		
Refund	N/A	N/A	26	Refund vs. spot	$(\pi_R^* - \pi_s^*)/\pi_s^* = 13.41\%$
Profit	32	32.9	36.3	No-refund vs. spot	$(\pi_{NR}^* - \pi_s^*)/\pi_s^* = 2.72\%$
Example 2: The advance buyer will abandon the service for no refunds ($U > V_1$). $V_2 = 32$, $H = 2$, $V_1 = 50$, $U = 60$, $q = 0.4$, $c = 0$					
Period 1 price	N/A	23.3	23.3	Refund vs. no-refund	$(\pi_R^* - \pi_{NR}^*)/\pi_{NR}^* = 51.61\%$
Period 2 price	32	N/A	32		
Refund	N/A	N/A	2	Refund vs. spot	$(\pi_r^* - \pi_s^*)/\pi_s^* = 10.16\%$
Profit	32	23.3	35.3	No-refund vs. spot	$(\pi_{NR}^* - \pi_s^*)/\pi_s^* = -27.34\%$
Example 3: The advance buyer will not cancel without a refund ($U < V_1$). $V_2 = 35$, $H = 2$, $V_1 = 70$, $U = 50$, $q = 0.6$, $c = 0$					
Period 1 price	N/A	30	30	Refund vs. no-refund	$(\pi_R^* - \pi_{NR}^*)/\pi_{NR}^* = 26.0\%$
Period 2 price	35	N/A	35		
Refund	N/A	N/A	22	Refund vs. spot	$(\pi_R^* - \pi_s^*)/\pi_s^* = 8.0\%$
Profit	35.0	30.0	37.8	No-refund vs. spot	$(\pi_R^* - \pi_s^*)/\pi_s^* = -14.3\%$

expected surplus from advance purchase is

$$ESA_R = (1-q)V_1 + q(U + R - H) - P_{1R}. \quad (6)$$

To induce advance purchase, P_{1R} needs to be sufficiently low to satisfy $ESA_R \geq ESW_R$. The seller maximizes profit by increasing P_{1R} until $ESA_R = ESW_R$.[4] The optimal price is given in (7):

$$P_{1R}^* = (1-q)V_1 + q(U + R^* - H) - ESW_R. \quad (7)$$

It is important to note that the optimal period 1 price, P_{1R}^*, can be higher or lower than the optimal resale price, P_{RS}^* (see Table 2 in which $P_{1R}^* > P_{RS}^*$ in Example 1, and $P_{1R}^* < P_{RS}^*$ in Example 2). A higher advance price is possible for a limited capacity service because customers may pay it to guarantee capacity.

The seller's profit under a refund policy is given in (8):

$$\begin{aligned}\pi_R^* &= (1-q)(P_{1R}^* - c) + q(P_{1R}^* - R^* + P_{RS}^* - c)\\ &= (P_{1R}^* - c) + q(P_{RS}^* - R^*). \quad (8)\end{aligned}$$

2.2.3. The Profit Advantage of Refunds for Cancellation. Comparing the two optimal advance-selling strategies (with and without refunds) leads to the following lemma about the optimal price and profits under the two advance-selling strategies (see the appendix for proofs of lemmas and propositions):

Lemma 1 (Price and Profit under the Two Advance-Selling Strategies). *The following relationships hold for the two advance selling strategies,*

(a) $P_{1R}^* = P_{iNR}^*$ *and*

(b) $\pi_R^* = \pi_{NR}^* + q(P_{RS}^* - R^* - c\delta)$,

where $\delta = 0$ *if* $U \leq V_1$ *and* $\delta = 1$, *otherwise*.[5]

Let CS_R^* and CS_{NR}^* denote consumer surplus under the optimal price of the two strategies. Let $\Delta\pi = \pi_R^* - \pi_{NR}^*$ and $\Delta CS = CS_R^* - CS_{NR}^*$. Propositions 1 and 2 examine the conditions under which the refund policy is advantageous.

Proposition 1 (Profit Advantage of Refunds). *Compared with a no-refund policy, offering refunds for service cancellations improves both profit and efficiency if*

(a) *the customer hassle cost of cancelling is sufficiently low and*

(b) *the surplus from the alternative is sufficiently high.*

Formally, $\Delta\pi > 0$, $\Delta CS = 0$ *if* $H < H_{\max}$ *and* $U > U_{\min}$, *where* $H_{\max} = V_2 - c\delta$, $U_{\min} = V_1 - V_2 + H$, $\partial\Delta\pi/\partial H < 0$, $\partial\Delta\pi/\partial U < 0$.

Proposition 2 (Generality of the Advantage of Refunds). *Offering refunds for service cancellation can be profitable.*

(a) *without requiring a price premium,*

(b) *when the cancelled unit has to be sold at a lower price,*

(c) *when the advance buyer is willing to abandon the service for no refund, and*

(d) *without hurting consumers.*

[4] Note that in the basic model, if the buyer waits, the refunds become irrelevant. Hence, $ESW_R = ESW_{NR}$.

[5] When $U > V_1$, the advance buyer will pursue the alternative and therefore will not consume the prepurchased service. In this case, the profit advantage of the refunds, $\pi_R^* - \pi_{NR}^* = q(P_{RS}^* - R^* - c)$, is negatively affected by the cost because, under the no-refund policy, reselling does not take place, so the seller avoids the cost of serving the cancelled unit. However, under the refund policy, the seller incurs this cost since the cancelled unit will be resold to the later buyer.

The results presented in Propositions 1 and 2 are not obvious. For example (see Proposition 1), why should a service provider make it easy for customers to cancel by reducing hassle costs instead of making cancellations more difficult (i.e., $\partial\Delta\pi/\partial H < 0$), and why is offering a refund for service cancellation more profitable when the alternative is more rather than less attractive to consumers ($\partial\Delta\pi/\partial U \geq 0$)? Also (see Proposition 2), why does the service provider profit from (a) offering refunds for service cancellations without charging a higher price for this option, (b) letting customers cancel a service they purchased at a high price and then offering the cancelled units to low valuation customers at a lower price, or (c) offering a refund to customers who intend to cancel the service without demanding a refund? We answer these questions and present illustrating examples below.

First, unlike previous research in which refunds for product returns are offered with a price premium relative to a policy of no refunds, the profit advantage of refunds for service cancellations does not require such a price premium ($P^*_{1R} = P^*_{iNR}$). What drives this profit advantage is the multiple selling of limited capacity. Because customer cancellations occur before consumption, opportunistic cancellations under which buyers order products with the intention of returning them after use are not a problem, so charging a price premium under the refund to recoup profit loss from free riding is not required.

Second, the profit advantage of service cancellations (under limited capacity) prevails even if cancelled services have to be resold at a lower price because the same unit is, in fact, sold twice, first with a cancellation fee (i.e., $P^*_{1R} - R^*$) to the advance buyer who cancels, and then to the late buyer at a resale price, P^*_{RS}. As shown in Lemma 1, the profit of a refund policy is $\pi^*_R = \pi^*_{NR} + q(P^*_{RS} - R^*)$, when $U \leq V_1$. The refund, R^*, can be interpreted as the seller's cost of repurchasing the capacity for resale, and P^*_{RS} is the revenue from reselling. This transaction is profitable as long as the net gain is positive, $P^*_{RS} > R^*$. Because the profit advantage of refunds for service cancellations is determined by comparing the resale price with the refund but not with the advance price, the seller can benefit from motivating the more valuable customer to release the service by offering him or her a partial refund and reselling the unit to a low-valuation costumer.

Example 1 in Table 2 illustrates such a case where a seller improves profit by "letting the *more valuable* customers escape." As shown in this example, although the optimal resale price is lower than the optimal advance price ($P^*_{1R} = 32.9 > P^*_{RS} = 32$), by allowing the high-paying buyer to cancel and then reselling the unit to a lower-paying buyer, the seller increases profit by more than 10%:

$$(\pi^*_R - \pi^*_{NR})/\pi^*_{NR} = 10.40\%.$$

Third, the profit advantage of refunds for cancellation exists even in the presence of customers who intend to cancel the service without receiving a refund (i.e., $U > V_1$). The role of the refund is to motivate these customers to notify the seller about their cancellations (instead of not showing up), which allows the seller to resell the service. The required refund in this case is just sufficient to compensate for the cost of notifying the seller about the cancellation. Example 2 in Table 2 illustrates such a case where the seller profits by "offering refunds to customers who do not ask for them." As shown in Example 2, although the advance buyer would walk away from the purchased service without demanding a refund ($V_1 = 50 < U = 60$), it is more profitable for the seller to voluntarily offer a refund ($R^* = 2$), which motivates the customer to notify the seller about cancellations and increases profit by more than 51%: $(\pi^*_R - \pi^*_{NR})/\pi^*_{NR} = 51.6\%$.

Fourth, service providers may find it profitable to solicit service cancellations (through large refunds) even if buyers find alternatives that are not attractive relative to the purchased service (i.e., $U < V_1$). In this case, as Expression 5 shows, the optimal refund is $R^* = H + V_1 - U$. Therefore, the higher the surplus from the alternative, U, the smaller is the optimal refund, R^*, required to induce cancellation and the more profitable is the refund policy. The positive relationship between the seller's profit under a refund policy and the surplus of the alternative discovered here ($\partial\Delta\pi/\partial U \geq 0$) is intriguing because it suggests that offering refunds for service cancellations allows the service provider to profit from the alternatives found by customers, and the better the alternative, the more the seller profits. Example 3 in Table 2 illustrates a case where the alternative is not attractive enough relative to the purchased service ($V_1 = 70 > U = 50$). However, by motivating the customer to leave via a sufficient refund ($R^* = 22$), the seller increases profit by 26%:

$$(\pi^*_R - \pi^*_{NR})/\pi^*_{NR} = 26.0\%.$$

Fifth, sellers can increase the profit advantage of refunds for service cancellations by decreasing the hassle cost of cancelling, $\partial\Delta\pi/\partial H < 0$ (a lower H implies a lower required refund, thus a higher profit). This holds because service cancellations occur before consumption, so free renting does not exist, and lower hassle costs can only increase "legitimate cancellations" and more profitable multiple selling. In contrast, retailers cannot profit by decreasing hassle costs on product returns, because low hassle costs encourage opportunistic behavior of returning products for the benefit of free renting (Davis et al. 1988).

Sixth, the profit advantage of refunds for service cancellations is not at the customers' expense ($CS^*_R =$

CS^*_{NR}). Offering a partial refund does not reduce customer surplus because (1) the seller does not need to increase the price under the refund policy (i.e., $P^*_{1R} = P^*_{iNR}$) and (2) customer cancellation is implemented by self-selection, under which the advance buyer cancels only if this leads to a higher surplus. Hence, whenever a refund policy improves the seller's profit, it increases efficiency and enhances social welfare because it helps the seller without hurting the buyer.

Finally, Xie and Shugan (2001) suggest that, when buyer valuation for the service is state dependent, a refund policy can lead to a higher profit if the cost of providing the service is sufficiently high, because such refunds save the cost of serving the customers in low-valuation states. In our model, the profit advantage of refunds is *not* driven by such cost savings. Proposition 1 and Table 2 imply that a refund for service cancellations can be profitable even if the incremental costs of providing the service are zero (which approximates the situation for services with low marginal costs such as airlines, hotels, and continuing education courses). Our work complements Xie and Shugan (2001) by providing a different reason for the profit advantage of offering refunds for service cancellations—the opportunity for *multiple selling* in a capacity-constrained service.

It is important to note that, although our model assumes a constant valuation for the advance buyer, it can be applied to situations under which a buyer's valuation for the service varies depending on his or her consumption state (see Png 1989, Shugan and Xie 2004 for discussions on the state-dependent consumption utility based on personal factors). Under this scenario, a customer may select an alternative rather than consume the purchased service when confronting an unfavorable state. For example, a ticket to a baseball game may be of high value to a customer in good health but of lower value to a customer who is ill. In the latter case, watching the game at home is more valuable than going to the stadium. Under a no-refund policy, a sick customer has no incentive to inform the seller about a cancellation, so reselling the service is not possible. However, a refund just high enough to cover the customer's hassle costs of cancelling will motivate the customer to notify the seller about the cancellation, which will give the seller an opportunity to collect a cancellation fee (priced lower than the refund) from the advance buyer and resell the freed slot. Hence, refunds for service cancellations can be profitable even if a buyer's valuation for the service varies depending on his or her consumption state.

2.3. Advance Selling vs. Spot Selling

In this section we compare the profit of the two advance-selling strategies against the profit of a spot-selling strategy.

The profits of the two advance-selling strategies are given in (3) and (8). The profit of a spot-selling strategy is determined by the price and demand in the spot period (i.e., period 2). The seller can charge a high price ($P_s = V_1$) or a low price ($P_s = V_2$), which affects the demand. For example, consider the case where the surplus of an alternative is sufficiently high that the advance shopper will pursue the alternative if found. Under a high price ($P_s = V_1$), the low-valuation shopper will be priced out of the market. Hence, the seller's expected profit is $\pi_s = (1-q)(V_1 - c)$. Under a low price ($P_s = V_2$), demand is higher than capacity; hence, the seller's expected profit is $\pi^*_s = V_2 - c$.

Proposition 3 compares profits under all three strategies.

Proposition 3 (Advance Selling vs. Spot Selling). *Offering refunds for service cancellations can turn advance selling from an inferior to a superior strategy compared with spot selling when the following three conditions hold*:

(a) *The customer hassle cost of cancelling is sufficiently small*.

(b) *The surplus from the alternative is sufficiently high*.

(c) *The probability for the customer to find an alternative is in a mid range*.

Formally, $\pi^*_{NR} < \pi^*_s < \pi^*_R$, *if* $H < \widetilde{H}_{\max}$, $U > U_{\min}$, *and* $q_{\max} > q > q_{\min}$, *where* $\widetilde{H}_{\max} < H_{\max}$, $U_{\min}$, *and* $H_{\max}$ *are given in Proposition* 1, $q_{\max}$, $q_{\min}$, *and* $\widetilde{H}_{\max}$ *are given in the appendix*.

Proposition 3 highlights an intriguing result: Offering a partial refund for cancellation can alter advance selling from a less to a more profitable strategy compared with spot selling ($\pi^*_{NR} < \pi^*_s < \pi^*_R$). We now explain why such a situation occurs when the three conditions given in Proposition 3 hold.

First, it is easy to understand why a small H and a large U are required for Proposition 3. As discussed earlier, the profitability of refunds increases with U but decreases with H, because the higher the surplus of the alternative or the lower the hassle cost of cancelling, the lower the required refund is (when the buyer finds the alternative and wants to cancel). Note that the condition for the hassle cost in Proposition 3 ($H < \widetilde{H}_{\max} < H_{\max}$) is stronger than that in Proposition 1 ($H < H_{\max}$). This is because the former compares three strategies ($\pi^*_{NR} < \pi^*_s < \pi^*_R$), but the latter only compares two ($\pi^*_{NR} < \pi^*_R$).

Second, a large q means that there is a high probability that the early shopper will find an alternative if he or she waits. Hence, the seller has to offer a sufficiently low advance price to induce advance purchase. As a result, when q is sufficiently high, under no refund policy, the price needed to convince the buyer to self-select advance buying over spot buying can be too low to make advance selling profitable.

Hence *spot selling* dominates *advance selling without refund* if q is sufficiently large (i.e., $\pi^*_{NR} < \pi^*_s$ if $q > q_{\min}$). While a large q also leads to a low advance price under a refund policy, offering refunds for cancellation can improve the profit of advance selling (see Proposition 1). Hence, *spot selling* will not dominate *advance selling with refund* as long as q is not too high (i.e., $\pi^*_R > \pi^*_s$ if $q_{\max} > q$).

This suggests that although q reduces the profit of advance selling, such a negative effect is weaker under a refund policy than under a no-refund policy. Under a no-refund policy, the seller is always hurt by the low advance price caused by a large q. However, under a refund policy, the seller is hurt by such a low advance price only when the advance buyer fails to find an alternative. When such an alternative is found (with a probability q), the advance buyer cancels the prepurchased service by paying a cancellation fee and the seller resells the cancelled unit in period 2 (the resale price is not affected by q). For this reason, one can find a mid range of q, within which advance selling without refund is less profitable, but advance selling with refund is more profitable than spot selling, $\pi^*_{NR} < \pi^*_s < \pi^*_R$.

Two examples in Table 2 (Examples 2 and 3) illustrate how offering a partial refund for cancellation turns advance selling from an inferior to a superior strategy compared with spot selling. For instance, as shown in Example 2, compared with spot selling, advance selling reduces profit by more than 27% when refunds are not offered for cancellations: $(\pi^*_{NR} - \pi^*_s)/\pi^*_s = -27.3\%$. However, by offering refunds for service cancellations, advance selling increases profit by more than 10%, compared with spot selling: $(\pi^*_R - \pi^*_s)/\pi^*_s = 10.2\%$.

2.4. A More General Setting of Capacity Constraints

In this section we show that our findings apply in the more general context of buyers and capacity. Consider a service provider with capacity constraint such that the capacity is sufficient to serve advance shoppers but insufficient to serve all customers. Specifically, let N_1, N_2, and Q denote the number of advance shoppers, the number of later shoppers, and the seller's capacity, respectively, where $N_1(1-q) + N_2 > Q \geq N_1$. Note that our basic model is a special case where $N_1 = N_2 = Q = 1$. Other assumptions remain the same as in the basic model.

Proposition 4 reveals that our main findings can hold in this more general setting (see the appendix for a detailed analysis).

Proposition 4 (General Setting of Capacity Constraints). *In a general setting of capacity constraints, offering refunds for service cancellation can turn advance selling from an inferior to a superior strategy* (*i.e.*, $\pi^*_{NR} < \pi^*_s < \pi^*_R$, *if* (a) $H < \widehat{H}_{\max}$, (b) $U > \widehat{U}_{\min}$, *and* (c) $Q_{\max} > Q > Q_{\min}$, *where* $\widehat{H}_{\max}$, $\widehat{U}_{\min}$, $Q_{\max}$, *and* $Q_{\min}$ *are given in the appendix*).

Note that the condition on q ($q_{\max} > q > q_{\min}$) in Proposition 3 (where capacity is fixed, $Q = 1$) is now expressed by a more general condition on capacity ($Q_{\max} > Q > Q_{\min}$). Such a mid-range capacity is necessary for two reasons. First, it ensures the existence of the advance selling equilibrium (i.e., advance shoppers will make a purchase in period 1). A too-large or too-small capacity offers advance shoppers an incentive to wait. A too-large capacity motivates waiting because such a high capacity reduces the customer's need to guarantee service use through advance purchase. A too-small capacity also motivates waiting because a very small capacity implies that it is optimal for the seller to charge a high spot price (i.e., selling to high-valuation customers only). Under such a high price, the low-valuation customers will not compete for capacity in period 2, which reduces shoppers' need to use advance purchase to secure guaranteed service.

Note that, although our model assumes a discrete distribution for later shoppers' valuation, with a mid-range capacity, the advance-selling equilibrium can exist even if the later shoppers' valuation follows a continuous distribution. When the latter shoppers have a continuous distribution of v, the seller is able to vary price level continuously. Intuitively, if the price in period 2 is high enough, all advance shoppers (with high valuation) would obtain their desired capacity if they waited. However, it may not be in the seller's best interest to charge such a high price to encourage the advance shoppers to defer purchase, especially when capacity is sufficiently large. This is because a low spot price increases demand and decreases capacity availability in period 2, which motivates advance shoppers to pay a price premium in period 1 to guarantee use of the desired service. As suggested in Xie and Shugan (2001), when capacity is in the mid range, such a premium advance-selling strategy can be more profitable than pure spot selling.

Furthermore, a mid-range capacity, $Q_{\max} > Q > Q_{\min}$, is also necessary to ensure that both $\pi^*_{NR} < \pi^*_s$ and $\pi^*_s < \pi^*_R$ hold simultaneously. On the one hand, a larger capacity implies a higher probability for advance shoppers to find capacity in period 2 if they wait; hence, a lower price is necessary to induce advance sales. For this reason, the profit of advance selling (with and without refunds) decreases with Q. On the other hand, offering refunds can improve the profit of advance selling. As a result, when Q is in the mid range, $Q_{\max} > Q > Q_{\min}$, *spot selling* dominates *advance selling without refund* ($\pi^*_{NR} < \pi^*_s$) but is, in turn, dominated by *advance selling with refund* (i.e., $\pi^*_R > \pi^*_s$).

3. Implications of a Cancellation Policy on Yield Management

Our research on refunds for cancellations can be linked to the yield-management system (YMS) literature involving selling low-priced tickets to advance buyers but reserving some capacity for later shoppers who are willing to pay higher prices (see Weatherford and Bodily 1992 and McGill and van Ryzin 1999 for an overview of the relevant literature). YMSs are commonly implemented in the travel industry, where business travelers are willing to pay a high price to satisfy important needs arising close to the consumption time (Desiraju and Shugan 1999, Biyalogorsky et al. 2005). How many units to reserve (block) for the high-paying, late-arriving customers (*highs*) is a crucial question. If too many highs arrive, the seller regrets not blocking more units, but if not, blocked units are wasted, because capacity is perishable. Although the existing YMS research derives the optimal units to be blocked under different scenarios, it does not consider the opportunity of profit from customer cancellations through multiple selling.

Following the YMS research, consider a market where low-valuation customers (*lows*) arrive early and highs arrive late (i.e., $V_2 > V_1$). The seller can offer a discounted price in period 1 and full price in period 2 and make a decision on how many units to block for highs at full price in period 2. As in the previous yield-management literature (e.g., Littlewood 1972, Biyalogorsky et al. 1999), it can be assumed that (a) the number of highs that show up in period 2 is a random variable Y with cumulative distribution function, $F(y) = \text{Prob}(Y < y)$, and probability mass function $p(y) = \text{Prob}(Y = y) = F(y) - F(y-1)$ and (b) the number of lows is sufficiently large that all unblocked units can be sold out in period 1 as long as the discounted price is sufficiently low.

Let k denote the number of units reserved for highs in period 2 and β^k denote the probability that more than $k-1$ highs will show up in period 2, that is, $\beta^k = 1 - F(k-1)$. Under a no-refund policy, the seller decides whether to reserve the kth unit for highs in period 2 at full price or whether to advance sell it to lows at a discounted price in period 1 by comparing the expected marginal unit revenue from the two alternatives (Belobaba 1989). When no refunds are offered, the expected revenue from blocking the kth unit is $\beta^k V_2$, and the expected marginal unit revenue from advance selling the unit is P^*_{iNR}. The seller will reserve the kth unit as long as the former is higher: $\beta^k V_2 > P^*_{iNR}$.

Under refunds for cancellations, lows are motivated to pursue alternatives and notify the seller about cancellations, which allows reselling freed units to highs. Because cancelled units substitute for blocked units, fewer units can be blocked under refunds for cancellations compared with under no refunds (where there are no incentives to notify concerning cancellations). Note that even if zero units are blocked, refunds for cancellations allow sellers to retain some capacity for selling to highs in period 2. Blocked units create waste because it is likely that some will go unsold. Offering refunds for cancellations can reduce the number of blocked units and can thereby increase capacity utilization.

The YMS research suggests the use of overbooking as a strategy for selling unused airline seats or hotel rooms resulting from unannounced cancellations (no shows). Under overbooking, sellers continue to sell the service after capacity is fully booked, expecting that demand will match supply at the time of service delivery, because some buyers will fail to show up to claim the service. However, overbooking has some drawbacks. First, customers are often denied service when the number of overbooked customers exceeds the number of no shows (this is called *bumping* in the airline industry and *walking* in the hotel industry). These practices create high customer dissatisfaction and bad publicity. Under refunds for cancellations, customers are never denied service, so customer satisfaction and loyalty are likely to be higher. By offering refunds for service cancellations, the seller has less need for overbooking (in particular when there is sufficient spot demand) because such refunds motivate potential no shows to notify service providers about cancellations. Moreover, some services, such as the theatre, opera, and concerts, never use overbooking (because bumping cannot be tolerated and also because of the difficulty to place customers in alternative performances). For such services, the more appealing alternative to improve capacity utilization is to offer refunds for cancellations.

4. Conclusion

This paper provides a theory on the economics of refunds for service cancellations. We propose that a capacity-constrained service provider can profit from offering partial refunds for service cancellations, because such refunds allow the service provider to capture some of the consumer-added surplus that is created when customers find alternative opportunities and cancel the purchased service. The provider captures the surplus by retaining part of the price for the initial sale and by reselling the cancelled service. When a refund policy improves profit, it is also economically efficient.

Our paper contributes to the literature in several ways. We show that under refunds for service cancellations, customers may not have to pay a price premium as they do when they buy products under money-back guarantees. Service providers do not have to charge a premium because the moral-hazard behavior that exists under product returns is absent in service cancellations. We also show that, as opposed to recent research on overselling service capacity in which a provider can upsell the service to high-paying customers who show up after the capacity is already sold, service cancellations can be optimal even if the provider down-sells the service, that is, resells it at a price that is lower than the advance price. Our research also offers a new reason that advance selling has a profit advantage compared to spot selling—it allows for the multiple selling of service units under fixed capacity. Selling before the service delivery date and offering partial refunds for cancellation makes it possible for the service provider to profit from those customers who find other alternatives later and do not consume the service. Finally, unlike the literature on yield management that assumes that the number of no-show advance buyers is exogenous, our model allows endogenous cancellations by advance buyers. Hence, refunds for cancellations can reduce no shows and improve capacity utilization.

Managers for services with limited capacity can profit from refunds-for-service cancellations for several reasons:

- Partial refunds (i.e., charging a cancellation fee) allow service providers to (1) capture part of the customer-added surplus created when customers find better alternatives and cancel their purchases and (2) resell the cancelled units.
- Refunds can increase profit even if the resale price is below the advance price (i.e., a refund is profitable as long as the resale price is higher than the required refund).
- Refunds can increase profit even if advance buyers would abandon the service without demanding a refund (i.e., refunds motivate potential no shows to notify the seller about cancellation, which allows the seller to resell the cancelled service).

When refunds are offered for service cancellations, the service providers should simplify the process of cancelling and refunding because the required refund decreases when the customer's hassle cost of cancelling decreases.

Moreover, refunds for service cancellations can benefit buyers and improve efficiency for the following reasons:

- Refunds can improve capacity utilization, as the number of units blocked for high-paying customers can be reduced (more blocking increases the likelihood that service units will remain unsold).
- Refunds are more customer friendly than overbooking (because buyers are never denied service) and can reduce the need for overbooking (because potential no shows are motivated to notify service providers about cancellations, thereby reducing no shows).

A service provider can also profit by providing a flexible cancellation policy under which a refund for cancellation is offered only if the service provider expects the service to be sold out (which means that reselling the cancelled service is likely). Under a flexible cancellation policy, refund offers can be changed as the time for service delivery approaches. For example, the seller can raise the refund for cancellations if it appears that demand for the service is higher than expected and lower or cancel the refund if it appears that service units will remain unsold.

Several aspects of service cancellations invite future research. First, how will the cancellation timing affect the profit advantage of a cancellation policy and the optimal refund? Second, how would refunds for cancellations help reduce no shows (the refunds motivate customers to notify service providers about cancellations) and the need to overbook? Using refunds for cancellations with less overbooking can increase efficiency because the variance in capacity utilization will decrease as service providers are notified about cancellations instead of trying to guess no shows. Third, similar to product-return policies (Wang 2004, Padmanabhan and Png 2004), service cancellation policies may have an impact on service distribution channels.

Finally, similar to warranties and money-back guarantees, refunds for service cancellations relate to the topic of real options (for an extensive discussion on the benefits of using real options or combining financial options with real options, see Amram and Kulatilaka 1999). Under refunds for service cancellations, the price of the option to cancel is the cancellation fee (i.e., the nonrefundable portion of the service price that is retained by the service provider on cancellation). Future research should explore how the theory of real options can be applied to manage risks in markets for products and services. Empirical studies on cancellation policies in different service industries can provide insights to help approach these unexplored issues.

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Appendix. Proofs

Proof of Lemma 1. (a) The optimal prices under the two advance-selling strategies (see Equations (2) and (7)) are:

$$P^*_{iNR} = \begin{cases} V_1 - ESW_{NR} & \text{if } U \le V_1 \\ (1-q)V_1 + qU - ESW_{NR} & \text{if } U > V_1 \end{cases} \tag{A1}$$

$$P^*_{1R} = (1-q)V_1 + q(U + R^* - H) - ESW_R, \tag{A2}$$

where R^* is given in (A3):

$$R^* = [H + (1-\delta)(V_1 - U)] = \begin{cases} H + V_1 - U & \text{if } U \le V_1 \\ H & \text{if } U > V_1, \end{cases} \tag{A3}$$

where $\delta = 0$ if $U \le V_1$, and $\delta = 1$, otherwise.

Note that the advance shopper receives the same surplus from waiting, $ESW_{NR} = ESW_R = ESW$. Substituting (A3) for R^* in (A2), we have

$$P^*_{1R} = P^*_{iNR} = \begin{cases} V_1 - ESW & \text{if } U \le V_1 \\ (1-q)V_1 + qU - ESW & \text{if } U > V_1. \end{cases} \tag{A4}$$

(b) The profits of the two strategies (see Equations (3) and (8)) are:

$$\pi^*_{NR} = P^*_{iNR} - c + \begin{cases} 0 & \text{if } U \le V_1 \\ qc & \text{if } U > V_1, \end{cases} \tag{A5}$$

$$\pi^*_R = (P^*_{1R} - c) + q(P^*_{RS} - R^*). \tag{A6}$$

Let $P^*_{1R} = P^*_{iNR}$. (A6) becomes:

$$\pi^*_R = \pi^*_{NR} + q(P^*_{RS} - R^* - c\delta), \quad \text{where } \delta = 0 \text{ if } U \le V_1, \text{ and } \delta = 1 \text{ otherwise.} \quad \square \tag{A7}$$

Proof of Proposition 1. Under a refund strategy, the optimal resale price is the late shopper's valuation, $P^*_{RS} = V_2$. Let

$$\Delta\pi = \pi^*_R - \pi^*_{NR}, \quad \Delta CS = CS^*_R - CS^*_{NR},$$
$$U_{\min} = V_1 - V_2 + H, \quad \text{and} \quad H_{\max} = V_2 - c\delta.$$

(A7) reveals

$$\Delta\pi = q(P^*_{RS} - R^* - c\delta) = q\begin{cases} V_2 - [H + V_1 - U] = U - U_{\min} & \text{if } U \le V_1 \\ V_2 - (H + c) = H_{\max} - H & \text{if } U > V_1. \end{cases} \tag{A8}$$

Hence, $\Delta\pi > 0$, if

$$U > U_{\min} \quad \text{and} \quad H < H_{\max}. \tag{A9}$$

Because the optimal advance price offers the advance buyer a surplus of ESW under both strategies, $\Delta CS = 0$. Since a refund policy can increase profit ($\Delta\pi > 0$) without reducing buyer surplus ($\Delta CS = 0$), it improves efficiency whenever it improves profit. $\square$

Proof of Proposition 2. We now prove that $\Delta\pi > 0$ can be satisfied in the following four situations:

(a) $P^*_{1R} = P^*_{iNR}$,
(b) See Example 1 in Table 2.
(c) $U > V_1$, and
(d) $CS^*_R = CS^*_{NR}$.

Let $U > U_{\min}$ and $H < H_{\max}$. Proposition 1 shows $\Delta\pi > 0$.

(a) As shown in Lemma 1 $P^*_{1R} = P^*_{iNR}$.
(b) Consider the case $U \le V_1$ and

$$q < \min\left[\frac{V_1 - V_2}{V_1 - c}, \frac{V_1 - V_2}{U}\right].$$

In this case, the seller will charge a high price (V_1) in period 2 if the advance shopper waits. As a result, $ESW = qU$ and $P^*_{1R} - P^*_{RS} = V_1 - ESW - V_2 = V_1 - V_2 - qU$. Hence, $P^*_{1R} > P^*_{RS}$ given $q < (V_1 - V_2)/U$.

(c) See proof for Proposition 1.
(d) See proof for Proposition 1. $\square$

Proof of Proposition 3. We now show $\pi^*_{NR} < \pi^*_s < \pi^*_R$, if the following conditions hold:

$$\text{(i) } H < \widetilde{H}_{\max}, \quad \text{(ii) } U > U_{\min}, \quad \text{(iii) } q_{\max} > q > q_{\min}, \tag{A10}$$

where

$$\widetilde{H}_{\max} = \frac{(V_2 - c)^2}{(V_1 - c) + (V_2 - c)} < H_{\max},$$
$$U_{\min} = V_1 - V_2 + H \tag{A11}$$

$$q_{\max} = 1 - \sqrt{\frac{H}{H + (V_1 - V_2)}}, \qquad q_{\min} = \max[q_a, q_b],$$

$$q_a = \frac{V_1 - V_2}{V_1 - c}, \qquad q_b = \begin{cases} 1 - \sqrt{1 - \dfrac{(V_1 - V_2)}{U}} & \text{if } U \le V_1 \\ 1 - \sqrt{1 - \dfrac{(V_1 - V_2)}{V_1 - c}} & \text{if } U > V_1. \end{cases} \tag{A12}$$

(a) *Spot Selling*. Given

$$U > U_{\min} = V_1 - V_2 + H > (V_1 - V_2)\lambda,$$

the advance shopper will pursue the alternative when it is found. Given $q > q_a$, it is optimal for the seller to charge a low price, $P^*_s = V_2$. The profit of spot selling is $\pi^*_s = V_2 - c$.

(b) *Advance Selling, No Refunds versus Advance Selling with Refunds*. Given $U > U_{\min}$, and $H < \widetilde{H}_{\max} \le H_{\max}$, we have $\pi^*_R > \pi^*_{NR}$ (see Proposition 1).

(c) *Advance Selling, No Refunds versus Spot Selling*. Given $U > U_{\min}$ and $q > q_a$, we have $P^*_{2NR} = V_2$ and $ESW_{NR} = qU + (1-q)(V_1 - V_2)/(2-q)$. Compare:

$$\begin{aligned} &\pi^*_s - \pi^*_{NR} \\ &= (P^*_s - c) - (P^*_{iNR} - c) \\ &= \frac{1}{2-q}\begin{cases} -Uq^2 + 2Uq - (V_1 - V_2) & \text{if } U \le V_1 \\ -(V_1 - c)q^2 + 2(V_1 - c)q - (V_1 - V_2) & \text{if } U > V_1. \end{cases} \end{aligned} \tag{A13}$$

Hence, $\pi^*_s > \pi^*_{NR}$ if $q > q_b$.

(d) *Advance Selling with Refunds versus Spot Selling*. Given $U > U_{\min}$, $q > q_a$, we have $P^*_{2R} = V_2$ and

$$ESW_R = qU + (1-q)(V_1 - V_2)/(2-q).$$

Compare:

$$\pi^*_s - \pi^*_R = (P^*_s - c) - [(P^*_{1R} - c) + q(P^*_{RS} - R^*)] = \frac{(2-q)qH - (1-q)^2(V_1 - V_2)}{2-q}. \tag{A14}$$

Hence, $\pi^*_s < \pi^*_R$ if $q < q_{\max}$.

Note that $q_{\max}$ is a decreasing function of H, but $q_{\min}$ is not affected by H. Given $H < \widetilde{H}_{\max}$, we have $q_{\max} > q_{\min}$. □

Proof of Proposition 4. We show $\pi^*_{NR} < \pi^*_s < \pi^*_R$ when the following conditions hold:

$$U > \widehat{U}_{\min}, \quad H < \widehat{H}_{\max}, \quad \text{and} \quad Q_{\max} > Q > Q_{\min}, \tag{A15}$$

where

$$\widehat{U}_{\min} = \max[U_{\max}, U_0], \qquad \widehat{H}_{\max} = \min[H_0, H_1],$$
$$Q_{\min} = \max[Q_1, Q_2, Q_3], \qquad Q_{\max} = Q_4,$$
$$U_0 = \frac{H[(1-q)(N_1-T)+N_2]+N_2(V_1-V_2)}{(1-q)(N_1-T)+N_2},$$
$$H_0 = \frac{(1-q)(N_1-T)(V_1-c)+N_2(V_2-c)}{(1-q)(N_1-T)+N_2},$$

$U_{\max}$ is given in Proposition 1, and H_1, Q_1 to Q_4 are defined below.

(i) Three strategies:

(a) *Spot Selling*. When both U and Q are sufficiently large, $U > U_{\min}$ and

$$Q > Q_1 = \frac{(V_1-c)(1-q)N_1}{V_2-c},$$

the optimal price is $P^*_s = V_2$ and the profit of spot selling is

$$\pi^*_s = (V_2-c)Q. \tag{A16}$$

(b) *Advance Selling, No Refund*. Let $1 < T \le N_1$ be the capacity allocated for advance sales. When both U and Q are sufficiently large, $U > U_{\min}$ and

$$Q > Q_2 = \frac{-c[(1-q)N_1+qT]+(N_1-T)(1-q)V_1+TV_2}{V_2-c},$$

the optimal period 2 price is $P^*_{2NR} = V_2$. If advance shoppers decide to wait, their expected surplus is

$$ESW_{NR} = qU + (1-q)(V_1-V_2)\lambda_2,$$

where

$$\lambda_2 = \frac{Q}{(1-q)N_1+N_2}$$

is the probability for a customer to find capacity in period 2. If advance shoppers decide to buy, the probability for them to get capacity in period 1 is $\lambda_{11} = T/N_1$. If they fail to get capacity in period 1, the probability for them to get capacity in period 2 is

$$\lambda_{12NR} = \frac{Q-T}{(1-q)(N_1-T)+N_2}.$$

The expected surplus from advance purchase is

$$ESA_{NR} = \begin{cases} \lambda_{11}[V_1 - P_{iNR}] + (1-\lambda_{11})B_{NR} & \text{if } U \le V_1 \\ \lambda_{11}[(1-q)V_1 + qU - P_{iNR}] + (1-\lambda_{11})B_{NR} & \text{if } U > V_1, \end{cases}$$

where $B_{NR} = qU + (1-q)(V_1-V_2)\lambda_{12NR}$. The optimal price in period 1 for a given T, $P_{iNR}(T)$, can be determined by setting $ESA_{NR} = ESW_{NR}$:

$$P_{iNR}(T) = \begin{cases} V_1 + \dfrac{1}{\lambda_{11}}[(1-\lambda_{11})B_{NR} - ESW_{NR}] & \text{if } U \le V_1 \\ V_1 + q(U-V_1) + \dfrac{1}{\lambda_{11}}[(1-\lambda_{11})B_{NR} - ESW_{NR}] & \text{if } U > V_1. \end{cases} \tag{A17}$$

$$\begin{aligned}\pi_{NR}(T) &= (P_{iNR}(T) - c + qc\delta)T + (V_2-c)(Q-T) \\ &= (P_{iNR}(T) - V_2 + qc\delta)T + (V_2-c)Q. \end{aligned}\tag{A18}$$

(c) *Advance Selling with Refund*. When Q is sufficiently large, $Q > Q_2$, the optimal period 2 price is $P^*_{2R} = V_2$. If advance shoppers decide to wait, their expected surplus is

$$ESW_R = qU + (1-q)(V_1-V_2)\lambda_2.$$

If advance shoppers decide to buy, the probability for them to get capacity in period 1 is $\lambda_{11} = T/N_1$. If they fail to get capacity in period 1, the probability for them to get capacity in period 2 is

$$\lambda_{12R} = \frac{Q-(1-q)T}{(1-q)(N_1-T)+N_2}.$$

The expected surplus from advance purchase is

$$ESA_R = \lambda_{11}[(1-q)V_1 + q(U+R-H) - P_{1R}] + (1-\lambda_{11})B_R,$$

where $B_R = [qU + (1-q)(V_1-V_2)\lambda_{12R}]$. The optimal price in period 1 for a given T, $P_{1R}(T)$, can be determined by setting $ESA_R = ESW_R$:

$$\begin{aligned} P_{1R}(T) &= V_1 + q(U - V_1 + R^* - H) + \frac{1}{\lambda_{11}}[(1-\lambda_{11})B_R - ESW_R] \\ &= \begin{cases} V_1 + \dfrac{1}{\lambda_{11}}[(1-\lambda_{11})B_R - ESW_R] & \text{if } U \le V_1 \\ V_1 + q(U-V_1) + \dfrac{1}{\lambda_{11}}[(1-\lambda_{11})B_R - ESW_R] & \text{if } U > V_1, \end{cases} \end{aligned} \tag{A19}$$

$$\begin{aligned}\pi_R(T) &= [P_{1R}(T) - c) + q(V_2 - R^*)]T + (V_2-c)(Q-T) \\ &= [P_{1R}(T) - V_2 + q(V_2 - R^*)]T + (V_2-c)Q. \end{aligned}\tag{A20}$$

(ii) Comparing:

(a) *Advance Selling, No Refunds versus Advance Selling with Refunds*. For any given T,

$$\begin{aligned}\pi_R(T) - \pi_{NR}(T) &= \{[P_{1R}(T) - V_2 + q(V_2 - R^*)]T\} \\ &\quad - \{(P_{iNR}(T) - V_2 + qc\delta)T\} \\ &= [P_{1R}(T) - P_{iNR}(T) + q(V_2 - R^* - c\delta)]T. \end{aligned}$$

Substitute (A17) for $(P_{iNR}(T)$ and (A19) for $(P_{1R}(T)$ and find the derivative of $\{\pi_R(T) - \pi_{NR}(T)\}$ with respect to U and H, respectively:

$$\begin{cases} \dfrac{\partial[\pi_R(T) - \pi_{NR}(T)]}{\partial U} > 0 & \text{if } U \le V_1 \\ \dfrac{\partial[\pi_R(T) - \pi_{NR}(T)]}{\partial H} < 0 & \text{if } U > V_1. \end{cases}$$

Hence, $\pi_R(T) - \pi_{NR}(T) > 0$ if

$$\begin{cases} U > U_0 = \dfrac{H[(1-q)(N_1-T)+N_2]+N_2(V_1-V_2)}{(1-q)(N_1-T)+N_2} & \text{if } U \le V_1 \\ H < H_0 = \dfrac{(1-q)(N_1-T)(V_1-c)+N_2(V_2-c)}{(1-q)(N_1-T)+N_2} & \text{if } U > V_1. \end{cases} \tag{A21}$$

(b) *Advance Selling, No Refunds versus Spot Selling.*

$$\begin{aligned} \pi_{NR}(T) - \pi_s^* &= [(P_{iNR}(T) - V_2 + q\tilde{c})T + (V_2 - c)Q] - (V_2 - c)Q \\ &= (P_{iNR}(T) - V_2 + qc\delta)T \end{aligned}$$

$$\frac{\partial[\pi_{NR}(T) - \pi_s^*]}{\partial Q} = \frac{-(1-q)N_2(V_1-V_2)T}{[(1-q)N_1 + N_2][((1-q)(N_1-T)+N_2)]} < 0. \tag{A22}$$

(A22) reveals that $\pi_{NR}(T) < \pi_s^*$ if Q is sufficiently large. Let $f_{NR-S}(Q) = \pi_{NR}(T) - \pi_s^*$ and $Q_3 = f_{NR-S}^{-1}|_{\pi_{NR}(T)=\pi_s^*}$. Hence, $\pi_{NR}(T) < \pi_s^*$, if $Q > Q_3$.

(c) *Advance Selling with Refunds versus Spot Selling.*

$$\begin{aligned} \pi_R(T) - \pi_s^* &= [(P_{1R}(T) - c) + q(V_2 - R^*)]T \\ &\quad + (V_2 - c)(Q - T) - (V_2 - c)Q \\ &= (P_{1R}(T) + q(V_2 - R^*) - V_2 + c)T, \end{aligned}$$

$$\frac{\partial[\pi_R(T) - \pi_s^*]}{\partial Q} = \frac{-(1-q)N_2(V_1-V_2)T}{[(1-q)N_1 + N_2][((1-q)(N_1-T)+N_2)]} < 0. \tag{A23}$$

(A23) reveals that $\pi_R(T) > \pi_s^*$ if Q is sufficiently small. Let $f_{R-S}(Q) = \pi_R(T) - \pi_s^*$, and $Q_4 = f_{R-S}^{-1}|_{\pi_R(T)=\pi_s^*}$. Hence, $\pi_R(T) > \pi_s^*$ if $Q < Q_4$.

Let T_{NR}^* and T_R^* be the optimal T, $1 < T \le N_1$, under no-refund policy and refund policy, respectively. By definition, $\pi_{NR}^* = \pi_{NR}(T_{NR}^*)$ and $\pi_R^* = \pi_R(T_R^*) \ge \pi_R(T_{NR}^*)$. Taking (a) to (c) together, we have shown $\pi_{NR}^* < \pi_s^* < \pi_R(T_{NR}^*) < \pi_R^*$, if $Q_3 < Q < Q_4$.

Finally, as π_R^* decreases with H but π_s^* is not affected by H, $Q_{\max}$ is a decreasing function of H. To ensure $Q_{\max} > Q_{\min}$ is not an empty set, a sufficiently small H is required. Let $g(H) = Q_{\max} - Q_{\min}$ and $H_1 = g^{-1}|_{Q_{\max}=Q_{\min}}$. Hence, $Q_{\max} > Q_{\min}$ if $H < H_1$. □

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