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Scott Fay,

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Partial-Repeat-Bidding in the Name-Your-Own-Price Channel

Scott Fay

Department of Marketing, University of Florida, Campus Box 117155, Gainesville, Florida 32611-7155, faysa@ufl.edu

This paper presents an initial examination of an emerging business model, the Name-Your-Own-Price (NYOP) channel, as popularized by priceline.com. Focusing on how to optimally structure such market interactions, I ask whether it is more profitable to restrict individuals to a single bid, as is currently done by *Priceline*, or conversely, to allow consumers to continue bidding if the previous offer was rejected. I find that both market structures yield the same expected profit. In practice, a single-bid policy may not be perfectly enforceable, especially in the Internet environment, because a sophisticated user can circumvent such a policy by camouflaging one's identity or otherwise manipulating the bidding procedure. Thus, *Priceline's* single-bid restriction is likely to result in *Partial-Repeat-Bidding*, the case in which some consumers are limited to a single bid while other, sophisticated users may rebid. I ask whether such surreptitious bidding is detrimental to the NYOP firm and find that profits are lower than if such opportunistic behavior were absent. Surprisingly, I find that the impact of the number of repeat bidders on profits is not monotonic. Thus, if it is prohibitively costly or logistically infeasible for the NYOP firm to eliminate surreptitious rebidding behavior, the firm may, in fact, benefit from encouraging, rather than discouraging, users to rebid. The direction that increases profits depends on the percentage of sophisticated bidders.

Key words: priceline; name-your-own-price channel; sequential search; bidding; pricing; e-commerce; reverse auctions

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1. Introduction

1.1. Background and Key Research Questions

The Name-Your-Own-Price (NYOP) channel, as popularized by priceline.com, has rapidly become a familiar business model in e-commerce. Under this system, as in an auction, buyers rather than sellers suggest a price for a product with a transaction occurring only if a seller is willing to accept the quoted price. However, unlike an auction, a NYOP firm faces consumers that arrive asynchronously, thus necessitating the firm to make acceptance decisions before observing all bids. A price threshold determines the minimum acceptable bid. This paper provides an initial examination of this unique market and seeks to address several key managerial questions: (1) What is the optimal price cutoff? (2) Is it profitable to restrict consumers to a single bid? (3) In the event that a single-bid restriction cannot be perfectly enforced, is surreptitious rebidding detrimental to the NYOP firm? (4) If so, does the NYOP firm necessarily benefit from suppressing such behavior, even if complete elimination is not feasible?

As a new, evolving business model, there is no consensus on how to best structure this sales mechanism. For example, in regards to a single-bid restric-

tion, *Priceline* and eBay Travel only allow consumers to place a single bid for a given item.¹ However, other sites, such as *All Cruise Auction* (www.allcruiseauction.com), openly allow consumers to rebid if a previous bid was rejected. There is at least one instance—the undisclosed German intermediary studied in Hann and Terwiesch (2003)—where a NYOP firm has reversed previous restrictions and now allows consumers to rebid. Thus, it appears uncertain as to what effect a single-bid restriction has on profits.² Furthermore, one must note that a single-bid restriction might not be perfectly

¹ *Priceline's* policies, as outlined in its FAQ's (www.priceline.com), state that "the airlines only allow you to make one Name Your Own Price® request for the same itinerary (same price, passengers, cities, and travel dates) within a 7-day period.... Duplicates are automatically swept from our system." This same restriction applies on eBay Travel since it searches via the *Priceline* system.

² On the one hand, if consumers can only bid once, they cannot start low and ratchet up their bids until one is accepted. Thus, they are induced to express a "high willingness-to-pay" (Dolan and Moon 2000) and often end up overpaying (Dolan 2001), i.e., bidding above the actual threshold price. On the other hand, consumers will bid below their reservation value. Thus, for some rejected consumers, their reservation values exceed the "asking price." Allowing such users to rebid could capture some of this lost surplus.

enforceable. On the Internet, which accords the user an inherent degree of anonymity, sophisticated bidders can circumvent the policy by disguising a rebid as if it has originated from a new consumer. For example, one can make repeated bids for the same itinerary on *Priceline* by logging-in with alternate e-mail addresses and using different credit cards.³ There is also an array of techniques that allow consumers to rebid without violating *Priceline's* membership agreement.⁴ Thus, it is important to consider how such surreptitious rebidding affects a NYOP firm.

This paper offers a contribution to the marketing literature on two primary dimensions. First, it presents an initial examination of a unique and important business model. The emergence of the Internet has allowed firms to use a wider range of pricing mechanisms and, thus, how to structure such mechanisms, including the NYOP model, is of increased importance to both practitioners and marketing researchers. Although *Priceline* is the most prominent NYOP firm, many other firms have used some version of this business model to sell both travel and nontravel products.⁵ Large growth of nontraditional auction formats is expected.⁶ However, the reader should be

alerted to the fact that this paper does not provide insight into which markets are most suitable for the NYOP mechanism. In fact, for the simplified model presented in the text, posted prices weakly dominate the NYOP format, thus causing one to question why any retailer would implement the NYOP mechanism.⁷ Second, this paper identifies and studies a novel phenomenon, *Partial-Repeat-Bidding*, i.e., the situation in which a portion of the population is restricted to a single bid while others can rebid. The intuition developed in this paper not only has important implications for NYOP markets but also for a broad range of non-NYOP markets. Modelers commonly assume that the selling mechanism is fully known by all consumers—the firm is committed to posted prices, transactions only occur after negotiation, or, in the case of auctions, that the auction rules are known by all participating parties. Clearly, such assumptions are representative of many store environments—no negotiation occurs at the supermarket; almost all consumers haggle to some degree when making a new-car or used-car purchase.⁸ However, in other environments, negotiation may take place surreptitiously—the publicly stated policy is that the sticker price is nonnegotiable, but price concessions can be obtained if one gains direct access to the manager or owner (i.e., someone who has the authority to haggle).⁹ This paper provides an approach for modeling such situations.

1.2. Related Literature

Although a common topic for the popular press, the NYOP channel has garnered only limited attention from scholars. This paper offers the first attempt to model the NYOP channel from the firm's perspective, considering how one should structure these market interactions. In contrast, previous papers have focused on consumer behavior issues such as calculating the transaction costs of bidding (Hann and Terwiesch 2003), examining whether consumers' bids follow rational patterns (Spann et al. 2004), and studying consumers' attitudes toward "naming" one's price rather than "selecting" a price from a set of alternatives (Chernev 2003).

There is extensive literature in both marketing and in economics on auctions (e.g., Vickrey 1961,

³ This paper is not the first to assert that anonymity can alter market interactions. For example, Friedman and Resnick (2001) study how, in the Internet world, the availability of cheap pseudonyms allows people to easily shed negative reputations and thus makes it more difficult to obtain cooperative behavior in equilibrium.

⁴ For example, Biddingfortravel.com specializes in promoting "informed" bidding on *Priceline*. This site does not endorse any bidding technique that violates *Priceline's* membership agreement. But, it does provide many instances where the nonjet option, allowing for off-peak times and using nonvalid airports, allow for "free rebids." For example, suppose a consumer wishes to fly from Gainesville, FL (GNV) to Kansas City, MO (MCI). FOE is a small airport in Topeka, KS—a city near Kansas City. All available itineraries between GNV and FOE make at least two connections. The consumer could place a bid of \$150 for a one-connection flight between GNV and MCI and not allow travel to FOE. If that bid is rejected, the consumer could now bid \$160 and allow travel to either MCI or to FOE. However, because there are no one-connection flights between GNV and FOE, the consumer has effectively placed a second bid on the same itinerary. Similar strategies can be used when purchasing hotel rooms by manipulating which zones you indicate you are willing to accept. Details on how to generate free rebids are given at <http://pub210.ezboard.com/fpricelineandexpediabiddingmemberannouncements.showMessage?topicID=1137.topic>.

⁵ *Priceline* itself is a significant entity to study, having generated nearly \$3 billion in total revenue since its inception in April 1998 (Williams 2002). *Priceline's* service expands beyond travel services—airline tickets, hotel rooms, rental cars, vacations, and cruises—into long distance, home financing, and new cars. Other sites that have used the NYOP mechanism include *Cybra-Direct*, *imandi*, *MyGeek*, *Respond*, and *NexTag* for nontravel goods (Dolan and Moon 2000, Doyle 2000) and *Expedia's Price Matcher*, *eBay Travel*, and *All Cruise Auction* for travel services.

⁶ *Jupitermedia* predicts that, in contrast to online auction revenues, which are only expected to double between year 2000 and

year 2004, sales through other forms of "dynamic pricing," which includes NYOP, are expected to leap sevenfold during that same period (Hof 2000).

⁷ In the concluding section of this paper, I propose several exogenous considerations that might justify the superiority of the NYOP mechanism.

⁸ See Desai and Purohit (2004) for an examination of how haggling can offer strategic advantages to a firm.

⁹ For example, in many jewelry stores, haggling is possible but not publicized.

Riley and Samuelson 1981, Rothkopf 1991, Sinha and Greenleaf 2000; see McAfee and McMillan 1987 for a survey of the economics literature). However, the NYOP channel differs substantially from the environment studied in the auction literature. In an auction, all potential consumers gather in a common locale and place bids, thus allowing the seller to make decisions based on the entire pool of bids (e.g., sell n items to the n highest bidders). However, a NYOP firm faces consumers that arrive at the firm sequentially, with possibly substantial lags between them. Thus, a bid must be accepted or rejected before all bids have been submitted.¹⁰

Several papers have compared sequential selling to auctions, both when sequential selling takes place through posted prices (De Vany 1987) and when consumers propose their own prices (Arnold and Lippman 1995). Note that the goal of each of these papers is to advise firms on when to use sequential selling and when to employ auctions. In contrast, this paper is concerned with structuring the sequential selling mechanism itself and in how to choose price thresholds. A similar approach is employed by Riley and Zeckhauser (1983), who conclude that a seller encountering risk-neutral buyers one at a time should quote a single take-it-or-leave-it price to each buyer. Although their setting is in some ways more general than my model (i.e., they allow both the firm and consumers to make price offers), a key assumption in their analysis is that the firm can fully commit to any strategy. In the NYOP setting, this would imply that a single-bid restriction is binding for all consumers. In contrast, this paper focuses on a situation in which such a commitment is not possible, i.e., the *Partial-Repeat-Bid* case in which a single-bid restriction is impossible or too costly to perfectly enforce.

The rest of this paper is organized as follows: The basic model is analyzed in §2. Then, the model is extended to incorporate transaction costs for placing bids. Section 3 summarizes the core results, and the appendix contains the mathematical details for this extension. Section 4 offers concluding remarks.

2. Model and Results

2.1. Model

There are q_i identical items to be sold by a monopolist over an exogenously given period of time. The number of risk-neutral consumers is normalized to one. Each buys at most one unit of the product and has a reservation price R_i , where R_i is distributed uniformly on the interval $[a, b]$. Without loss of generality, assume that the marginal cost of production is

zero. With probability λ , q_0 items are available; else q_1 items are available, where $1 > q_1 > q_0 > 0$. Supply is modeled as having only two possible quantity levels to ease exposition. All the results that follow can also be obtained assuming a continuous distribution of quantities, albeit at a cost of increased complexity.

The game sequence is as follows:

I. The firm chooses and announces \underline{P}_0 and \underline{P}_1 (where $\underline{P}_0 \geq \underline{P}_1$).

II. Nature determines the realization of q_i ($i = 0, 1$). This is observed by the firm but not by consumers.

III. Consumers make bids b_i one at a time with order chosen randomly. A transaction occurs at a price of b_i if only if $b_i \geq \underline{P}_i$ and there are units remaining to be sold.¹¹

Discussion of the Model. This paper employs a simple, stylized model, yet it retains many realistic properties that are present in the NYOP channel. First, the model allows consumers to have heterogeneous valuations for the good. Second, it acknowledges that variations in supply may be a source of price fluctuations and because such supply shocks are not observable by consumers, consumers may be uncertain of the price threshold that is in effect. As a concrete example, the number of hotel rooms for a particular city available for sale through *Priceline* will depend on the amount of excess inventory held by its hotel providers. This excess inventory will vary with demand by non-NYOP consumers, influenced by such factors as whether a large conference is in town. Third, the model allows for sequential selling. Independent draws from the population of potential consumers are made one at a time. The first selected consumer arrives at the firm and places a bid. The firm compares this bid to the prevailing threshold price and sells a unit of the good if the bid is at least as great as the threshold price. Then, this process repeats itself as another independent draw is made. Bidding continues until no unserved consumer desires to place a bid. Fourth, all players behave rationally—the firm chooses its threshold price to maximize profit and each consumer's bidding strategy maximizes her expected payoff (given the information she possesses). An equilibrium is defined as a set of prices and bids such that no player can increase its expected payoff through unilateral action.

This setup is roughly in accordance with the procedure followed at *Priceline*.¹² Although its exact pro-

¹⁰ For example, *Priceline* promises to decide whether to accept a bid within one hour of submission, usually in less than 15 minutes. In practice, decisions are usually available within a few minutes.

¹¹ Although this setup allows for the possibility of stock-outs, in equilibrium, no stock-outs will occur because the firm is assumed to be able to perfectly anticipate the distribution of bids. See Bialogorsky and Gerstner (2004) for an example of how contingency pricing can be useful in mitigating situations in which demand cannot be perfectly forecasted.

¹² The use of threshold prices is also consistent with the model proposed by Hann and Terwiesch (2003), whose basis was an undisclosed German NYOP intermediary.

protocols are not publicly disclosed, it is believed that *Priceline* determines minimum acceptable prices based on the excess inventories available at participating carriers (Elkind 1999). A transaction occurs if the price exceeds the “asking price” that is in effect and there is a match available in inventory.¹³

Consumers observe the announced price thresholds but do not observe q_i . Not knowing which cut-off is in effect, each potential bid has an associated probability of acceptance (depending on λ), which I assume is public information.¹⁴ Although *Priceline* does not make such announcements, as noted in footnote 14, there are many sites that list both winning and rejected bids on *Priceline*.¹⁵ Thus, by observing the history of bids and the acceptance decisions, one can approximate the probability of winning. Note that this does not imply that consumers can observe all underlying parameters, i.e., I only require the consumers to know the distribution of price thresholds, not the

factors that determined the firm’s choice. Thus, in the case of Partial-Repeat-Bidding, the consumers who abide by the single-bid restriction are not aware that other consumers have found a surreptitious way to rebid.

Before proceeding further, I note some limitations of this model. A key assumption made in this setup is that the price threshold remains constant throughout the bidding, i.e., once the initial realization of q_i is made, the firm cannot adjust this threshold in response to the realized stream of bids.¹⁶ I also limit consideration to a monopolist. Thus, although in reality there may be multiple NYOP firms offering travel services, I assume that they serve distinct, nonoverlapping segments of consumers. Furthermore, I assume that although the firm knows the distribution of consumer values, it cannot identify individual consumers (and thus set individual-specific prices). These (and other) limitations of this stylized model are described more fully in the concluding section of this paper.

¹³ There are several reasons to believe that acceptance prices are pre-set on *Priceline* rather than searched for on a transaction-by-transaction basis. First, many forums document instances of nearly instantaneous rejections. It seems unlikely that queries to all suppliers could be made so quickly. Second, many users report instances where lower bids have been preferred to higher ones. For example, someone bids \$90 for a 4-star hotel in the Tampa area and is rejected. She then places a bid of \$70 for a 3-star hotel in that same area. This bid is accepted and accommodations are provided at a 4-star hotel. (Note that *Priceline* reserves the right to upgrade any bid.) Either pre-set thresholds are being used or *Priceline* prefers revenues of \$70 to revenues of \$90. The former explanation is more likely.

¹⁴ This model represents a simplification of the observed behavior at *Priceline*. *Priceline*’s partners prohibit it from revealing prices (Lieber 2002). However, other sites such as Biddingfortravel.com, Flyertalk, priceline-deals.com, priceline-bids.com, and Mypriceline.com, at one time or another, have sprung up to provide lists of winning bids. *Priceline* has even encouraged these sites by paying commissions and directing advertising dollars towards them (Lieber 2002). However, because there are variations in “supply-and-demand conditions,” consumers cannot discern “prevailing prices” even if the history of winning bids is observable (Kanna and Kopalle 2001). Note that consumers would be able to deduce the “prevailing prices” if they could observe contemporaneous bids of their peers. However, such an observation is unlikely. Note that a given price threshold likely does not last for a lengthy period of time, maybe a few hours or, at most, a day. Because information sites such as those listed above include reports on only a very small percentage of all bids on *Priceline*, it is rare for a consumer to observe bidding outcomes for a given itinerary that occurred within the past week, let alone the last hour. Instead, one is likely to receive information about bids placed weeks or months earlier. Although this is useful in gauging the general distribution of bid acceptance rates, it does not allow a consumer to observe the price threshold that is currently in effect.

¹⁵ One might also gather this information from personal experience. Datamonitor (2002) reports that a majority of bids on *Priceline* come from consumers that have used the system previously (for presumably similar itineraries). Furthermore, *Priceline* occasionally supplies this information directly to consumers by posting a screen during a user’s session that states the approximate success rates of possible bids, ranging from highly unlikely to highly likely.

2.2. Optimal Consumer Bidding Behavior

To calculate the most profitable threshold prices for the firm, one must first consider how consumers will respond to the range of possible prices. Each consumer chooses her bid(s) to maximize expected surplus given the information she possesses. Several characteristics of optimal behavior are immediately evident. First, only bids of \underline{p}_1 and \underline{p}_0 can be optimal. Bidding above \underline{p}_0 is never optimal because, compared to $b_i = \underline{p}_0$, it does not increase one’s probability of acceptance but does decrease the payoff from an accepted bid. Likewise, $b_i = \underline{p}_1$ is strictly preferred to $\underline{p}_0 > b_i > \underline{p}_1$. Second, a consumer would never choose to bid above her reservation value. Third, optimal bidding behavior depends on the rules of the game, e.g., whether the consumer can rebid if her initial bid is rejected.

Repeat Bid. In general, if there is no restriction against rebidding and no costs of placing bids,¹⁷ each consumer will optimally start low and keep bidding until either she reaches her reservation value or her

¹⁶ The motivation for this assumption is that although bid acceptance levels in NYOP markets do fluctuate over time, price thresholds seem to be fixed over finite intervals. Perhaps, reoptimization of prices occurs only in discrete intervals. For example, every x hours, the firm readjusts its prices (given its existing inventory and predicted demand); or, an exogenous shock in its inventory allotment motivates the firm to revisit its price threshold (e.g., Hotel Y appropriates a block of rooms to *Priceline*). The model’s validity simply requires multiple bids be placed within a time frame in which the price threshold is held constant. This period of time does not have to be lengthy.

¹⁷ The case of positive bidding costs is explored as an extension to this model in §3.

bid is accepted, whichever comes first.¹⁸ With only two threshold prices, the optimal bidding sequence is to first bid \underline{P}_1 as long as $\underline{P}_1 \leq R_i$. Then, one bids \underline{P}_0 if that first bid was rejected and $\underline{P}_0 \leq R_i$. Thus, the optimal bid sequence is

$$b_i = \begin{cases} \underline{P}_1; \underline{P}_0 & \text{if } R_i \geq \underline{P}_0, \\ \underline{P}_1 & \text{if } \underline{P}_0 > R_i \geq \underline{P}_1, \\ 0 & \text{if } \underline{P}_1 > R_i. \end{cases} \quad (1)$$

Single Bid. If a consumer is restricted to place at most one bid, she chooses the bid that yields the highest expected surplus. This optimal bid is

$$b_i = \begin{cases} 0 & \text{if } \underline{P}_1 > R_i; \text{ else} \\ \underline{P}_1 & \text{if } (R_i - \underline{P}_1) \cdot \text{prob}(\text{win bid} | \underline{P}_1) > (R_i - \underline{P}_0) \cdot \text{prob}(\text{win bid} | \underline{P}_0), \\ \underline{P}_0 & \text{if } (R_i - \underline{P}_0) \cdot \text{prob}(\text{win bid} | \underline{P}_0) \geq (R_i - \underline{P}_1) \cdot \text{prob}(\text{win bid} | \underline{P}_1). \end{cases} \quad (2)$$

Thus, to determine her optimal bid, the consumer must take into account the probability of winning her bid.

2.3. Firm Pricing and Profits

A fundamental question in structuring NYOP transactions is: Does the firm benefit from limiting consumers to a single bid? Proposition 1 compares the profits with and without a single-bid restriction.

PROPOSITION 1. *Expected profit when all consumers are limited to a single bid is equal to expected profit when all consumers are given the option to rebid.*

PROOF. If consumers can all rebid (the *All-Repeat-Bid* case), they follow the strategy given in Equation (1). Given \underline{P}_i , the firm will sell to all consumers for which $R_i \geq \underline{P}_i$. To sell q_i units, the firm chooses \underline{P}_i such that $q_i = (b - \underline{P}_i)/(b - a)$ or $\underline{P}_i = b - q_i(b - a)$ for $i = 0, 1$. This yields a profit given in the last column of Table 1.²⁰ For the firm to optimize by selling all q_i units, profit must be increasing in q_i . This requires the additional condition that $a > b(1 - 1/(2q_i))$. Because $q_i < 1$, a sufficient condition is

$$a > \frac{b}{2}. \quad (3)$$

¹⁸ An implicit assumption is that a second bid can be made instantaneously. Thus, the same price threshold will be in effect for both bids.

¹⁹ I assume that in the case of indifference between two bids, the consumer chooses the higher bid. This assumption is not critical for the results that follow.

²⁰ This would also be the outcome under an English, ascending-bid auction in which units are sold to the q_i highest bidders (assuming that there are no transaction costs associated with delaying acceptance decisions until all bids have been submitted).

Table 1 Profit and Prices Under Single-Bid and All-Repeat-Bid

Single-Bid	All-Repeat-Bid	Profit
$\underline{P}_0^{\text{SB}} = b - (\lambda q_0 + (1 - \lambda)q_1) \cdot (b - a)$	$\underline{P}_0^{\text{ARB}} = b - q_0(b - a)$	$\lambda q_0(b - q_0(b - a)) + (1 - \lambda) \cdot q_1(b - q_1(b - a))$
$\underline{P}_1 = b - q_1(b - a)$	$\underline{P}_1 = b - q_1(b - a)$	

For the remainder of the paper, condition (3) is assumed to hold.

Now, consider the effect of a single-bid restriction assuming it is perfectly enforced, i.e., the *Single-Bid* case. Consumers follow the strategy given in (2). If one bids \underline{P}_0 , then her bid is accepted in both states-of-the-world and $\text{prob}(\text{win bid} | \underline{P}_0) = 1$. However, a bid of \underline{P}_1 is accepted only in the high-supply state: $\text{prob}(\text{win bid} | \underline{P}_1) = (1 - \lambda)$.²¹ Define \hat{R} as the reservation value such that the surplus from bidding \underline{P}_1 equals the surplus from bidding \underline{P}_0 : $(1 - \lambda)(\hat{R} - \underline{P}_1) = \hat{R} - \underline{P}_0$. This is solved by

$$\hat{R} = \frac{\underline{P}_0 - \underline{P}_1(1 - \lambda)}{\lambda}. \quad (4)$$

Consumers with $R_i \geq \hat{R}$ bid \underline{P}_0 ; those with $\underline{P}_1 \leq R_i < \hat{R}$ bid \underline{P}_1 . Note that all consumers with $R_i \geq \underline{P}_1$ will place an acceptable bid in the high-supply state. To sell all q_1 units, the firm sets $\underline{P}_1 = b - q_1(b - a)$ —the same as in *All-Repeat-Bid*. Only consumers with $R_i \geq \hat{R}$ bid acceptably high in the low-supply state. To sell all q_0 units, the firm sets \underline{P}_0 such that $\hat{R} = b - q_0(b - a)$. Substituting for \hat{R} from (4) and using $\underline{P}_1 = b - q_1(b - a)$ yields the optimal price threshold, $\underline{P}_0^{\text{SB}}$, listed in the first column of Table 1. Profit to the firm is

$$\Pi_{\text{SB}} = \underline{P}_0^{\text{SB}} \frac{b - \hat{R}}{b - a} + (1 - \lambda) \underline{P}_1 \frac{\hat{R} - \underline{P}_1}{b - a}.$$

Substituting for $\underline{P}_0^{\text{SB}}$, \underline{P}_1 , and \hat{R} , reduces to the same profit as *All-Repeat-Bid*, given in the last column of Table 1.

Discussion. In *Single-Bid*, high-value consumers ($R_i \geq \hat{R}$) bid $\underline{P}_0^{\text{SB}}$ in both states-of-the-world. In comparison to *All-Repeat-Bid*, the firm earns less profit in the low-supply state because $\underline{P}_0^{\text{SB}} < \underline{P}_0^{\text{ARB}}$. But, this is offset by the increase in revenue in the high-supply state because these consumers pay $\underline{P}_0^{\text{SB}}$ rather than \underline{P}_1 .²²

²¹ These probabilities assume there are no stock-outs, i.e., situations where a bid exceeds the threshold price but no units remain to be sold. Given that the firm has full information about the distribution of reservation values, the firm will never optimize by choosing such a low price because in that case, the firm could improve its profit by marginally increasing its price.

²² Note that welfare under the two scenarios is identical because distribution of the product is the same in both cases, i.e., the q_i

2.4. Partial-Repeat-Bidding

Suppose that some consumers are aware of techniques to circumvent a single-bid restriction, as was discussed in the introduction of this paper. If a NYOP firm establishes a single-bid policy, some consumers will be able to rebid when an initial bid is rejected, while others will not. To model this situation, suppose a random percentage (ρ) of consumers can rebid. I label these consumers as sophisticated.²³ There are now two distinct segments of consumers. The sophisticated consumers follow the bidding strategy described by Equation (1). The unsophisticated consumers follow the bidding strategy given by Equation (2).

How does Partial-Repeat-Bidding affect the firm's profitability? The answer is summarized in Proposition 2.

PROPOSITION 2. *The presence of sophisticated consumers reduces profit to the firm (compared to Single-Bid and All-Repeat-Bid). However, the impact of the percentage of sophisticated consumers on profit is not monotonic. If the portion of sophisticated consumers is sufficiently small ($\rho < 1/(1 + \lambda)$), profit is decreasing in ρ . However, for larger values of ρ ($\rho > 1/(1 + \lambda)$), profit is increasing in ρ .*

PROOF. In the high-supply state, both sophisticated and unsophisticated consumers with $R_i > \underline{P}_1$ will place acceptable bids. To sell all q_1 units, the firm sets $\underline{P}_1 = b - q_1(b - a)$ —the same as before. However, the setting of \underline{P}_0 is a bit more complex. The sophisticated consumers with $R_i \geq \underline{P}_0$ will (eventually) place acceptable bids in the low-supply state. This will result in $\rho(b - \underline{P}_0)/(b - a)$ sales. For the unsophisticated consumers, only those with $R_i \geq \hat{R}$ will place an acceptable bid. The size of this segment is $(1 - \rho)(b - \hat{R})/(b - a)$.²⁴ To find the optimal \underline{P}_0 , set total

highest-value consumers receive the good. Thus, total consumer surplus is also unaffected by this single-bid restriction. Furthermore, standard posted prices could also mimic this outcome, posting a price of $\underline{P}_0^{\text{ARB}}$ in the low-supply state and a price of \underline{P}_1 in the high-supply state.

²³ This terminology is used merely to distinguish those consumers who are aware of the option to rebid from those consumers for which a single-bid restriction is binding. Both unsophisticated and sophisticated consumers are assumed to be utility-maximizing decision makers who are aware of the price thresholds and the probability of success for each of these thresholds. For example, one could think of sophisticated users of *Priceline* as those who are familiar with the rebidding techniques described on the Biddingfortravel.com site (as discussed in footnote 4).

²⁴ This derivation assumes that at least some unsophisticated consumers will place a bid of \underline{P}_0 . This will be true only if $q_0 > q_1\rho(1 - \lambda)$. If this condition is not met, then the firm sets \underline{P}_0 knowing that demand only will come from the sophisticated users: $\rho(b - \underline{P}_0)/(b - a) = q_0$. This results in a price threshold $\underline{P}_0^{\text{PR}} = b - q_0(b - a)/\rho$. The firm earns a profit of $\lambda q_0 \underline{P}_0^{\text{PR}} + (1 - \lambda)q_1 \underline{P}_1 = \lambda q_0(b - q_0(b - a)/\rho) + (1 - \lambda)q_1(b - q_1(b - a)/\rho)$, which is strictly less than Π_{SB} for all $\rho < 1$.

demand equal to the quantity available for sale:

$$\rho \frac{b - \underline{P}_0}{b - a} + (1 - \rho) \frac{b - \hat{R}}{b - a} = q_0. \quad (5)$$

Substituting for \hat{R} using (4) and $\underline{P}_1 = b - q_1(b - a)$, one derives the threshold in the low-supply state:

$$\underline{P}_0^{\text{PR}} = b - q_1(b - a) + \frac{\lambda(q_1 - q_0)(b - a)}{1 - \rho(1 - \lambda)}. \quad (6)$$

The profit to the firm is

$$\begin{aligned} \Pi_{\text{PR}} = & (1 - \rho) \left[\underline{P}_0^{\text{PR}} \frac{b - \hat{R}}{b - a} + (1 - \lambda) \underline{P}_1 \frac{\hat{R} - \underline{P}_1}{b - a} \right] \\ & + \rho \left[\lambda \underline{P}_0^{\text{PR}} \frac{b - \underline{P}_0^{\text{PR}}}{b - a} + (1 - \lambda) \underline{P}_1 \frac{b - \underline{P}_1}{b - a} \right]. \end{aligned} \quad (7)$$

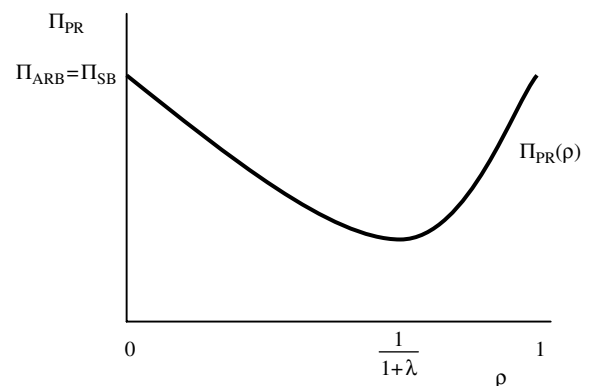
This equation is long and complex once one substitutes for the price thresholds and \hat{R} . However, it is straightforward to verify that $\underline{P}_0^{\text{PR}} = \underline{P}_0^{\text{SB}}$ (and thus $\Pi_{\text{PR}} = \Pi_{\text{SB}}$) when $\rho = 0$ and $\underline{P}_0^{\text{PR}} = \underline{P}_0^{\text{ARB}}$ (and thus $\Pi_{\text{PR}} = \Pi_{\text{ARB}}$) when $\rho = 1$. Furthermore, the derivative of profit with respect to ρ is

$$\frac{\partial \Pi_{\text{PR}}}{\partial \rho} = \frac{\lambda(b - a)(1 - \lambda)^2(q_1 - q_0)^2(-1 + \rho + \lambda\rho)}{(1 - \rho(1 - \lambda))^3}. \quad (8)$$

Note that all terms except for $(-1 + \rho + \lambda\rho)$ can be signed as positive for all relevant parameter values. Thus, the sign of $\partial \Pi_{\text{PR}}/\partial \rho$ is the sign of $(-1 + \rho + \lambda\rho)$. This is negative for $\rho < 1/(1 + \lambda)$ and positive for $\rho > 1/(1 + \lambda)$. So, profits follow a nonmonotonic pattern as illustrated in Figure 1. Profits would be maximized at either $\rho = 0$ or $\rho = 1$.

Discussion. The case of *Partial-Repeat-Bidding* is treacherous for the firm. The price threshold that maximizes profit on the segment of consumers that can rebid is higher than the optimal threshold for consumers that are effectively restricted to a single bid. If there are consumers in both segments, then a single

Figure 1 Profit Under Partial-Repeat-Bidding as a Function of ρ



price threshold cannot be optimal for each segment simultaneously. On the one hand, if the firm establishes a price threshold optimized for the single-bid segment (i.e., at a moderate level), the sophisticated consumers, especially those with high reservation values, will act to the detriment of the firm by taking advantage of the low prices that prevail in the high-supply state. On the other hand, a high price threshold targeted at the sophisticated consumers makes it difficult to attract suitable bids from the segment that is restricted to a single bid. Instead, unsophisticated consumers are likely to bid low and, thus, only receive the good in the high-supply state.

These results suggest that the NYOP firm would like to completely eliminate repeat bidding or ensure that all consumers are aware of this option. However, in some situations, neither of these options may be available to the firm. For example, it is unlikely that *Priceline's* single-bid restriction is perfectly enforced. Eliminating all rebidding may be infeasible due to technological constraints or because such restrictions may be too costly to enforce. Furthermore, allowing all consumers to rebid would probably violate *Priceline's* agreement with its suppliers.²⁵ Thus, global changes in ρ may not be at the firm's discretion. Instead, the firm may only be able to implement incremental policy changes that will push ρ in one direction or another. For example, *Priceline* could increase its advertising on Biddingfortravel.com. This funding would add legitimacy to the site as well as subsidize the site's efforts to generate awareness. The results given in Proposition 2 suggest that if ρ is small, *Priceline* should decrease support for an information source such as *BiddingForTravel*. If there are few sophisticated consumers, price thresholds will be chosen so as to target the unsophisticated consumers and, thus, the firm would like to decrease the amount of surreptitious bidding that is occurring. However, if the number of sophisticated consumers is large, prices are targeted at this segment and it is the unsophisticated consumers that are acting against the firm's interest by not continuing to bid in those cases when their reservation values exceed the threshold price. Here, *Priceline* would benefit from engaging in actions that make the loopholes in its single-bid restriction more widely known.

3. Transaction Costs

The previous section assumed that bidding is costless for the consumer. In this section, I extend the model to account for transaction costs, which previous research has found to be of modest size (Hann

and Terwiesch 2003).²⁶ Such costs include the time required to log onto the NYOP site, to select bid parameters (e.g., dates of travel, origination, destination, and maximum number of connections when bidding on air travel), to choose a bid price, to enter payment information, and to wait for a response as to whether the bid was accepted. Suppose the cost of placing an initial bid is c_0 and the cost of placing a second bid is c . I allow for rebidding costs to differ from the cost of placing the initial bid because the required steps may differ under these two procedures. For example, to rebid one might not need to reenter the itinerary and payment information, but only needs to adjust the bid amount (implying $c < c_0$).

A consumer whose first bid is accepted earns a net surplus of $R_i - b_i - c_0$. If that initial bid is rejected but her second bid of $b_{i,0}$ is accepted, the surplus would be $R_i - b_{i,0} - c_0 - c$. If neither bid is accepted, her surplus is $-(c_0 + c)$. Note that when there are transaction costs, a consumer who can rebid may not necessarily initiate bidding at the low price threshold (\underline{p}_0), as prescribed in Equation (1). Instead, she may bid at the higher threshold (\underline{p}_1) to reduce the amount of transaction costs she will incur. Such a strategy will be optimal for the consumer if c is sufficiently large or if the difference between the two threshold prices is sufficiently small.

The presence of transaction costs impacts the firm in a number of ways. Not surprisingly, consumers are not willing to pay as much for the product if they incur costs when bidding. What is more interesting is that transaction costs affect the profit from the available bidding mechanisms asymmetrically. Proposition 3 summarizes the important findings.

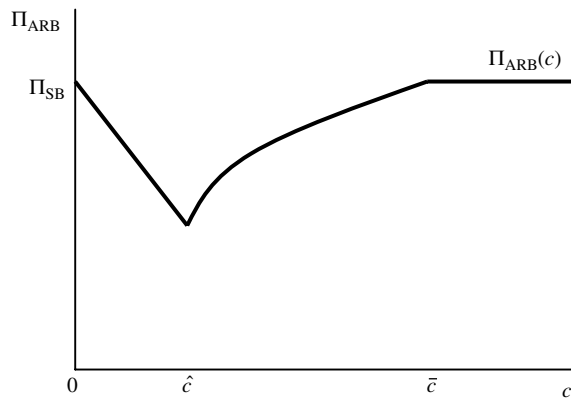
PROPOSITION 3. *In the absence of sophisticated consumers, the firm strictly benefits from imposing a single-bid restriction as long as transaction costs are not too large ($c_0 < \bar{c}_0$ and $c < \bar{c}$, where $\bar{c}_0 = (1 - \lambda)(b - 2q_1(b - a))$ and $\bar{c} = c_0 + (b - a)(1 - \lambda)(q_1 - q_0)$). The presence of sophisticated consumers reduces profit to the firm compared to Single-Bid. Profit under Partial-Repeat-Bidding follows a U-shaped pattern, indicating that profit is decreasing in ρ if the portion of sophisticated consumers is sufficiently small, but increasing in ρ for larger values of ρ .*

In the appendix, I derive the results summarized in Proposition 3. In the text, I provide a brief description of the intuition behind these results.

Proposition 3 compares the profits with and without a single-bid restriction when there is perfect enforcement of this restriction. The equivalency

²⁵ *Priceline* asserts that the airlines themselves require it to impose the single-bid restriction. See Footnote 1.

²⁶ This paper, using data from a German NYOP intermediary that sold products valued at approximately \$100 each, calculated transaction costs to be on the order of 5.50 Euro—or approximately \$5.00.

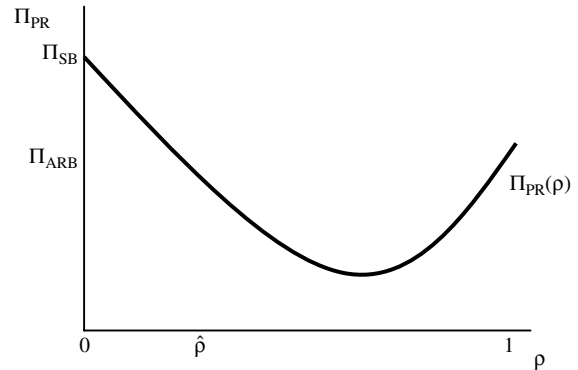
Figure 2 Profit Under All-Repeat-Bid as a Function of c 

result found in the absence of transaction costs (Proposition 1) no longer holds. Figure 2 shows how profit under *All-Repeat-Bid* varies with the cost of placing a second bid, c . It is obvious from Figure 2 that profits in *All-Repeat-Bid* are not monotonic in c . Note that, in the absence of transaction costs, more bidding occurs under *All-Repeat-Bid* than in *Single-Bid*, i.e., those consumers with reservation values above \hat{R} will place a second bid in the low-supply state. When such bidding is costly, the extra transaction costs reduce how high consumers will be willing to bid on a second try.²⁷ As c becomes larger, this maximum second bid becomes smaller and, thus, profit to the firm is reduced. This situation is represented by the downward-sloping portion of $\Pi_{ARB}(c < \hat{c})$. However, the firm could reduce the difference between the low-supply and high-supply thresholds so that some consumers will forego placing a low initial bid of \underline{P}_1 . This is optimal for $c > \hat{c}$. Let \hat{P} represent the price threshold such that consumers are indifferent between bidding \hat{P} initially rather than first bidding \underline{P}_1 and then \hat{P} if that first bid fails.²⁸ Although setting $\underline{P}_0 = \hat{P}$ reduces the price paid in the low-supply state, it increases the average price paid in the high-supply state. As c increases, \hat{P} increases, i.e., it becomes easier to induce consumers to forego placing a low initial bid, and thus also is more profitable. If c is sufficiently large ($c \geq \bar{c}$), consumers will not place a second bid even if the firm sets the same price thresholds as in the *Single-Bid* case. Thus, profit without a single-bid restriction will be the same as profit without such a restriction.

²⁷ Transaction costs (c_0) will also reduce consumers' initial bids. However, because all mechanisms require at least one bid, the effect on profit from c_0 is symmetric across the *All-Repeat-Bid*, *Single-Bid*, and *Partial-Repeat-Bidding* cases. The constraint on c_0 that is imposed in Proposition 3 ensures that the firm maintains its incentive to sell all q_i units.

²⁸ Note that both these strategies lead to accepted bids in both states-of-the-world. Thus, \hat{P} will not be a function of R_i .

Figure 3 Profit Under Partial-Repeat-Bidding When There Are Transaction Costs



Now turn to the case of *Partial-Repeat-Bidding*. Figure 3 depicts how profit will vary with ρ . Note that this figure assumes that transaction costs are positive but not overwhelmingly large, i.e., $c < \hat{c}$ and c_0 satisfies the condition given in Proposition 3.²⁹ Thus, $\Pi_{SB} > \Pi_{ARB}$. By definition, $\Pi_{PR} = \Pi_{SB}$ when $\rho = 0$ and $\Pi_{PR} = \Pi_{ARB}$ when $\rho = 1$. *Single-Bid* remains more profitable than *Partial-Repeat-Bidding* when there are positive transaction costs. In addition to the intuition developed in the basic model, surreptitious rebidding now has another disadvantage: it reduces the available surplus because additional frictional costs are incurred by sophisticated consumers. In comparison to *All-Repeat-Bid*, the impact of *Partial-Repeat-Bidding* is less clear. Giving only some, rather than all, consumers the option to rebid can enhance profit. By discouraging some high-value consumers from rebidding, transaction costs can be avoided and, thus, a higher threshold price can be maintained. Note that the size of this beneficial effect is decreasing in ρ . But, on the other hand, intuition developed in §2.4 indicates that the disparity in bidding strategies between sophisticated and unsophisticated consumers makes it more difficult to extract the surplus of these consumers. When ρ is sufficiently small ($\rho < \hat{\rho}$), this first effect will dominate and thus $\Pi_{PR} > \Pi_{ARB}$. When the proportion of sophisticated consumers is sufficiently large ($\rho > \hat{\rho}$), the firm will be more profitable under *All-Repeat-Bid*.

4. Concluding Remarks

Managerial Implications

The results from this paper offer guidance on how a NYOP firm can establish bidding rules to maxi-

²⁹ If $c > \hat{c}$, when all consumers can rebid, the firm would choose its price thresholds such that no consumers will rebid. This same equilibrium could be replicated in *Partial-Repeat-Bidding*. Thus, for all ρ , we would have $\Pi_{PR} \geq \Pi_{ARB}$. For even larger c ($c > \bar{c}$), no consumers would want to place a second bid even at *Single-Bid* equilibrium prices. In this case, $\Pi_{PR} = \Pi_{ARB} = \Pi_{SB}$ for all ρ .

mize its profit. Proposition 1 shows that a single-bid restriction does not improve a firm's profit, i.e., the firm could do just as well by allowing all of its customers to rebid. This may seem to imply that either policy is equally good. However, one should note that it is likely to be technically difficult or costly to enforce a single-bid policy, especially in the online environment in which users can easily mask their true identities. Furthermore, Proposition 2 indicates that such surreptitious rebidding will reduce profit. On the other hand, a policy of allowing all consumers to rebid could be instituted quite easily by announcing the rebid option on the site and by reminding each person whose bid was rejected that she could "try again." This analysis suggests that a NYOP firm that is currently using a single-bid restriction, such as *Priceline*, could improve its profit by eliminating such a restriction.

This relatively strong recommendation should be tempered a bit. First, it is necessary to note that the preceding results are derived from a model that assumes consumers do not incur any costs of bidding. In fact, casual observation reveals that such frictional costs are present, e.g., a consumer must wait for a response to a previous bid before proceeding on with a subsequent bid. Previous research (in a similar setting to this paper) has measured such costs as being nontrivial (Hann and Terwiesch 2003). Once one accounts for these transaction costs (Proposition 3), the single-bid restriction, assuming it is perfectly enforced, does strictly benefit the firm. Furthermore, even if such a restriction cannot be perfectly enforced, it may be preferable to a policy that openly allows rebidding. This will be true if surreptitious bidding is relatively rare. On the other hand, if violations of the single-bid restriction are more prevalent ($\rho > \hat{\rho}$), we return to the recommendation that the firm should eliminate this restriction.

Second, we need to be aware that a firm may face external constraints that prevent it from following this recommendation. For example, *Priceline's* suppliers may voice strong objections if *Priceline* were to switch to a policy of openly allowing rebids and, thus, openly reveal the prices that are prevailing on this channel.³⁰ In this case, the firm is constrained to impose a single-bid restriction, with some amount of surreptitious rebidding being inevitable. However, the firm may be able to influence the magnitude of this rebidding to enhance profit. If this surreptitious behavior is relatively rare, then one could improve profit by engaging in actions

that discourage such rebidding. For example, *Priceline* could refuse to advertise on information sites, such as *Biddingfortravel.com*, which describe ways to rebid; it could attempt to close loop-holes within its site that can be used to generate "free rebids"; or, it could terminate the accounts of users that violate this single-bid restriction. On the other hand, the results in Proposition 2 indicate that the firm would benefit from *encouraging* rebids if surreptitious rebidding is already prevalent. In short, *Priceline* should attempt to gauge how much surreptitious rebidding is occurring, or else, it does not know whether to treat the violators of its single-bid policy and sites such as *BiddingForTravel* as foes or as partners.

Limitations and Directions for Future Research

This paper represents a first step at studying the NYOP channel. As such, there are several important unresolved issues relating to this channel that would be ripe for future research. One such issue is that this manuscript does not provide a justification for why a firm would employ an NYOP mechanism rather than posted prices or an auction format because both of these mechanisms weakly dominate NYOP in this simple framework.³¹ Several possible advantages of the NYOP mechanism are: it may soften competition (because it makes prices less visible and more difficult to compare across channels); it allows the firm to collect better information about demand (thus providing guidance for subsequent inventory and targeting decisions); or it appeals to a particular segment³² that receives a psychological benefit from purchasing through this unique mechanism (perhaps because it gives them a feeling of greater control over purchase price or makes them think they are getting a "good deal").³³

There are a number of limitations of the stylized model employed in this paper, thus causing one to question the robustness of the preceding results. Future research should address some of the most prominent modeling assumptions. These include:

1. *The current model is primarily static.* Price thresholds are adjusted with the initial realization of q_i , but then held constant throughout the exogenously

³⁰ Such objections may also help explain why a firm would use the more onerous NYOP mechanism in the first place rather than the simpler mechanism of posted prices.

³¹ One would need to address this limitation to determine whether NYOP is likely to become more prevalent than is currently observed.

³² In recent work, Chen et al. (2002) demonstrate how the introduction of an "infomediary" may allow for enhanced price discrimination. Similarly, an NYOP firm offers an additional channel through which to market to consumers. Presumably, this supplemental channel would be particularly useful to a supplier if the segment of consumers that patronage a NYOP site would not purchase through traditional channels.

³³ The author thanks the area editor and editor for many of these suggestions.

given bidding period. Such a restriction prevents one from accounting for some undoubtedly interesting dynamics. On the supply side, the NYOP firm may be able to alter the price threshold in a more continuous fashion to adjust for depletion of its inventory levels and to account for the information that is revealed through the bid realizations that have thus far been observed. Perhaps, rather than allowing price thresholds to be adjusted continuously, a more simple extension would be to have the length of the bidding period determined endogenously, e.g., the firm sets a cutoff such that if inventory drops below this cutoff, the firm will reoptimize the price threshold. Furthermore, consumers' bidding strategies may contain interesting dynamics. Note that real consumers choose not only whether to bid/rebid but also when to do so, e.g., a consumer could defer bidding until a later date in the hope that the price threshold may drop. Thus, it would be interesting to consider how expectations of price fluctuations affect bidding behavior and how that impacts the optimal structure of the NYOP mechanism.

2. *The assumption of a monopoly NYOP firm.* It would be interesting to determine whether the primary results of this paper extend to the case of competition.³⁴ In reality, a NYOP firm is likely to face competition both from other rivals that employ the NYOP mechanism as well as from competitors in other more traditional channels.³⁵ For example, airlines must decide how to allocate seats among a variety of travel agencies. The number of seats allotted to the NYOP channel impacts the price in each channel and, thus, also consumers' choices between the NYOP and non-NYOP channels.

3. *The assumption that consumers are perfectly informed.* In reality, Priceline does not announce threshold prices or the density function for these thresholds.

4. *The absence of buyer regret.* A common feeling expressed by users of priceline.com is that they overpaid for the product—"If Priceline accepted this bid, how much lower could I have bid?" Humphrey et al. (2004) provides an initial study of emotional response

to a brokered ultimatum game, emphasizing how the process of a current negotiation can influence one's willingness to revisit that site.

5. *Issues of fairness are ignored.* Consumers may view the outcome under *All-Repeat-Bid* as being more equitable because everyone pays the same price. In contrast, under a single-bid policy, there is heterogeneity in the price paid.³⁶

Acknowledgments

The author thanks Steve Shugan, the area editor, and four anonymous reviewers for their insightful and constructive feedback. This paper was presented at the 2003 Marketing Science Conference at the University of Maryland. I appreciate all of the comments made by seminar participants.

Appendix

Transaction Costs: Derivation of Proposition 3

Single-Bid. Define \hat{R}_L as the minimum R_i that would be willing to bid \underline{P}_1 (assuming that this bid will be accepted if only if the high-supply state is realized). At this reservation value the consumer is indifferent between bidding \underline{P}_1 (and only winning her bid with probability $1 - \lambda$) and not bidding at all: $(1 - \lambda)(\hat{R}_L - \underline{P}_1) - c_0 = 0$. This reduces to

$$\hat{R}_L = \underline{P}_1 + \frac{c_0}{1 - \lambda}. \quad (\text{A.1})$$

All consumers with reservation values above this threshold will place an acceptable bid in the high-supply state. The firm will set \underline{P}_1 so as to sell all q_1 units: $(b - \hat{R}_L)/(b - a) = q_1$. Substituting in for \hat{R}_L and solving for \underline{P}_1 yields

$$\underline{P}_1 = b - q_1(b - a) - \frac{c_0}{1 - \lambda}. \quad (\text{A.2})$$

Define \hat{R} as the R_i that is indifferent between bidding \underline{P}_1 and bidding \underline{P}_0 : $(1 - \lambda)(\hat{R} - \underline{P}_1) - c_0 = \hat{R} - \underline{P}_0 - c_0$. This reduces to the expression given in (4). Only consumers with reservation values above \hat{R} place an acceptable bid in the low-supply state. Setting this demand equal to q_0 : $(b - \hat{R})/(b - a) = q_0$, one solves for the optimal price threshold (using Equation (4) and \underline{P}_1 derived in (A.2))

$$\underline{P}_0^{\text{SB}} = b - (b - a)(\lambda q_0 + (1 - \lambda)q_1) - c_0. \quad (\text{A.3})$$

Profit to the firm is $q_0 \underline{P}_0^{\text{SB}} + (1 - \lambda)(q_1 - q_0)\underline{P}_1$. Substituting in the price thresholds given in (A.2) and (A.3),

$$\Pi_{\text{SB}} = \lambda q_0(b - q_0(b - a)) + (1 - \lambda)q_1(b - q_1(b - a)) - q_1 c_0. \quad (\text{A.4})$$

This expression assumes that the firm will sell all available units. For this to be the optimal strategy, profits must be increasing in q_i . Requiring the derivative of Π_{SB} w.r.t. q_1 to be positive leads to the condition $c_0 < \bar{c}_0$, where \bar{c}_0 is defined in Proposition 3. Note that this is a stronger condition than the one imposed by condition (3).

³⁴ See Shankar and Bolton (2004) for an empirical examination of how competitor factors influence retailers' pricing strategies.

³⁵ Note that a NYOP firm can influence its appeal to consumers (and the degree of cannibalization of sales through traditional channels) by adjusting the structure of its selling mechanism, e.g., bidding restrictions, the size of transaction costs, and the version of the product it offers. For example, airline tickets purchased through traditional travel agencies are for a specific itinerary. However, a ticket on Priceline is airline transportation from point A to point B on a particular day, but on an unnamed airline/aircraft at an unnamed time through an unnamed connection. One could adjust the appeal of the NYOP product and the level of competition between channels by altering what information is revealed to consumers, e.g., allowing users to select an evening arrival time rather than the current 6 am–10 pm window.

³⁶ For example, in *Single-Bid*, transactions occur at both $\underline{P}_0^{\text{SB}}$ and \underline{P}_1 in the high-supply state (where $\underline{P}_0^{\text{SB}} > \underline{P}_1$).

All-Repeat-Bid. When all consumers have the option to rebid, there is no change in the derivation of the price in the high-supply state and, thus, the optimum threshold is given by (A.2). The optimal low-supply state is a bit more complex and depends on whether or not any consumers will actually use their option to rebid. First, assume that rebidding does occur (as will be expected when c is sufficiently small). The downward-sloping segment of Figure 2 illustrates this case. A consumer whose initial bid of \underline{P}_1 is rejected will be willing to bid $\underline{P}_0^{\text{ARB}}$ only if $R_i - c \geq \underline{P}_0^{\text{ARB}}$. Thus, demand in the low-supply state will be: $(b - (\underline{P}_0^{\text{ARB}} + c)) / (b - a)$. Setting this equal to the supply, q_0 , and solving for $\underline{P}_0^{\text{ARB}}$, yields

$$\underline{P}_0^{\text{ARB}} = b - q_0(b - a) - c. \quad (\text{A.5})$$

Profit to the firm will be $\lambda q_0 \underline{P}_0^{\text{ARB}} + (1 - \lambda) q_1 \underline{P}_1$. Substituting in the price thresholds from (A.2) and (A.5),

$$\Pi_{\text{ARB}} = \lambda q_0(b - q_0(b - a)) + (1 - \lambda) q_1(b - q_1(b - a)) - q_1 c_0 - \lambda q_0 c. \quad (\text{A.6})$$

Note that (A.6) and (A.4) only differ in the last term ($-\lambda q_0 c$). Thus, profit is strictly higher when no consumer can rebid and this difference is increasing in c .

The preceding analysis assumes that consumers will rebid. However, if c is sufficiently large, the consumer would prefer to initiate bidding at the higher threshold price to avoid this bidding cost. Furthermore, the firm could manipulate \underline{P}_0 to induce consumers to forego an initial low bid. Define \hat{P} as the price for which a consumer is indifferent between only bidding \hat{P} and the strategy of first bidding \underline{P}_1 and then bidding \hat{P} if that bid is rejected. This will hold if $\lambda c = (1 - \lambda)(\hat{P} - \underline{P}_1)$ —the expected benefit from avoiding the cost of rebidding is exactly offset by the expected increase in the price paid. Using (A.2), one can solve for \hat{P} :

$$\hat{P} = b - q_1(b - a) - \frac{c_0}{1 - \lambda} + \frac{\lambda}{1 - \lambda} c. \quad (\text{A.7})$$

Note that this price is increasing in c , i.e., it is easier to induce consumers to forego rebidding as c gets larger. Define \bar{c} as the rebid cost at which (A.3) and (A.7) are equal. For any c above this threshold, the firm can choose the same price thresholds as in *Single-Bid* and replicate the profit given in (A.4). This situation is illustrated by the right-most horizontal line segment in Figure 2. For smaller transaction costs, $\hat{P} < \underline{P}_0^{\text{SB}}$, and thus $\Pi_{\text{ARB}} < \Pi_{\text{SB}}$.³⁷ Furthermore, note that compared to the *Single-Bid* case, there will be an increase in the number of consumers that will be willing to bid at the low-supply threshold price. Define \hat{R}_{DEV} as the reservation value for which a consumer is indifferent between bidding \hat{P} rather than \underline{P}_1 :

$$\begin{aligned} (1 - \lambda)(\hat{R}_{\text{DEV}} - \hat{P}) + \frac{\lambda(\hat{R}_{\text{DEV}} - \hat{P})q_0(b - a)}{b - \hat{R}_{\text{DEV}}} - c_0 \\ = (1 - \lambda)(\hat{R} - \underline{P}_1) - c_0. \end{aligned}$$

³⁷ In neither case will consumers actually rebid. But, in the *All-Repeat-Bid* case, the firm faces the additional constraint that $\underline{P}_0 \leq \hat{P}$. If this constraint is binding, then it must reduce the firm's profit.

The expression for \hat{R}_{DEV} is quite complex algebraically. The profit to the firm from choosing \hat{P} is

$$\Pi_{\text{DEV}} = (1 - \lambda) \left(\frac{\underline{P}_1(\hat{R}_{\text{DEV}} - \hat{R}_L)}{b - a} + \frac{\hat{P}(b - \hat{R}_{\text{DEV}})}{b - a} \right) + \lambda \hat{P} q_0. \quad (\text{A.8})$$

Substituting for the price thresholds, one can arrive at the following expression:

$$\Pi_{\text{SB}} - \Pi_{\text{DEV}} = \frac{\lambda q_0^2(b - a)(c_0 + (b - a)(1 - \lambda)(q_1 - q_0) - c)}{(1 - \lambda)(c + q_0(b - a))}. \quad (\text{A.9})$$

This expression is strictly positive at $c = 0$ and is decreasing in c . Thus, the strategy of choosing \hat{P} becomes more profitable as c becomes larger. Because (A.6) is decreasing in c , we can define \hat{c} as the level of transaction costs for which (A.6) and (A.8) are equal.³⁸ Therefore, when there is not a single-bid restriction, profit will follow the pattern illustrated in Figure 2—the firm chooses the thresholds given by (A.2) and (A.5) to earn a profit given in (A.6) when $c < \hat{c}$; for $\hat{c} < c < \bar{c}$, the firm earns the profit given in (A.8) by choosing the thresholds given in (A.2) and (A.7); and, for $c \geq \bar{c}$, the firm chooses the prices from (A.2) and (A.3) to earn the profit listed in (A.4).

Partial-Repeat-Bidding. I restrict attention to the case where $c < \bar{c}$ and $c_0 < \bar{c}_0$, where \bar{c} is defined in the preceding paragraph and \bar{c}_0 is defined in Proposition 3. This first condition ensures that under *All-Repeat-Bid*, the firm sets price thresholds such that some consumers will choose to rebid. If this were not the case, under *Partial-Repeat-Bidding*, the firm could replicate the profit in (A.8) by choosing the price threshold given in (A.7). Thus, in contrast to Figure 3, there would not be any region for which $\Pi_{\text{PR}} < \Pi_{\text{ARB}}$.

In the presence of sophisticated users, the firm could choose to set prices such that no consumers use this rebidding option in equilibrium, i.e., $\underline{P}_0 = \hat{P}$ as defined in (A.7). From Table 1, we know that $\underline{P}_0^{\text{SB}}$ maximizes the firm's profit given that no rebidding occurs. However, the restriction $c < \bar{c}$ ensures that the firm would have to price below $\underline{P}_0^{\text{SB}}$ to convince users to forego using this option to rebid.³⁹ Thus, a firm that uses this strategy under *Partial-Repeat-Bidding* must earn less profit than would be possible under *Single-Bid*.

Now turn to the situation where rebidding does occur in equilibrium. The derivation of the price threshold in the high-supply state, \underline{P}_1 , is the same as in the previous mechanisms and, thus, the optimum threshold is given by (A.2). Now, unsophisticated consumers will bid at the high threshold, $\underline{P}_0^{\text{PR}}$, only if $R_i \geq \hat{R}_{\text{PR}}$, where \hat{R}_{PR} is given by

$$\hat{R}_{\text{PR}} = \frac{\underline{P}_0^{\text{PR}} - \underline{P}_1(1 - \lambda)}{\lambda}. \quad (\text{A.10})$$

³⁸ The closed-form expression for \hat{c} is extremely complex algebraically.

³⁹ Technically, a weaker condition, $c < \bar{c}$, is sufficient to show that when the firm chooses to price at \hat{P} , $\Pi_{\text{PR}} < \Pi_{\text{SB}}$. In the range $\hat{c} < c < \bar{c}$, $\Pi_{\text{PR}} = \Pi_{\text{ARB}} < \Pi_{\text{SB}}$. If the firm chooses to price at \hat{P} when $c < \hat{c}$, i.e., when that would not be the optimum strategy under *All-Repeat-Bid*, then $\Pi_{\text{PR}} < \Pi_{\text{ARB}} < \Pi_{\text{SB}}$.

The sophisticated consumers with $R_i \geq \hat{R}_L$ will place an initial bid of \underline{P}_1 . Then, only consumers with $R_i \geq \underline{P}_0^{\text{PR}} + c$ would place a second bid of $\underline{P}_0^{\text{PR}}$. The firm chooses $\underline{P}_0^{\text{PR}}$ such that exactly q_0 units will be demanded at that price:

$$(1 - \rho) \frac{b - \hat{R}_{\text{PR}}}{b - a} + \rho \frac{b - \underline{P}_0^{\text{PR}} - c}{b - a} \equiv q_0. \quad (\text{A.11})$$

Solving for $\underline{P}_0^{\text{PR}}$ using (A.10) and (A.2), the optimal price threshold is found:

$$\underline{P}_0^{\text{PR}} = b - \frac{(b - a)(q_1(1 - \lambda)(1 - \rho) + \lambda q_0) + \lambda c \rho + (1 - \rho)c_0}{1 - \rho(1 - \lambda)}. \quad (\text{A.12})$$

The profit to the firm is

$$\begin{aligned} \Pi_{\text{PR}} = (1 - \rho) \left[\underline{P}_0^{\text{PR}} \frac{b - \hat{R}_{\text{PR}}}{b - a} + (1 - \lambda) \underline{P}_1 \frac{\hat{R}_{\text{PR}} - \hat{R}_L}{b - a} \right] \\ + \rho \left[\lambda \underline{P}_0^{\text{PR}} \frac{b - \underline{P}_0^{\text{PR}} - c}{b - a} + (1 - \lambda) \underline{P}_1 \frac{b - \hat{R}_L}{b - a} \right]. \end{aligned} \quad (\text{A.13})$$

This equation is quite unwieldy once one substitutes for the threshold prices. However, one can confirm that $\Pi_{\text{PR}} = \Pi_{\text{SB}}$ when $\rho = 0$ and that $\Pi_{\text{PR}} = \Pi_{\text{ARB}}$ when $\rho = 1$.

To prove that $\Pi_{\text{PR}} < \Pi_{\text{SB}}$ for all intermediate values of ρ , note that Π_{SB} does not vary with c . Thus, demonstrating that $\partial \Pi_{\text{PR}} / \partial c \leq 0$ would be sufficient to prove that $\Pi_{\text{PR}} < \Pi_{\text{SB}}$. Again, this expression is quite unwieldy. However, evaluating the function at $c = 0$ reveals

$$\left. \frac{\partial \Pi_{\text{PR}}}{\partial \rho} \right|_{c=0} = - \frac{\lambda(c_0 + (b - a)(1 - \lambda)(q_1 - q_0))^2(1 - \rho(1 - \lambda))}{(b - a)(1 - \rho(1 - \lambda))^3} < 0 \quad \forall \rho \in (0, 1). \quad (\text{A.14})$$

Combining this with the fact that $\partial \Pi_{\text{PR}} / \partial c|_{\rho=0} = 0$, when costs become nonzero, profits under *Partial-Repeat-Bidding* fall for all positive levels of ρ . Furthermore, one can show that this decline in profits accelerates as c increases:

$$\frac{\partial^2 \Pi_{\text{PR}}}{\partial c^2} = - \frac{2\lambda(1 - \lambda)(1 - \rho)\rho^2}{(b - a)(1 - \rho(1 - \lambda))^2} < 0 \quad \forall \rho \in (0, 1). \quad (\text{A.15})$$

Thus, profits must be decreasing in c over the relevant range of parameters, i.e., when profits are given by (A.13).

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