Joint Bidding in the Name-Your-Own-Price Channel: A Strategic Analysis

Wilfred Amaldoss

Fuqua School of Business, Duke University, Durham, North Carolina 27708, wilfred.amaldoss@duke.edu

Sanjay Jain

Mays Business School, Texas A&M University, College Station, Texas 77843, sjain@tamu.edu

In this paper, we study the name-your-own-price (NYOP) channel. We examine theoretically and empirically whether asking consumers to place a joint bid for multiple items, rather than bid one item at a time as practiced today, can increase NYOP retailers' profits. Relatedly, we also examine whether allowing consumers to self-select whether to place a joint bid or itemwise bids increases retailers' profits and consumers' surplus. We construct a dynamic model that incorporates both demand uncertainty and supply uncertainty to address these issues. Our theoretical analysis identifies the conditions under which joint bidding can increase both NYOP retailers' profits and consumers' surplus. We find that some consumers might bid more for the very same items when they place joint bids. The increase in bid amount is related to the fact that joint bidding reduces the chance of mismatch between NYOP retailers' costs and consumer bids. We conducted a laboratory study to assess the descriptive validity of some of the model predictions, because there are no field data on joint bidding in the NYOP channel. The results of the study are directionally consistent with our theory.

Key words: pricing; bidding; Internet; experimental economics
History: Accepted by David E. Bell, decision analysis; received July 9, 2007. This paper was with the authors
   1 month for 1 revision. Published online in *Articles in Advance* August 20, 2008.

1. Introduction

With the advent of the Internet, retailers have adopted several innovative pricing mechanisms. One such method is the name-your-own-price (NYOP) mechanism pioneered by Priceline. In this pricing method, the NYOP retailer lists a set of perishable goods available for sale but does not post prices. These goods are also opaque in the sense that some important product information (e.g., flight time, number of stops, and identity of the service provider) is not revealed to consumers at the time of bidding. The consumers, who arrive asynchronously to the market, evaluate the opaque products and then place bids for them. The bid is visible to the NYOP retailer but not to the service providers such as airlines or hotels. The service providers frequently change the prices of goods according to their yield management policy, but the price changes are not revealed to consumers. The spread between a consumer's bid and the prevailing lowest price is retained by the NYOP retailer (Kannan and Kopalle 2001). The sales revenue of Priceline, which is the leading NYOP retailer in the United States, was more than $2 billion in 2005, and it is expected to cross $4 billion in 2007, implying that the NYOP mechanism is a viable business model.[1]

The NYOP model is still evolving, and there is no consensus on how best to structure the pricing mechanism. For example, prominent NYOP retailers like Priceline and Expedia's Price Matcher allow consumers only to place a single bid for a given item. A German NYOP retailer, however, allows consumers to bid repeatedly for the very same item (see Hann and Terwiesch 2003). A recent theoretical analysis shows that if it is prohibitively costly to prevent surreptitious repeat bidding then the NYOP retailer might benefit by encouraging repeat bidding (Fay 2004).

In practice, NYOP retailers often sell more than one category of products. For example, Priceline and Expedia's Price Matcher sell airline tickets, hotel rooms, and car rentals. This observation raises an interesting question. In theory, would it be profitable for NYOP retailers to ask consumers to place a *joint* bid for multiple items rather than bid separately for each item? It seems that joint bidding might encourage consumers to place lower joint bids than they would have if they were bidding individually for each item. Therefore, a NYOP retailer's profits could potentially decline if it allowed joint bidding. Intuitively, joint bidding might encourage consumers to bid less than what they would bid under itemwise bidding. Indeed, consumers usually expect a discount when buying multiple items in a bundle

---

[1] Priceline has also extended its business to international markets such as the United Kingdom, Hong Kong, and Taiwan (source: priceline.com).

(Estelami 1999).[2] However, one needs to recognize that a consumer's willingness to pay for some of the individual items is sometimes inconsistent with the seller's corresponding reservation price. A joint bid is more flexible in that it is more likely to cover the sum of the seller's reservation prices. Furthermore, the improved chances of getting both of the items could increase a bidder's willingness to place a higher joint bid. This raises the possibility that joint bidding could improve both consumer surplus and the retailer's profits.

1.1. Overview

The focus of this paper is to examine how NYOP retailers can augment the basic bidding mechanism to increase their profits. In particular, we examine the theoretical and managerial implications of three different types of bidding strategies: *itemwise bidding*, where consumers place a separate bid for each item; *joint bidding*, in which consumers place a joint bid for several items; and *mixed bidding*, where consumers can place itemwise or joint bids. Our theoretical analysis suggests that often joint bidding, rather than itemwise bidding, is more profitable for a NYOP retailer. This is because, when consumers are asked to place joint bids, some consumers bid more for the very same items. Thus, joint bidding can be more profitable than itemwise bidding even when we do not take into account the convenience of placing a single bid. Yet this increase in profits is not necessarily at the expense of the consumer—in fact, consumer surplus can also be higher under the joint bidding strategy. Furthermore, joint bidding may also dominate mixed bidding.

Because there are no field data on these new bidding mechanisms, we conducted a laboratory investigation to examine whether the behavior of financially motivated agents conforms to the model predictions. We ran a between-subject experiment with 100 subjects—50 subjects were allowed only itemwise bidding, and the other 50 subjects were given the additional option of bidding jointly. The experimental results are encouraging. As predicted, allowing for joint bidding increased NYOP retailer profits and consumer surplus. Additionally, subjects bid more for the very same items when they were allowed to bid jointly.

1.2. Related Literature

Our work is in the spirit of the initial efforts to refine the NYOP mechanism (Hann and Terwiesch 2003, Fay 2004, Terwiesch et al. 2005). They examined the theoretical implications of allowing for repeat bidding, whereas we are interested in understanding the

impact of joint bidding. In contrast to conventional wisdom, the frictional costs involved in placing repeat bids in a NYOP channel are substantial (Hann and Terwiesch 2003). The joint bidding option considered in our model will help to reduce frictional costs faced by consumers. Frictional costs, however, are not necessary to obtain our theoretical results.

As noted earlier, the goods sold through NYOP channels are opaque. For example, a consumer bidding for an air ticket may not know exact flight times, number of stops, or even the name of the airline. Because of the resulting uncertainty about product features, goods sold through NYOP retailers are ex ante very different from the goods that can be purchased from posted price markets such as the service provider's direct channel and traditional retail outlets. Consequently, the NYOP channel tends to attract low-valuation consumers. However, at the time of consumption (ex post) the products are similar. Thus, the opacity of the goods may help the service provider to liquidate excess supply by attracting a different segment of consumers through the NYOP channel (Fay and Xie 2008, Wang et al. 2005). Fay (2007) examined the role of competition among firms selling opaque goods. If firms are competing to sell opaque products with little brand loyalty, then opaque goods increase price competition and dampen firm profits. However, if there is significant brand loyalty, opaque goods help soften competition and improve a firm's profits (Fay 2007). Our focus is on how to further improve the profitability of the NYOP channel by allowing consumers to place joint bids.

Some researchers have investigated how consumers behave in this channel. On studying the bids placed at a German NYOP retailer, Spann and Tellis (2006) note that sometimes there is a drop in the sequence of bids made by individual customers, and they attribute this drop to irrational consumer behavior. However, such a drop in bid sequence may be observed if consumers are allowed to bid repeatedly and if they expect a service provider's prices to vary over time because of yield management policy. Unlike the German NYOP retailer, but consistent with Priceline, we do not allow repeated bidding in our model. However, we allow for the possibility that a service provider's costs could vary over time. In another study, Ding et al. (2005) examine how emotions temper bidding behavior. Our experimental investigation examines how financially motivated individuals may behave if given the option to place joint bids.

Our work is also related to the literature on optimal stopping theory, where researchers typically attempt to answer the question: When should a decision maker optimally stop searching for new alternatives? (e.g., Bertesekas 1987). For example, when should a firm trying to sell an asset stop searching for new

---

[2] On surveying the prices of 480 product bundles, Estelami (1999) reports that on average consumers save 8% by purchasing bundles.

offers? It is useful to note that offers are randomly generated in these models, and hence offers are not the outcome of a strategic process. In the NYOP mechanism, on the contrary, consumers are strategic decision makers and hence make offers in response to a firm's equilibrium strategy. Thus, our work is more closely related to equilibrium search models in which consumers search for prices and firms decide on prices based on consumers' equilibrium strategies (see for example, Reinganum 1979). However, this literature examines price search by consumers and does not focus on the issue of bidding for multiple items. The product bundling literature uses a static model to examine the advantages of selling multiple goods (Adams and Yellen 1976, Schmalensee 1984, McAfee et al. 1989, Bakos and Brynjolfsson 2000). Our work differs from the bundling literature because we consider a multi-period search model that involves supply and demand uncertainties.

Finally, the literature on auctions is related to our work. There are several formats of auctions such as the English auction, the Dutch auction, the first-price sealed-bid auction, and the second-price sealed-bid auction (see McAfee and McMillan 1987 for a review, Rothkopf 1991, Sinha and Greenleaf 2000).[3] As Rothkopf and Harstad (1994) showed, the results of single-item auctions may not apply to multi-item auctions. Demange et al. (1986) study a multi-item auction where each item is auctioned independently in an English auction but all of the auctions open and close at the same time. The final price vector in this auction can be close to the minimum competitive equilibrium price vector. Mishra and Garg (2006) obtain similar results for the Dutch auction. In all of these one-sided auctions, there are several buyers and one seller and consequently the buyers compete to win the object. In contrast, in the basic NYOP mechanism consumers arrive asynchronously and hence there is no direct competition among consumers.

The remainder of this paper is organized as follows. Section 2 introduces the theoretical model and analyzes its implications. Section 3 discusses a laboratory study. Finally, §4 concludes the paper by summarizing the findings and discussing their managerial implications.

2. Model
Consider a NYOP retailer who sells *perishable goods* such as airline tickets and hotel rooms. The service provider varies its price over time for these goods according to the prevailing demand condition

and its yield management policy. Note that the service provider's selling price is the marginal cost for the NYOP retailer. We capture the variation in the marginal costs of the NYOP retailer by assuming that the marginal cost at time t for product j, namely $c_j(t)$, is a random variable distributed according to a cumulative distribution $\phi_j(c, t)$. The marginal costs can be viewed as the minimum prices at which the NYOP retailer will be open to sell its goods (see Hann and Terwiesch 2003 and Fay 2004 for a similar assumption).[4] An important feature of the NYOP channel is that retailers often face an *uncertain supply* of goods. For example, Priceline is not certain that if it rejects a consumer bid, the same airline ticket will be available for sale in the next period at the same cost. One reason for this uncertainty is that Priceline gets an opportunity to sell tickets at low prices only when the airlines are not able to sell them at higher prices through their direct channels of distribution. Because the same tickets are being concurrently sold using multiple channels, Priceline cannot be sure that the tickets will remain available at the same price in the next period. This uncertainty is captured in our model by letting the costs vary over time. For simplicity, we assume that $\phi_j(c, t) = \phi_j(c)$. In other words, the costs are drawn from the same distribution in each period. Having outlined some important characteristics of the market, we proceed to discuss the behavior of consumers and retailers in our framework.

2.1. NYOP Retailer Behavior
In our formulation, the NYOP retailer first decides whether it wants to (i) sell the items separately or (ii) sell them jointly or (iii) allow consumers to decide whether to place a joint bid or itemwise bids. We label the first mechanism as *itemwise bidding*, the second as *joint bidding*, and the third as *mixed bidding*. The NYOP retailer's decision about which mechanism to use, of course, depends on which mechanism will help the NYOP retailer earn more expected profits. Note that the NYOP retailer is unaware of its exact costs at the beginning of our game because of the yield management policy of the firm producing the good. However, the retailer discovers the prevailing marginal costs before it decides whether or not to accept a bid from a consumer. On comparing its marginal cost against the consumer bid amount and assessing the resulting expected profits, the NYOP retailer decides whether to accept or reject a bid.

2.2. Consumer Behavior
We assume that consumer i places a value v_j^i on item j. If the consumer bids for multiple items, then

---

[3] The first-price sealed-bid auction and the Dutch auction are strategically equivalent in some conditions, in that the bids are the same in both auctions. Similarly, the English auction and the second-price sealed-bid auction are strategically equivalent.

[4] In the case of airline tickets, $c_j(t) \geq 0$ is the amount that a retailer like Priceline will be asked to pay the airlines for procuring the ticket(s).

we assume that the valuation of the two items is the sum of the two individual valuations, implying that the products are neither complements nor substitutes. The valuation v_j^i is distributed across the population according to the pdf $f_j(\cdot)$, which is common knowledge. In our formulation, the consumer is not aware of the costs of the retailer but knows the corresponding cumulative distribution $\phi_j(c)$. It is a standard practice in modeling games with asymmetric information among players to assume that the cost distribution is common knowledge (e.g., Fudenberg and Tirole 1991). This is equivalent to assuming that consumers have some belief about the distribution of NYOP retailer's threshold prices and that the belief is correct in equilibrium. Thus, the assumption of common knowledge of costs makes the presentation simple but is not critical for our model formulation.

Based on her knowledge of the NYOP retailer's cost distribution $\phi_j(c)$ and her own valuation for the items, the consumer decides on the bid amount x. On observing the bid, the NYOP retailer decides whether or not to accept the bid. If the retailer accepts the bid, then the game ends with the NYOP retailer earning a profit of $(x - c)$ and the consumer gaining a surplus of $(v - x)$, where v is the valuation of the product by the consumer. But if the NYOP retailer rejects the bid, then there is some probability γ that the retailer may get an opportunity to sell to another consumer in the following period. Because $0 \le \gamma < 1$, there is some probability that there will not be a new consumer in the next period. The parameter γ, therefore, reflects the uncertainty in demand. Next we examine the theoretical implications of this parsimonious model.

2.3. Analysis

Consider first the simplest case where $v_j^i = v_k^i = v^i$. In this case, because the valuations of both the products are identical, we are ruling out traditional reasons for selling products together.[5] In this polar case, is there any incentive still to allow for joint or mixed bidding? To appreciate the answer to this question, let the cost distribution function be identical and binomial so that p is the probability that the cost is c_L and $(1 - p)$ is the probability that the cost is c_H ($c_H > c_L$). Though the cost distributions for the two items are identical, the realized cost of each item could be different. In Online Appendix B (all appendices are provided in

the e-companion)[6] we show that the main insights of our analysis would apply in the case when the costs are continuously distributed. In Online Appendix C, we show that our main result would also hold in cases where the valuations for the two products are different and not perfectly correlated. Furthermore, the analysis can accommodate situations in which the cost distributions for the two products are different. Thus, the main insights of our analysis would hold in more general models.

In our formulation, the NYOP retailer's decision problem seems to resemble the classical search problem where the retailer decides when to terminate its search and accept a bid. Because the consumer is not passive in our game, it adds a layer of complexity to the traditional search models. Indeed, the consumer can optimally react to the NYOP retailer's equilibrium strategy. To analyze equilibrium behavior in this game, we study the stationary Markov perfect equilibrium. Next we discuss equilibrium implications of itemwise and joint bidding.

Itemwise Bidding. Denote the NYOP retailer's equilibrium strategy by $\xi_I(x; c)$, which gives the probability that a NYOP retailer with a cost c will accept a consumer bid of x. Similarly, denote the consumer's equilibrium strategy by $x(v_j^i)$, which specifies the amount x that consumer i with valuation v_j^i would bid for item j. Then let V_I be the equilibrium value of the game for the NYOP retailer. This value could be affected by the equilibrium behavior of both the retailer and the consumer. The NYOP retailer's decision of whether or not to accept the bid x is given by

$$\xi_I(x, c) = \begin{cases} 1 & \text{if } x \ge c + \gamma V_I, \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

This is consistent with the business practice of a German NYOP retailer that Hann and Terwiesch (2003) studied. Much like the German NYOP retailer, Priceline typically accepts a bid if it exceeds a threshold but rejects it otherwise (see Fay 2004). This threshold may be greater than the NYOP retailer's marginal cost, because $V_I \ge 0$. Thus, the retailer will earn positive margins in all situations. This result makes intuitive sense. Note that if the retailer waits for the next period there is some chance that a high-valuation consumer may enter the market and bid b_H. Consequently, the low-cost retailer is more aggressive in its bid acceptance strategy and consumers, in turn, are willing to bid a higher amount for low-cost items.

The consumer, of course, does not observe the retailer's costs and knows only the cost distribution.[7]

---

[5] For example, it is argued that when the valuations of the two products are negatively correlated then offering bundles can be attractive to the sellers (Adams and Yellen 1976; see also Schmalensee 1984 and McAfee et al. 1989 for a discussion of the theoretical implications of bundling in contexts where consumer reservation values follow a wider class of distributions). But when the reservation prices are perfectly positively correlated, then there is no additional incentive for firms to bundle products. Hence, we focus on this extreme case.

[6] An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

[7] Alternatively, we could assume that the consumers are aware of the distribution of thresholds $\xi_I(\cdot)$.

Consequently, consumer i has to choose the optimal bid $x_I(v_j^i)$, given the retailer's equilibrium strategy. Therefore, we have

$$x_I(v_j^i) \in \underset{0 \leq x_j^i \leq v_j^i}{\arg\max} \left\{ \int_0^\infty (v_j^i - x_j^i)\xi_I(x, y)\, d\phi_j(y) \right\}. \quad (2)$$

Equations (1) and (2) define the conditions necessary for determining the equilibrium Markov perfect strategies, given the equilibrium value of the game. The value of the game in turn depends on the equilibrium strategies of the players. Next we determine the equilibrium value of the game.

Recall that the cost distribution is binominal. Further denote the NYOP retailer's acceptable bid by $\xi_I(x, c_H) = b_H$ and $\xi_I(x, c_L) = b_L$ when the costs are high and low, respectively. In this case, it is easy to see that a consumer cannot benefit by bidding any amount other than $\{0, b_L, b_H\}$. A consumer with valuation v therefore has to compare the expected payoffs for bidding 0, b_L, and b_H and then bid the amount that maximizes her profits. First note that, if $v < b_L$, the consumer bids nothing because she will not get the product by bidding any positive amount less than b_L. Among the consumers making a positive bid, the consumer who is indifferent between bidding b_L and b_H is given by v_1, which is defined as

$$(v_1 - b_L)p = v_1 - b_H. \quad (3)$$

Note that the cutoffs must satisfy

$$b_L = c_L + \gamma V_I, \quad (4)$$

$$b_H = c_H + \gamma V_I. \quad (5)$$

Using these bids, we obtain

$$v_1 = \frac{b_H - pb_L}{1 - p} \quad (6)$$

$$= \frac{c_H - pc_L + \gamma V_I(1 - p)}{1 - p}. \quad (7)$$

Note that as γ increases, the cutoff increases. This is reasonable because an increase in γ increases the outside option for the retailer and fewer consumers will be able to afford the resulting b_H. It follows from this discussion that the optimal bidding strategy for the consumer is

$$x_I(v_j^i) = \begin{cases} b_H & \text{if } v_j^i \geq v_1, \\ b_L & \text{if } v_j^i \in (b_L, v_1), \\ 0 & \text{otherwise.} \end{cases} \quad (8)$$

The value of the itemwise bidding game for NYOP retailer, when it knows that it has low costs in the current period, is given by

$$W_L = (b_L - c_L)(F(v_1) - F(b_L))$$
$$+ (b_H - c_L)(1 - F(v_1)) + \gamma F(b_L)V_I. \quad (9)$$

Similarly, the value of the game when the retailer has high costs is

$$W_H = (b_H - c_H)(1 - F(v_1)) + \gamma F(v_1)V_I. \quad (10)$$

Hence, the overall value of the itemwise bidding game V_I is implicity defined by the following equation:

$$V_I = pW_L + (1 - p)W_H. \quad (11)$$

Because b_L and v_1 are functions of V_I, it is not possible to give a closed-form solution for a general $F(\cdot)$. However, we can obtain a closed-form solution for a uniform distribution of consumer valuations. For other distributions, it is possible to numerically assess the value of the game. If $f(\cdot)$ is uniform with range $(0, 1)$ and we focus on interior solutions, then the value of the game is given by

$$V_I = \frac{p(c_H - c_L)(pc_L + 1 - p - c_H)}{(1 - p)(1 - \gamma + p\gamma(c_H - c_L))}. \quad (12)$$

Now using (12) we can calculate NYOP retailer's bid acceptance thresholds for different bidding mechanisms.

Joint Bidding. In this case a consumer places a single bid x_{jk}^i for both items j and k. Let $\phi_{jk}(\cdot)$ denote the cumulative distribution for the total cost of the two items. Also let $\xi_J(x_{jk}, c_{jk})$ define the NYOP retailer's bid acceptance strategy when it receives a joint bid x_{jk} and its total cost is c_{jk}. Note that the retailer will have different thresholds for the three possible total costs for the two products: $2c_L$, $c_L + c_H$, or $2c_H$. Denote the corresponding thresholds by b_{ll}, b_{lh}, and b_{hh}. If the value of the joint game is V_J then we have

$$b_{ll} = 2c_L + \gamma V_J, \quad (13)$$

$$b_{lh} = c_L + c_H + \gamma V_J, \quad (14)$$

$$b_{hh} = 2c_H + \gamma V_J. \quad (15)$$

Given these bid acceptance thresholds, a consumer will place a joint bid from the set $\{0, b_{ll}, b_{lh}, b_{hh}\}$ depending on her total valuation for the two products. As discussed earlier in itemwise bidding, we can now compute the value of the game. If $f(\cdot)$ is uniform, then we find that (see Online Appendix A for details)

$$V_J = \frac{p(c_H - c_L)[(-p^3 - 3p^2 + 6p)c_L + (-5p^2 + 10p + p^3 - 8)c_H + 8(1 - p)^2]}{4(1 - p)^2(1 - \gamma + p\gamma(c_H - c_L))}. \quad (16)$$

With the aid of the preceding equation, we can compute the equilibrium bid acceptance thresholds for NYOP retailer and optimal consumer bids.

Mixed Bidding. Now consider the case where the consumer can decide whether to place a joint bid or several itemwise bids. As before, the retailer will have threshold bid acceptance values for joint bidding as

well as itemwise bidding. Note, however, that these thresholds will be different from those for the consumer who places only itemwise bids or only joint bids. Let the value of this mixed game be denoted by V_M. The retailer will accept a joint bid x_{jk} if

$$x_{jk} \geq c_{jk} + \gamma V_M. \tag{17}$$

Hence, the retailer's cutoffs for joint bids are given by

$$b_{ll}^m = 2c_L + \gamma V_M, \tag{18}$$

$$b_{lh}^m = c_L + c_H + \gamma V_M, \tag{19}$$

$$b_{hh}^m = 2c_H + \gamma V_M, \tag{20}$$

where the superscript m is used to denote mixed bidding. Similarly, if the consumer bids itemwise, we can determine the corresponding cutoffs. In this case, we assume that if the retailer is left with only one item, then the expected value of this item is $V_M/2$. Note that, if the products are similar and the retailer has numerous products to offer, then the retailer can bundle the unsold item and offer it to another consumer and earn $V_M/2$. Therefore, the cutoffs in this case are

$$b_L^m = c_L + \frac{\gamma V_M}{2}, \tag{21}$$

$$b_H^m = c_H + \frac{\gamma V_M}{2}. \tag{22}$$

It is easy to see why the consumer will never place a joint bid b_{ll}^m when she can place itemwise bids (b_L^m, b_L^m).[8] With the itemwise bids the consumer can get one product when the costs are (c_L, c_H) but gets nothing with the joint bid b_{ll}^m. Also note that the consumer is indifferent between bidding b_{hh}^m and (b_h^m, b_h^m) because she gets both of the products in either case and the total bid amount remains the same. Therefore, the consumer's choice set is $\{0, (b_L^m, b_L^m), b_{lh}^m, b_{hh}^m\}$. With this setup, we can study a consumer's bidding strategy for a given valuation v and game value V_M. Of course, V_M is endogenous and needs to be determined. Using the approach discussed before, we can now determine V_M (see Online Appendix A for details). If $f \sim U(0, 1)$ then we obtain

$$V_M = \frac{p(c_H - c_L)(4pc_L - 3p^2c_L + 4 - 4c_H + 4p^2 - 8p - p^2c_H + 4pc_H)}{2(1-p)^2(1 - \gamma + \gamma p(c_H - c_L))}. \tag{23}$$

2.3.1. Comparison of Bidding Mechanisms. On examining the profitability of mixed bidding, we have the following result:

---
[8] This holds as long as there are no complementarities in the product.

PROPOSITION 1. *For any distribution $f(\cdot)$, mixed bidding is always dominated by joint bidding when $\gamma = 0$. If $\gamma > 0$ and $f(\cdot)$ is uniform with range $(0, 1)$, then mixed bidding is dominated by joint bidding.*[9]

The proposition establishes that a NYOP retailer can benefit by adopting the joint bidding mechanism. In other words, mixed bidding is less profitable.[10] We clarify the intuition for this result along with that for the next proposition, where we compare the profitability of joint bidding mechanism against that of itemwise bidding. On assuming that $f(\cdot) \sim U(0, 1)$, we obtain the following result:

PROPOSITION 2. (a) *If $p < 5/2 - \sqrt{17}/2 \approx 0.44$ or $p > (1 - c_H)/(1 - c_L)$, then joint bidding weakly dominates itemwise bidding, and furthermore $b_{ll} \geq 2b_L$ and $b_{hh} \geq 2b_H$.* (b) *There exist parameter ranges for which mixed bidding dominates itemwise bidding.*

The first part of the proposition identifies the conditions in which a NYOP retailer may find it profitable to ask consumers to place joint bids. Under these conditions, a consumer places a higher total bid under the joint bidding mechanism than she would under itemwise bidding. The second part of the proposition states that there exist conditions where it is profitable for a NYOP retailer to let consumers self-select whether they want to place a joint bid or bid separately for each item. In an attempt to clearly explain the intuition for Proposition 2, we first discuss the simple case when $\gamma = 0$ and then examine the case when $\gamma > 0$.

Case where $\gamma = 0$. If $\gamma = 0$, the NYOP retailer will accept any bid that is at or above its costs.[11] To grasp the intuition for the key results, we need to understand the answers to the following questions:

1. How does a consumer equilibrium bidding strategy change as a NYOP retailer moves from itemwise bidding to joint bidding?

2. How does a NYOP retailer's profits change as it moves from itemwise to joint bidding?

3. How does consumer surplus change as a NYOP retailer moves from itemwise bidding to joint bidding?

4. How can mixed bidding lead to improved consumer surplus and retailers' profits?

Consumer Bidding Strategy. Figure 1 shows consumer's bidding strategy when the NYOP retailer

---
[9] The proposition can also be shown to hold for a uniform distribution with range (a, b) where $c_H < b$.

[10] Of course, in our framework we did not include factors such as ease of implementation, which could make mixed bidding a desirable option.

[11] When $\gamma > 0$ the NYOP retailer can pursue a more aggressive bid acceptance strategy, namely accept only bids above costs. This, in turn, will influence consumers' bidding behavior.

Figure 1   Comparison of Bidding Under Itemwise and Joint Bidding Mechanisms When $\gamma = 0$
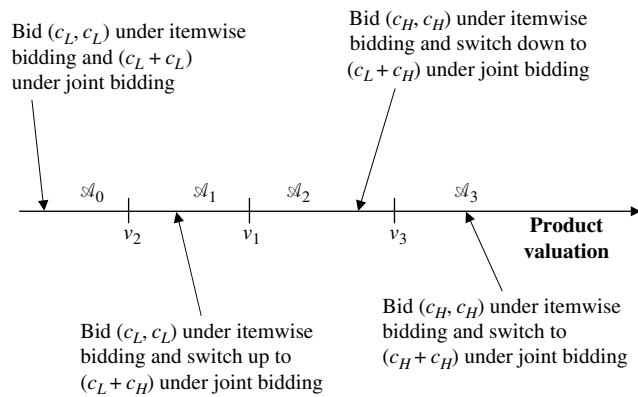
allows itemwise bidding or joint bidding. The low-valuation consumers lie on the left side of the valuation line depicted in Figure 1. Consumers in segment $\mathscr{A}_0$, namely $v < v_2$, place itemwise bids (b_L, b_L) or a joint bid b_{ll}. In this case, because $b_L = c_L$ and $b_{ll} = c_L + c_L$, we denote itemwise bids (b_L, b_L) by (c_L, c_L) and denote joint bid b_{ll} by $(c_L + c_L)$ to facilitate exposition. Shifting attention to the adjoining region $\mathscr{A}_1$, that is $v_2 < v < v_1$, note that consumers in this region also place itemwise bids (c_L, c_L). But under the joint bidding mechanism they bid $(c_L + c_H)$, which is more than $2c_L$. Thus, the consumers place a higher total bid under joint bidding. To understand the rationale for such behavior, focus attention on the consumer located at v_1. Recall that this consumer is indifferent between bidding (c_L, c_L) and (c_H, c_H) in the case of itemwise bidding. If this consumer were to place the joint bid $(c_L + c_L)$, then her expected surplus would be

$$U(c_L + c_L) = 2p^2(v - c_L) = pU(c_L, c_L) < U(c_L, c_L). \quad (24)$$

But if the same consumer were to place a joint bid $(c_L + c_H)$, then her surplus would be

$$U(c_L + c_H) = (1 - (1 - p)^2)(2v - c_L - c_H). \quad (25)$$

It can be easily shown that for the consumer at $v = v_1$, $U(c_L + c_H) > U(c_L + c_L)$. Hence, this consumer will place a higher bid under joint bidding than under itemwise bidding. Interestingly, we also find that $U(c_L + c_H) > U(c_L, c_L)$ if $v = v_1$. This implies that the consumer at v_1 would switch to placing a higher joint bid, *even if she had the freedom to choose between itemwise bidding and joint bidding.* Now to understand how joint bidding can sometimes increase the chance of getting both of the items, consider the implications of placing itemwise bids (c_L, c_H) against placing a joint bid of $(c_L + c_H)$. If the retailer's costs were (c_H, c_L), then the joint bid would go through, but not the itemwise bids, because of the mismatch between costs and itemwise bids. Thus, if only joint bidding were

allowed, then some consumers, who might have bid (c_L, c_L) under itemwise bidding, may place a higher joint bid $(c_L + c_H)$, because it increases the chance of getting both items. *In essence, the joint bidding mechanism eliminates mismatch between costs and bids, which is possible under itemwise bidding.*

Next consider the segment $\mathscr{A}_2$, namely $v_1 < v < v_3$. In this segment some consumers who place itemwise bids (c_H, c_H) will switch to placing a lower joint bid $(c_L + c_H)$. Because the joint bid amount is lower, consumers are not guaranteed of getting both the items. However, the joint bid $(c_L + c_H)$ increases the chance of getting both of the items relative to itemwise bids (c_L, c_H) or (c_H, c_L). Consequently, consumers in this segment are willing to take their chances by reducing their total bid amount and placing a joint bid. Finally, in region $\mathscr{A}_3$, namely $v > v_3$, consumers bid (c_H, c_H) under itemwise bidding and $b_{hh} = (c_H + c_H)$ under joint bidding. Because the total bids as well as the probability of bids going through remain the same under both bidding mechanisms, consumers are indifferent between them.

Impact on Consumer Surplus. In segment $\mathscr{A}_0$, as discussed earlier and illustrated in Figure 1, consumers will bid $b_{ll} = (c_L + c_L)$ under joint bidding but bid (c_L, c_L) under itemwise bidding. These consumers are worse off under joint bidding because it reduces their chance of getting at least one of the products. More precisely, under itemwise bidding these consumers will get both products with probability p^2 and any one product with probability $2p(1 - p)$. Under joint bidding, they will still get both products with probability p^2. However, they cannot get a single product under joint bidding. Thus, these consumers are better off if they bid itemwise. Next consider segment $\mathscr{A}_1$.

Consumers in segment $\mathscr{A}_1$ end up bidding more under the joint bidding mechanism, and this should hurt their surplus. However, as we have discussed before, the joint bid increases the probability of the transaction going through by reducing the likelihood of a mismatch between bid and costs. This aspect of joint bidding is helpful to consumers. We can show that low-valuation consumers, namely consumers with $v \in (v_2, v_4)$ as shown in Figure 2, are worse off under joint bidding. But consumers with valuations in the region (v_4, v_1) are actually better off under joint bidding even though they are bidding higher amounts (the derivation of the cutoff v_4 is in Online Appendix A and depicted in Figure 2). Again, this improvement in consumer surplus is a consequence of joint bidding reducing the probability of mismatch and thereby increasing the possibility that a consumer gets both items. Thus, the overall impact of the change in bidding mechanism on consumer welfare is ambiguous.

Figure 2   Comparison of Bidding Under Itemwise and Mixed Bidding Mechanisms When $\gamma = 0$
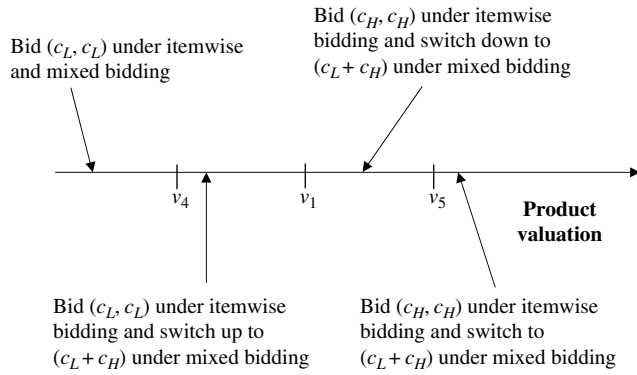
Note. $v_4 > v_2$.

Turning attention to segment $\mathscr{A}_2$, we find that consumers switch down to bidding $b_{lh} = (c_L + c_H)$. Note that these consumers always had the option of bidding $b_{hh} = 2c_H$, which is strategically equivalent to (c_H, c_H) when $\gamma = 0$ case, implying that consumer surplus improves with joint bidding in the segment. Finally, consumer surplus remains unchanged for people in segment $\mathscr{A}_3$. Thus, whether the overall consumer surplus is higher or lower will depend on the size of the segment $(v_4, v_1) \cup \mathscr{A}_2$ versus the size of the segment (c_L, v_4).

Impact on the NYOP Retailer's Profits. When $\gamma = 0$, the NYOP retailer does not earn any profits from consumers in segment $\mathscr{A}_0$, because their bids just cover the product costs under both itemwise bidding and joint bidding. However, consumers in segment $\mathscr{A}_1$ bid a higher amount under joint bidding as opposed to itemwise bidding. The higher bid amount also increases the chance that the NYOP retailer will be able to sell its products. The increased expected profits due to consumers switching to higher bids is given by

$$\Delta_1 = (c_H - c_L)p^2 \int_{v_1}^{v_2} f(v)\, dv = (c_H - c_L)p^2 \mathscr{A}_1, \quad (26)$$

where the first term $(c_H - c_L)$ is the additional revenue. Note that this additional revenue is realized only when the retailer has low costs for both products, which happens with probability p^2. Thus, as the size of segment $\mathscr{A}_1$ increases, the NYOP retailer's profits under the joint bidding mechanism increase compared with the profits under itemwise bidding.

In region $\mathscr{A}_2$, however, some consumers scale down their bids. This downward transition dampens the NYOP retailer's profits because the total bid $b_{lh} = (c_L + c_H)$ is lower than $2b_H = 2c_H$, and furthermore it reduces the chance of the transaction going through.

The expected loss that the retailer incurs as a result of consumers bidding a lower amount is given by

$$\Delta_2 = (c_H - c_L)(1 - (1-p)^2) \int_{v_1}^{v_3} f(v)\, dv$$
$$= p(c_H - c_L)(2 - p)\mathscr{A}_2. \quad (27)$$

Thus, as the size of segment $\mathscr{A}_2$ increases, it reduces the profitability of the joint bidding mechanism. Finally note that in segment $\mathscr{A}_3$ the total bid amount and the probability of the transaction going through are the same under both bidding mechanisms. Consequently, the size of $\mathscr{A}_3$ does not affect the relative profitability of joint bidding. Hence, whether the NYOP retailer prefers joint bidding or itemwise bidding will depend on the relative sizes of segments $\mathscr{A}_1$ and $\mathscr{A}_2$. The total impact on profits, if the NYOP retailer switches from the itemwise to the joint bidding mechanism, is given by

$$\Delta = \Delta_1 + \Delta_2 = p(c_H - c_L)(p\mathscr{A}_1 - (2 - p)\mathscr{A}_2). \quad (28)$$

This implies that joint bidding is more profitable iff

$$\frac{\mathscr{A}_1}{\mathscr{A}_2} > \frac{2 - p}{p}. \quad (29)$$

If segment $\mathscr{A}_1$ is sufficiently large compared with $\mathscr{A}_2$, then the retailer is better off under the joint bidding mechanism.

It is also useful to examine how (28) changes with model parameters. First, consider the case when c_H increases. We find that, as cost increases, the number of consumers who are able to make bids acceptable to the firm decreases. This implies that v_1 increases as c_H increases. Also note that an increase in c_H increases the other cutoffs, namely v_2 and v_3. For a uniform distribution with range $(0, 1)$, it turns out that as c_H increases both $\mathscr{A}_1$ and $\mathscr{A}_2$ increase. Furthermore, we find that an increase in c_H increases the profitability of the joint bidding option as long as $p < (5 - \sqrt{17})/2 \approx 0.44$.[12] An increase in c_L has an analogous but opposite effect on the profitability of the joint bidding mechanism.

Let us consider the impact of an increase in p on the size of valuation segments $\mathscr{A}_1$ and $\mathscr{A}_2$. Note that, unlike changes in costs, a change in p not only affects the sizes of regions $\mathscr{A}_1$ and $\mathscr{A}_2$ but also the probability of a transaction going through.[13] For the uniform

---

[12] This is under the assumption that $v_3 < 1$. If there is a corner solution then joint bidding always becomes more attractive as c_H increases. Also, note that if the distribution is skewed towards 0 (such as the exponential distribution) the positive effect of a change in c_H on $\mathscr{A}_1$ is likely to be higher than the negative effect of an increase in $\mathscr{A}_2$. Therefore, the result is likely to be stronger for the exponential distribution.

[13] More specifically, we have

$$\frac{\partial \Delta}{\partial p} = (c_H - c_L)[p(\mathscr{A}_1 + \mathscr{A}_2) - \mathscr{A}_2] + p(c_H - c_L)\left[p\frac{\partial \mathscr{A}_1}{\partial p} - (2 - p)\frac{\partial \mathscr{A}_2}{\partial p} \right].$$

case with range $(0, 1)$, it turns out that the sizes of consumer segment $\mathscr{A}_1$ and $\mathscr{A}_2$ are increasing in p. Furthermore, if $p < 0.32$ then joint bidding becomes more attractive as p increases. If $v_3 = 1$ (which happens for large values of p), an increase in p always increases the profitability of the joint bidding.[14]

Impact of Mixed Bidding. Figure 2 draws a contrast between mixed bidding and itemwise bidding. Our previous discussion shows that both consumer surplus and the NYOP retailer's profits increase in the region $(v_4, v_1) \cap \mathscr{A}_1 = (v_4, v_1)$. This raises the possibility that both consumer welfare and retailer profits could increase if the region (v_4, v_1) grows in size. In this case, a NYOP retailer could give consumers the flexibility to place itemwise or joint bids. For $\gamma = 0$, a consumer cannot be worse off under mixed bidding because she will always choose the mechanism that gives her higher utility.[15] However, if the region (v_4, v_1) is large enough and the region (v_1, v_5) is not too large, then the retailer's profits could also be higher. However, because the region $(v_4, v_1) \in \mathscr{A}_1$, the NYOP retailer always finds joint bidding to be more profitable than mixed bidding. Now we proceed to examine the case when $\gamma > 0$.

Case where $\gamma > 0$. We find that $\gamma > 0$ creates scope for the NYOP retailer to entertain the possibility that in the next period it may get more favorable costs or demand conditions. Consequently, the retailer will not sell its products at cost in the current period. Let b_L and b_H denote the itemwise bids acceptable to the NYOP retailer when the costs are c_L and c_H, respectively, and the corresponding value of the game for two items is $2V_I$. Also let the acceptable joint bids be b_{ll}, b_{lh}, b_{hh}, when both items' costs are low, one item's cost is low, and no item's cost is low, respectively. Denote the value of the joint bidding game by V_J. If $V_J > 2V_I$, then from (4) and (13) we know that

$$b_{ll} - 2b_L = \gamma(V_J - 2V_I) > 0. \tag{30}$$

In other words, when joint bidding is more profitable than itemwise bidding, the NYOP retailer will demand a joint bid b_{ll} which is more than the total itemwise bid amount $2b_L$. Thus, under joint bidding all consumers place a higher total joint bid except possibly those consumers who are transitioning down

from placing itemwise bids (b_H, b_H) to placing a joint bid b_{lh}. Note, however, that the opposite will hold when joint bidding is less attractive. This implies that an increase in γ can exacerbate the difference between the profitability of the two bidding mechanisms.

2.3.2. Numerical Simulation. We now study the case when the distribution of valuations is not uniform. Specifically, we examine how model parameters affect the profitability of the different bidding mechanisms when $\gamma > 0$. This allows us to explore the generalizability of our results and also address issues that we could not study using the uniform distribution. We consider the case where the value distribution is exponential. The exponential distribution, which is used widely in the marketing literature, captures an important market reality (e.g., Xie and Sirbu 1994). A large proportion of the consumers place low valuation for goods, and the exponential distribution is skewed toward the lower end of valuation. The probability density function for the exponential distribution is given by

$$f(x) = \begin{cases} \lambda \exp(-\lambda x) & \text{if } x > 0, \\ 0 & \text{otherwise.} \end{cases} \tag{31}$$

The analysis of this case cannot be done using analytical methods, and, therefore, we employ simulation methods. In particular, we draw different values of model parameters and solve for the equilibrium bids and acceptance thresholds for the NYOP retailer. Using this we calculate the equilibrium expected profits for the retailer under the joint and itemwise bidding mechanisms. We assume $c_L = 0$, p varies from 0.1 to 0.9, c_H varies from 0.1 to 0.9, γ varies from 0 to 1, λ from 0.1 to 1, with the parameter values changing in increments of 0.1.

Although it is not possible to obtain a closed-form equilibrium solution for the exponential distribution of valuations, we can still use the methodology described earlier to numerically determine a consumer's equilibrium bids and a retailer's bid acceptance thresholds for the three bidding mechanisms. For the itemwise bidding case, we have

$$W_L = (b_L - c_L) \int_{b_L}^{v_1} \lambda \exp(-\lambda x)\, dx + (b_H - c_L)$$

$$\cdot \int_{v_1}^{\infty} \lambda \exp(-\lambda x)\, dx + \gamma \int_0^{b_L} \lambda \exp(-\lambda x) V_I\, dx, \tag{32}$$

$$W_H = (b_H - c_H) \int_{v_1}^{\infty} \lambda \exp(-\lambda x)\, dx$$

$$+ \gamma \int_0^{v_1} \lambda \exp(-\lambda x) V_I\, dx. \tag{33}$$

The overall value of the itemwise bidding game must also satisfy the following equation:

$$V_I = pW_L + (1 - p)W_H. \tag{34}$$

Note that the first term captures the direct effect of change in p on probability of transaction going through, and the second term captures the effect of p due to changes in $\mathscr{A}_1$ and $\mathscr{A}_2$.

[14] Although regions $\mathscr{A}_0$ and $\mathscr{A}_3$ do not affect profits, for completeness we also report how model parameters affect the sizes of these regions. In particular, we find that, for interior solutions, $\mathscr{A}_0$ increases in p and c_H while $\mathscr{A}_3$ decreases in c_H and p.

[15] When $\gamma > 0$, this observation does not necessarily hold because the threshold values would differ across the two bidding mechanisms.

For given values of λ, p, γ, c_H, and c_L we can solve (6), (32), (33), and (34) simultaneously to determine v_1, b_L, b_H, and V_I. Using a similar approach, we can calculate the cutoffs and value functions for the joint and mixed bidding cases (see Online Appendix A for more details).

This additional analysis shows that joint bidding always dominates the mixed bidding mechanism. Thus, the finding reported in Proposition 1 is generalizable to an exponential distribution of valuations. Next we focus our attention on understanding how the model parameters affect a NYOP retailer's decision about whether to use itemwise bidding or joint bidding.

It is a standard practice in simulation studies to use regression analysis to understand the effect of model parameters on the key decision variable (e.g., Souza et al. 2004). In our data we find that in 67.75% of the cases joint bidding is more profitable than itemwise bidding.

Note that, for the exponential distribution, an increase in λ leads to a decrease in the mean valuation and the variance of the distribution. A logit analysis shows that joint bidding becomes less attractive for a NYOP retailer when the mean of valuation distribution increases (beta for $\lambda = 3.92$, $p < 0.001$). Note that as λ increases the exponential distribution shifts to the left and the variance also decreases. This leads to an increase in the proportion of consumers with moderate valuations who could switch from placing itemwise bids (b_L, b_L) to placing joint bid b_{lh}. Consequently, when λ grows in size the profitability of joint bidding increases. In other words, as the mean of the distribution increases then joint bidding is less attractive.

An increase in c_H, however, increases the attractiveness of joint bidding for a NYOP retailer (beta for $c_H = 7.55$, $p < 0.001$). This is because an increase in c_H raises v_1. Therefore, the mass of consumers who place itemwise bids (b_L, b_L) grows as c_H increases. Furthermore, these consumers will switch to placing a higher joint bid b_{lh} if given the option to place joint bids. The logit analysis also shows that joint bidding becomes less attractive as p increases (beta for $p = -25.77$, $p < 0.001$).

In general, as γ increases, the retailer can be more patient, and this should increase the value of game (both V_I and V_J). The logit analysis examines the relative profitability of joint bidding and itemwise bidding. We find that, as γ increases, joint bidding becomes more profitable (beta for $\gamma = 0.6868$, $p < 0.001$). This is because an increase in γ raises v_1. Therefore, the mass of consumers who place itemwise bids (b_L, b_L) grows as γ increases. These consumers will switch to placing a higher joint bid b_{lh} under the joint bidding scenario. Thus, as γ increases, joint bidding is more profitable.[16]

2.3.3. Discussion. In sum, our analysis of the three bidding mechanisms shows that both joint bidding and mixed bidding can help improve NYOP retailers' profits and consumer surplus compared to the itemwise bidding that is practiced today. The theoretical analysis also suggests that mixed bidding may dominate joint bidding if consumer valuations are uniformly distributed. The numerical analysis further clarifies that the theoretical results are generalizable to an exponential distribution of valuations.

3. Empirical Investigation

Experimental economists have used the laboratory as a test bed for designing innovative market institutions such as the Arizona Stock Exchange, the auction mechanism for leasing offshore drilling rights by the U.S. Government, and spot auction markets for electricity (e.g., Kagel et al. 1989, Rassenti et al. 2001). A laboratory test is often a useful first step in testing theoretical models, though it does not reflect all of the complexities of a field setting. Note that, if a model performs poorly in a controlled laboratory setting, then there is very little chance that it will survive in the field. But if a model survives a laboratory test, then it would be worthwhile to test it under rigorous field conditions and better understand the extent to which the model predictions are generalizable.

Because NYOP retailers do not currently offer joint bidding or mixed bidding, it is not possible to test our model predictions with field data. However, we can assess these bidding mechanisms in a laboratory setting. The goal of our experimental investigation is to examine whether giving consumers the option to place joint bids increases consumer surplus and retailers' profits as predicted by our model. Note that, if mixed bidding performs better than itemwise bidding, it follows that joint bidding will also perform better than itemwise bidding as pointed out in Proposition 1. Thus, by comparing itemwise bidding with

---

[16] In regions where joint bidding is superior to itemwise bidding, the mean profits from joint bidding, itemwise bidding, and mixed bidding are 0.375 (std = 0.268), 0.310 (std = 0.222), and 0.303 (std = 0.222), respectively. But in regions where itemwise bidding is more profitable than joint bidding, we find that the mean profits from joint bidding, itemwise bidding, and mixed bidding are 0.307 (std = 0.303), 0.329 (std = 0.326), and 0.283 (std = 0.280), respectively. Also note that itemwise bidding dominates mixed bidding on 79.59% of the occasions. We have also explored the issue of correlation in values using a normal distribution. In general, we find that joint bidding is more profitable for items with positively correlated valuations. This makes intuitive sense, because an increase in correlation increases the standard deviation of the joint value distribution, which improves the profitability of the joint bidding option.

mixed bidding, we seek answers for the following empirical questions:

1. Will consumers bid more when mixed bidding is allowed?

2. Will consumer surplus increase when mixed bidding is permitted?

3. Will NYOP retailers' profits improve if mixed bidding is allowed?

It is quite unlikely that our subjects solve for optimal behavior and accordingly bid for different items. It is possible that their bidding decisions are guided by some heuristics. For example, subjects could bid less when they have the option of placing joint bids. After all, they are used to getting discounts when products are purchased in bulk. If all subjects systematically engage in such discounting, then retailers are unlikely to realize more profits by allowing joint bidding. It is definitely convenient to place a single bid for multiple items rather than a separate bid for each item. However, it is cognitively more demanding to figure what that joint bid should be. Thus, to save cognitive effort and also avoid the potential risk of making financially imprudent decisions, some subjects might choose to bid one item at a time, even when offered the option of placing joint bids. Furthermore, some subjects, while making itemwise bids, might bid different amounts even if the items are the same. Such a behavior could potentially hurt consumer surplus, as well as retailers' profits. Thus, it is not clear whether, on average, subjects will bid more without hurting their surplus, and whether retailers will make more profit as implied by our model. Hence, we test our model in the laboratory.

3.1. Parameters

In our experimental study, we focused attention on the case where $\gamma = 0$, the probability of cost c being \$20 is $p = 0.7$, and the probability of its being \$40 is $1 - p = 0.3$. Though the two items have identical cost distributions, the realized cost of the items could be different. The valuations for the two items were identical and were drawn from the exponential distribution with mean 20. All subjects were exposed to the same set of valuations for items 1 and 2 over the 160 trials so that their bidding behavior could be compared. It is important to note that the valuations of the items changed from trial to trial and that the costs were different in each trial depending on the draws from the binomial distribution. Consequently, the decision faced by the subjects was not a trivial one. Furthermore, it is not easy to learn in such a noisy environment. The predicted mean profit for both items was \$4.57 if only itemwise bidding was allowed. The corresponding predicted mean bid and consumer surplus were \$46.5 and \$69.99, respectively. On the other hand, under mixed bidding

the NYOP retailer's profit should improve to \$5.15 for both items. The predicted mean bid for the two items and consumer surplus were \$55.35 and \$72.86, respectively.

3.2. Subjects

The subjects were undergraduate and graduate students who volunteered to participate in a bidding experiment for a monetary reward contingent on their performance in the experiment. In addition to their earnings, the subjects were promised a show-up fee of \$5.00. For this experimental study, we considered two treatments: itemwise bidding only, and mixed bidding where subjects were offered the option of placing joint bids. In each treatment, 50 subjects participated in 160 trials. Thus, a total of 100 subjects participated in this study.

3.3. Procedure

This study was conducted on the Web, with the server playing the role of seller and subjects playing the role of buyers. See Online Appendix D for instructions. Below we discuss the roles of the seller and buyer, rules of the bidding game, and information provided to subjects.

Seller. The seller had two different products, namely item 1 and item 2. It was not certain whether the seller's cost of these items would be high or low. The seller would accept an offer as long as it covered her cost. There was a 70% chance that the cost of item 1 was \$20 for the seller and a 30% chance that it was \$40. The cost distribution was the same for item 2. As noted earlier, the actual realized costs of items 1 and 2 could be different. On each trial, whether the cost of each item was high or low was determined by drawing a random number between 0 and 1 separately for each item. If the random number drawn for item 1 was less than or equal to 0.7, then item 1's realized cost was \$20, else the cost was \$40. Similarly, another random number was drawn for item 2. If this random number was less than or equal to 0.7, then item 2's realized cost was \$20, otherwise the cost was \$40. The computer played the role of the seller, and subjects were aware of this fact. This experimental design helped us to eliminate potential noise in the decisions of sellers and to more closely investigate the bidding behavior of buyers.

Buyer. Subjects played the role of buyers. We induced the desired valuations for items 1 and 2 by promising resale values for these items. Specifically, if subjects happened to win an item, then the difference between the resale value and their bid would be their profit. In each trial of the experiment, the subjects had to bid depending on the treatment and the resale values of the items. If only itemwise bidding was allowed, then they made separate bids for item 1

and item 2. On the other hand, if both types of bidding were allowed, then they first decided whether to bid itemwise or jointly, and then the bid amounts.

Bidding Rules. In itemwise bidding, the seller made independent decisions on whether or not to accept the bid for each item depending on the realized cost of that item. If the seller accepted the bid for an item, her profit was the difference between the bid and the realized cost while the buyer earned the difference between the resale value of that item and the accepted bid. In joint bidding, the seller either accepted or rejected the joint bid for both items. In other words, she sold both items or none. When a joint bid was accepted, the buyer earned the difference between the total resale value of the two items and the joint bid. The corresponding seller's profit was the difference between the joint bid and the total realized cost of items 1 and 2.

Information Provided to Subjects. At the commencement of each trial, subjects were informed of the values of item 1 and item 2, which changed over the 160 trials. They were also informed of the high and low costs and their corresponding probabilities. These costs and their probabilities remained the same throughout the experiment. After subjects decided on the bids, the realized cost of each item, along with the resulting earning for that trial, was communicated to subjects. To help subjects better appreciate the experiment, detailed examples were provided as part of the instructions to subjects. In addition, subjects played three practice trials to become conversant with the decision task. After becoming familiar with the game, subjects played 160 actual trials of the bidding game. At the end of the experiment, they were paid according to their cumulative earnings and then were debriefed and dismissed.

3.4. Results

The model makes specific predictions about how giving consumers the option to place joint bids will affect retailers' profits, consumer surplus, and bid amounts. The experimental results were qualitatively consistent with many of the predictions of the model predictions. We saw some departures, however, from the point predictions of the model.

3.4.1. Qualitative Predictions. We computed the mean profit, mean consumer surplus, and mean bid for each of the 100 subjects. Then we performed a one-way ANOVA on each of these dependent variables using bidding mechanism as the independent variable.

Bids. According to our model, subjects should bid more under mixed bidding. On average, subjects bid $47.28 when only itemwise bidding was allowed. When subjects were provided the option to place joint bids, they bid $55.35 on average. We could reject the

null hypothesis that these mean bids were the same ($F_{(1, 98)} = 133.14$, $p < 0.001$).

Our theory also makes specific predictions about how itemwise bids should change with consumer valuations of items. Specifically, consumers should bid (b_L, b_L) if valuations were low (namely, $20 = b_L < v < v_1 = 86.67$), else they should bid (b_H, b_H). We found that the average bid increased from $46.25 to $52.58 as we moved from the valuation region below v_1 to the one above it. On performing a subjectwise comparison of the average itemwise bids in these two regions of valuations, we found that the bids were not the same in the two regions ($t = 5.23$, $p < 0.01$)

Turning attention to mixed bidding, we found that bids increased when valuations were greater than v_1, that is 86.67. The average bid for $v < v_1$ was $54.99, and it increased to $57.15 for $v > v_1$ ($t = 3.47$, $p < 0.01$). Furthermore, in theory, mixed bidding should motivate consumers with intermediate valuations ($v_4 = 63.33 < v < v_1 = 86.67$) to bid b_{lh}, which is more than placing itemwise bids (b_L, b_L). Accordingly, in this intermediate range of valuations we found that the average bid was $47.90 under itemwise bidding but increased to $56.22 under mixed bidding. The difference in bid amounts was significant ($F_{(1, 98)} = 85.08$, $p < 0.001$).[17]

Another interesting question in the case of mixed bidding is whether subjects systematically switched from itemwise to joint bidding as predicted by theory.[18] According to our theory subjects with low valuations (namely $v < 63.33$) should place itemwise bids (b_L, b_L). In actuality, only 32.71% of the bids in this region were itemwise bids, implying that even subjects with low valuations placed joint bids and consequently bid larger amounts. Next subjects with intermediate valuations ($63.33 < v < 86.67$) should opt for joint bidding. Indeed, 75.83% of the bids in this region were joint bids b_{lh} as predicted by theory, and the rest were itemwise bids. Consumers with a little higher valuation ($86.67 < v < 141.1$) should also place a joint bid b_{lh} instead of itemwise bids (b_H, b_H). We found that subjects with such valuations preferred to place joint bids on 78.62% of occasions.

Consumer Surplus. Theoretically, the consumer cannot be worse off when accorded the option of placing joint bids. However, subjects could easily hurt themselves by making errors in bidding decisions. It

---

[17] On comparing the mean bid in the first 80 trials against that in the later 80 trials, we found no significant difference. This is not very surprising because the valuations were randomized over the 160 trials.

[18] Note that in the mixed bidding treatment we have bid information from 50 subjects for 160 trials each ($50 \times 160 = 8,000$ bids). Of the 8,000 bids, 3,800 bids were for $v < 63.33$, 2,900 bids for $63.33 < v < 86.67$, and 1,300 bids for $v > 86.67$.

was encouraging to note that the mean consumer surplus was \$72.34 under mixed bidding. In contrast, the consumer surplus when only itemwise bidding was allowed was \$68.33 ($F_{(1, 98)} = 44.76, p < 0.001$). As noted earlier, consumers with intermediate valuations (namely, $v_4 < v < v_1$) should place a joint bid b_{lh} under mixed bidding but bid (b_L, b_L) under itemwise bidding. Despite bidding more, consumers earned a larger surplus under mixed bidding even in this region of valuations. Specifically, consumer surplus improved from \$75.6 under itemwise bidding to \$81.35 under mixed bidding ($F_{(1, 98)} = 50.12, p < 0.001$).

Retailer's Profit. The model predicts that allowing for mixed bidding should increase the NYOP retailer's profit. The mean retailer's profit when only itemwise bidding was allowed was \$5.10, whereas the actual profit increased to \$8.37 under mixed bidding ($F_{(1, 98)} = 46.92, p < 0.0001$). Note that consumer surplus increased for intermediate valuations of v (namely, $v_4 < v < v_1$). This might raise the question of whether the retailer's profits declined for intermediate valuations of v. In theory, the retailer's profits should also improve in this region. In actuality, the retailer's profit was \$5.53 under itemwise bidding in this region but increased to \$8.87 on offering mixed bidding ($F_{(1, 98)} = 27.84, p < 0.001$).

3.4.2. Point Predictions. The experimental results were directionally consistent with many qualitative predictions of the theory. For completeness, we also report whether the actual outcomes conformed to the point predictions of the model.

Bids. If only itemwise bids were allowed then subjects should bid \$46.5, on average, for the two items. In actuality, subjects placed a mean bid of \$47.28, which was not significantly different from the theoretical prediction ($t = 1.61, p > 0.11$). Though the overall behavior is consistent with the equilibrium prediction, we observe deviations from the equilibrium predictions at the level of consumer valuation segments. Table 1 details the predicted and actual outcomes. For example, subjects actually bid \$46.25 instead of the predicted \$40.0 when $v < v_1$ ($t = 11, p < 0.001$). Though subjects should bid \$80 when $v > v_1$, they bid only \$52.58 ($t = 23, p < 0.001$).

Under mixed bidding, subjects bid \$55.25 on average, which is significantly more than the theoretical prediction of \$48.75 ($t = 13.05, p < 0.01$). This excessive bidding could be a consequence of either

Table 1   Itemwise Bidding

Valuation region	Predicted bid	Actual bid
$20 < v < 86.67$	40	46.25
$v > 86.67$	80	52.58

Table 2   Mixed Bidding

Valuation region	Bidding strategy	Predicted bid	Actual bid
$20 < v < 63.33$	Itemwise bidding	40	46.92
$63.33 < v < 86.7$	Joint bidding	60	58.09
$86.7 < v < 141.1$	Joint bidding	60	58.26

(i) subjects choosing inappropriate bidding mechanisms such as a joint bid when they should place itemwise bids or (ii) subjects bidding large amounts even though they have chosen the correct bidding mechanism. Table 2 shows the theoretical predictions and corresponding observed outcomes when subjects use the appropriate bidding mechanism. In theory, subjects should place joint bid $b_{lh} = \$60$ in the intermediate valuation region $63.33 < v < 86.67$ and in the higher valuation region $86.67 < v < 141.1$. In actuality, the average joint bids in these regions were \$58.09 and \$58.23, respectively, which are close to the equilibrium prediction ($p > 0.10$). Next subjects should bid itemwise $(b_L, b_L) = \$40$ in the low-valuation region. But the observed average itemwise bid was higher at \$46.92 ($p < 0.01$), and itemwise bids were placed on only 32.71% of occasions. Thus, the departures from equilibrium predictions were primarily driven by the tendency of our subjects to use inappropriate bidding mechanisms, especially using the joint bidding option in the low-valuation region.

Consumer Surplus. Using the bids predicted by theory and the actual valuations of items, we computed the mean earnings of individual subjects. If only itemwise bidding was permitted, then consumer surplus should be \$69.99 for items 1 and 2. On average, subjects actually earned \$68.32 for the two items. We could not reject the null hypothesis that the actual and predicted earnings were the same ($t = 0.59, p > 0.55$). The results were similar when subjects were given the option of placing joint bids (actual earning = 72.34, prediction = 72.86, $t = 0.16, p > 0.87$).

Retailer's Profit. The model provides point predictions on bids that subjects should place for different valuations of items. Using the predicted bid and the expected costs, we computed the expected profit as per theory. If only itemwise bidding were allowed, the mean profit should be \$4.57 for items 1 and 2. The actual mean profit was \$5.10. We could not reject the null hypothesis that these profits were the same ($t = 1.61, p > 0.11$). On the other hand, under mixed bidding the predicted mean profit for both items should be \$5.15, but the actual mean profit was \$8.37. Thus, mixed bidding produced more than the predicted increase in profit ($t = 9.47, p < 0.01$).

3.5.   Discussion

In sum, our experimental investigation suggests that the aggregate behavior of subjects is qualitatively

consistent with many predictions of our model. On average, retailers made more profits and subjects increased their bids without reducing their earnings when provided the option to bid jointly. Though the overall behavior is directionally consistent with the model, we observe deviations at the level of valuation segments and subjects tend to use joint bidding more often than predicted.

4. Conclusion

The NYOP channel has drawn a lot of attention from the public and the press for its innovativeness. The focus of our research was to explore whether the existing market institution can be further augmented. Toward this end, we developed a dynamic model of a NYOP retailer who faces both demand and supply uncertainty and examined the retailer's equilibrium bid acceptance strategy in the presence of strategic bidders. Our analysis focused on evaluating the profit and consumer surplus implications of three different bidding mechanisms: itemwise bidding, joint bidding, and mixed bidding. We find that in the presence of joint bidding some consumers may bid a higher amount than they would bid if they were placing itemwise bids. This increase in bid amount is related to the fact that joint bidding reduces the chance of a mismatch between the NYOP retailer's realized costs and consumer bids. Interestingly, the improved NYOP retailer's profit need not come at the cost of consumers, because joint bidding can also improve consumer surplus. Even if the NYOP retailer offers mixed bidding, where consumers can self-select whether they want to place itemwise or joint bids, we can observe improved profits and consumer surplus. In our framework, we also observe that joint bidding dominates mixed bidding. We conducted an experimental test of our model predictions. The test lends support to many qualitative predictions of our model. In particular, offering the option of joint bidding significantly improved consumer surplus and retailers' profits.

There are several avenues for further research. Although we investigated how NYOP retailers can augment their pricing mechanisms, we did not study the conditions under which service providers should consider selling their products through a NYOP channel in addition to selling their product through traditional retailers (see Fay and Xie 2008 and Wang et al. 2005 for possible modeling approaches). In our formulation, we assumed that the NYOP retailer's costs are exogenously determined. However, in a model that includes strategic upstream service providers (such as airlines) these costs can be endogenous to the model. It would also be useful to examine how joint bidding and mixed bidding may affect the

equilibrium strategies of service providers and NYOP retailers in such settings. It would also be interesting to study the implications of competition among NYOP retailers (see also Fay 2007). Finally, in the current research we subjected the model to a laboratory test, and future research can confront the model with field data when such data become available.

5. Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

References

Adams, W., J. Yellen. 1976. Commodity bundling and the burden of monopoly. *Quart. J. Econom.* **90** 475–498.

Bakos, Y., E. Brynjolfsson. 2000. Bundling and competition on the Internet. *Marketing Sci.* **19**(1) 63–82.

Berteskas, D. 1987. *Dynamic Programming: Deterministic and Stochastic Models.* Prentice Hall, Englewood Cliffs, NJ.

Demange, G., D. Gale, M. Sotomayor. 1986. Multi-item auctions. *J. Political Econom.* **94**(4) 863–872.

Ding, M., J. Eliashberg, J. Huber, R. Saini. 2005. Emotional bidders—An analytical and experimental examination of consumers' behavior in a Priceline-like reverse auction. *Management Sci.* **51**(3) 352–364.

Estelami, H. 1999. Consumer savings in complementary product bundles. *J. Marketing Theory Practice* **7**(3) 107–114.

Fay, S. 2004. Partial repeat bidding in the name-your-own-price channel. *Marketing Sci.* **23**(3) 407–418.

Fay, S. 2007. Selling an opaque product through an intermediary: The case of disguising one's product. *J. Retailing.* Forthcoming.

Fay, S., J. Xie. 2008. Probabilistic goods: A creative way of selling products and services. *Marketing Sci.,* ePub ahead of print March 31, http://mktsci.journal.informs.org/cgi/content/abstract/mksc.1070.0318v1.

Fudenberg, D., J. Tirole. 1991. *Game Theory.* MIT Press, Cambridge, MA.

Hann, I.-H., C. Terwiesch. 2003. Measuring the frictional costs of online transactions: The case of a name-your-own-price channel. *Management Sci.* **49**(11) 1563–1579.

Kagel, J., D. Levin, R. Battalio, D. Meyer. 1989. First-price common valuation auctions: Bidder behavior and winner's curse. *Econom. Enquiry* **27** 241–258.

Kannan, P., P. Kopalle. 2001. Dynamic pricing on the internet: Importance and implications for consumer behavior. *Internat. J. Electronic Commerce* **5**(3) 63–82.

McAfee, R., J. McMillan. 1987. Auctions and bidding. *J. Econom. Literature* **25**(2) 699–738.

McAfee, R., J. McMillan, M. Whinston. 1989. Multiproduct monopoly, commodity bundling and correlation of valuations. *Quart. J. Econom.* **104** 371–383.

Mishra, D., R. Garg. 2006. Descending price multi-item auctions. *J. Math. Econom.* **42** 161–179.

Rassenti, S., V. Smith, B. Wilson. 2001. Using experiments to inform the privatization/deregulation movement in electricity. Working paper, Economics Science Laboratory, University of Arizona, Tucson.

Reinganum, J. 1979. A simple model of equilibrium price dispersion. *J. Political Econom.* **87**(4) 851–858.

Rothkopf, M. 1991. On auctions with withdrawable winning bids. *Marketing Sci.* **10**(1) 40–57.

Rothkopf, M., R. Harstad. 1994. Modeling competitive bidding: A critical essay. *Management Sci.* **40**(3) 364–384.

Schmalensee, R. 1984. Gaussian demand and commodity bundling. *J. Bus.* **57**(1) S211–S230.

Sinha, A., E. Greenleaf. 2000. The impact of discrete bidding and bidder aggressiveness on sellers' strategies in open English auctions: Reserves and covert shilling. *Marketing Sci.* **19**(3) 244–265.

Souza, G., B. Bayus, H. Wagner. 2004. New-product strategy and industry clockspeed. *Management Sci.* **50**(4) 537–549.

Spann, M., G. J. Tellis. 2006. Does the internet promote better consumer decisions? The case of name-your-own-price auctions. *J. Marketing* **70**(1) 65–78.

Terwiesch, C., I. Hann, S. Savin. 2005. Online haggling at a name-your-price retailer: Theory and application. *Management Sci.* **51**(3) 339–351.

Wang, T., E. Gal-Or, R. Chatterjee. 2005. Why a name-your-own-price channel makes sense for service providers (Or: Who needs Priceline anyway?). Working paper, Marketing Department, University of Pittsburgh, Pittsburgh.

Xie, J., M. Sirbu. 1994. Price competition and compatibility in the presence of positive demand externalities. *Management Sci.* **41**(5) 909–926.