Competitive Reasons for the Name-Your-Own-Price Channel

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ABSTRACT

This paper shows that the Name-Your-Own-Price (NYOP) business model can help soften competition. When consumers differ in their frictional costs (i.e., the shopping hassle) they experience when bidding at a NYOP retailer, the NYOP format can be a mechanism for differentiating a retailer from a posted-price rival. Beyond providing a motivation for using a NYOP mechanism, competition also has important implications for the optimal structure of the NYOP format. For example, this paper shows that prohibiting re-bidding may benefit a NYOP firm by reducing price rivalry.

Keywords: Name-Your-Own-Price, Reverse Auctions, Pricing

Auctions of many different variants are sprouting up on the Internet and creating opportunities for researchers to analyze consumer and seller behavior in such environments (Cheema et al. 2005). The Name-Your-Own-Price (NYOP) format is one such new business model that offers a non-traditional way of determining prices and distributive allocations. Under the NYOP format, the seller sets a hidden threshold price, consumers bid for units of its product, and any bid that exceeds this threshold price is accepted. *Priceline* (www.priceline.com), an online seller of travel services, is the most prominent example of a NYOP firm. Unlike many of its hyped e-business peers that arose in the late 1990's, *Priceline* survived the Internet bust and even flourished. As a result, the NYOP mechanism has drawn the attention of both the popular press and academics (see Dolan and Moon 2000, Rust and Eisenmann 2000, and the literature cited below).

Aspects of the NYOP model that have been studied previously include: analyzing the optimality of consumer bidding (Spann and Tellis 2006); assessing the restriction of bids to discrete levels rather than from a continuous interval (Chernev 2003); examining the role of emotion in bidding behavior (Ding et al. 2005); and measuring the willingness-to-pay of bidders (Spann et al. 2004). Somewhat surprisingly, little attention has been paid to why a firm might choose a NYOP format. Presumably, a firm would want to employ a NYOP format only if it is more profitable than alternate mechanisms. Yet, much of the extant literature indicates that the NYOP format does not outperform posted prices. For instance, Fay (2004) notes that posted prices "weakly dominate NYOP in this simple framework" (p. 415). And, using data from a German NYOP retailer for three electronic products, Terwiesch, Savin, and Hann (2005) find that the retailer's profit would have been higher had the firm used posted prices (13.32 vs. 9.40 for DVD players, 8.61 vs. 4.96 for PDA's, and 5.97 vs. 5.41 for CD rewriters).

Furthermore, other papers in the literature suggest several disadvantages of the NYOP format relative to posted prices. In particular, due to uncertainty about the actual price threshold, consumers shade their bids and thus place bids that are well below their reservation values (Spann, Skiera, and Schafers 2004, Ding et al. 2005, Hann and Terwiesch 2003). And, Hann and Terwiesch (2003) demonstrate that the frictional costs associated with bidding are non-trivial. Thus, the NYOP format reduces the willingness-to-pay of consumers versus a posted-price format in which such frictional costs would not be incurred.

It is important to develop a deeper understanding of why the NYOP format may be preferred to alternative selling mechanisms in order to understand when and where such a business model would be advantageous, and to structure the NYOP mechanism properly. In this paper, I contribute to deepening this understanding by exploring how competition with a rival can affect the incentive to adopt the NYOP format. In particular, I demonstrate that (1) the NYOP format may be superior to posted prices because it can soften competition with a posted price rival; and (2) accounting for the role of the NYOP channel in softening competition has important implications for how a NYOP firm should set its rebidding policies.

The ability of the NYOP format to soften competition hinges on the fact that the frictional costs consumers face when bidding vary across consumers due to differences in opportunity costs of time, perceived difficulty of the task, experience, and other factors. Hann and Terwiesch (2003) find strong empirical evidence that frictional costs substantially vary across users. In particular, across the three products in their data, the median frictional cost per bid is approximately \$4.17 with a standard deviation of \$4.74.[1] The difference in the minimum and maximum frictional costs observed is \$58.64. Furthermore, these estimates are based on consumers who placed three or more bids for a particular item. The heterogeneity in frictional costs would likely be even higher among

[1] Hann and Terwiesch (2003) estimate the frictional costs (in EURO's) for 3 products, PDA's CD-RW drives, and MP3 players. The median frictional costs for bids on the three products are 6.08, 4.29, and 3.54, respectively. Standard deviations of costs are 7.57, 4.42, and 3.81. The minimum frictional costs are .44, .26, and .44. The maximum frictional costs are 65.59, 32.06, 22.33. The numbers in the text are averages across these three products converted into dollars (at a rate of EURO 1 = .90\$, which was the exchange rate when the original data was collected).

all potential consumers, i.e., consumers who place three or more bids, consumers who place less than three bids, and consumers who chose to purchase from an alternative posted-price retailer (and thus avoided presumably very high bidding costs).

This substantial heterogeneity in frictional costs provides an avenue for segmenting a market where there is both a NYOP and a posted-price option. An NYOP firm has an incentive to target consumers with low frictional costs while the posted-price firm sells to consumers with high frictional costs. Thus, the NYOP format offers a mechanism for reducing price competition and increasing mutual profit.[2]

The analysis in this paper is most applicable to settings in which a seller's primary threat comes from a single competitor who offers a very close substitute, such as the competition between *Hotwire* (which uses posted prices) and *Priceline* (which uses a NYOP format) in the U.S. travel market. Although many online intermediaries (e.g., *Orbitz*, *Expedia*, *Travelocity*), offline intermediaries (e.g., travel agents), and direct suppliers (e.g. *Delta Airlines*, *Marriott Hotels*, *Hertz Car Rental*) also sell travel services, *Hotwire* and *Priceline*, by offering "opaque" travel goods, serve a distinct market niche of the most price-sensitive and flexible travelers – the "mercenary traveler" (McGee 2003). The goods are "opaque" because consumers are not told the exact flight itinerary (supplier, connection city, or departure time) or the hotel property prior to purchase.[3] Because of this opacity, even if the *ex post* product assignment differs across the two firms, *ex ante* *Priceline* and *Hotwire* offer perfect substitutes, e.g., a flight between two cities any time on the specified days. Thus, price competition may be fierce if both firms offer posted prices. But, by selling through a NYOP format rather than through posted prices, *Priceline* is able to reduce price rivalry. Furthermore, since *Hotwire* and *Priceline* are the two dominant players in the opaque travel

[2] Other non-posted price mechanisms may also be able to mitigate price competition in this context. However, it is beyond the scope of the current paper to compare the NYOP format to all possible pricing mechanisms.
[3] Fay (2008) and Fay and Xie (2008) provide additional discussion of the role of opacity in market interactions.

market (McGee 2003), it is important that *Priceline* make its decisions in anticipation of *Hotwire*'s response, and vice-versa.

The NYOP format may be particularly useful for retailers competing online. Because they rely on the same manufacturers, retailers may find themselves selling a product that is undifferentiated from a rival's product. This difficulty is further compounded in online markets since the lack of physical locations eliminates geographically-based differentiation. In such settings, the NYOP format may be a valuable tool for creating differentiation and thus relaxing price competition. Furthermore, the success of the NYOP format relies on ensuring that consumers believe that the price threshold is drawn from a distribution, i.e., that consumers do not know the actual price threshold in effect at a given time. The online environment may facilitate such credibility. For example, an automated platform can be augmented to include a random component and can also ensure that the stated bidding restrictions are enforced (e.g., no re-bidding).[4] Furthermore, word-of-mouth, which flows more easily online, can inform consumers about the distribution of price thresholds and also demonstrate the unpredictable nature of the acceptance decision. For instance, numerous web forums, e.g., betterbidding.com, biddingfortravel.com, and flyertalk.com, now allow consumers to converse about their experiences in dealing with *Priceline*.

While the current paper offers one rationale for the NYOP format, namely to soften competition, I do not assert that this is the only possible motivation for using the NYOP format. Indeed, another key objective of this paper is to encourage future research that identifies alternative explanations. One such alternative is provided in Terwiesch et al. (2005) which argues that the

[4] There is some evidence that current NYOP sellers have indeed committed to such a decision structure. For example, *Priceline* determines whether a given bid is accepted using a complicated computer formula which includes a random element (Segan 2005) and employs a "randomizer" program for deciding whether to accept a bid for a hotel room (Malhotra and Desira 2002, Haussman 2001). In particular, rather than setting the threshold price equal to the lowest rate offered by the entire set of hotels that have rooms available, *Priceline* only compares the bidder's offer to the rates set by two randomly-selected hotels. Such an action is consistent with the speculation in Kannan and Kopalle (2001) that *Priceline* may "deliberately forgo a successful transaction" in order to influence consumers' expectations, i.e., persuade consumers to bid higher in the future.

NYOP mechanism can facilitate price discrimination. An illustrative example on p. 349 shows a potential benefit of the NYOP format. In this example, there are two types of customers. The first type has a reservation value of 101, per-bid frictional costs of .01, and believes the threshold price is drawn from U[0, 101]. The second has a reservation value of 300, per-bid frictional costs of 50, and believes the threshold price is drawn from U[0, 300]. The first type will place a single bid of 100.974, and the second will bid 150. As long as the first type sufficiently outnumbers the second type, the NYOP format is more profitable than posted prices. Based on this example, Terwiesch et al. speculate that for the NYOP format to be advantageous to the seller, the following is required: (1), substantial heterogeneity in valuations and (2), positive correlation between valuations and frictional costs. It appears that this example also relies on a third requirement – a positive correlation between valuations and the expected threshold price (so that the second type will bid higher).[5]

In the current paper, I introduce an environment in which the NYOP format can be advantageous to sellers without meeting any of these three requirements. In particular, in the current model, consumer valuations are homogenous, there is no correlation between valuations and frictional costs, and all consumers have the same expectations about the threshold price. This set-up ensures that the motivation for a seller to use a NYOP format is distinct from the motivation identified in Terwiesch et al. (2005).

In the next section, I present a duopoly model in order to explore the situations in which a firm might benefit from using a NYOP format. In section 3, I examine whether a NYOP firm should allow consumers to place multiple bids, focusing on how this choice depends upon a rival's response to the NYOP firm's bidding policy. Section 4 offers brief concluding comments, including directions for future research.

[5] Notice that if the second type also believed that the threshold price was drawn from U[0,101], they would not bid 150, but instead bid 101 or less.

2. Model

2.1 Specification of the Duopoly Game

Each of two retailers, "*A*" and "*B*", obtain units of a product from a manufacturer at the wholesale price, which I normalize to zero. The two firms play a two-stage game. In the first stage, the two retailers sequentially select a market format – either a posted price or a NYOP format.[6] In the second stage of the game, the firms choose their posted prices (if the posted-price format was selected in the first stage). In the event that both firms use the posted-price format, the prices (P_A and P_B) are chosen simultaneously. Finally, consumers decide whether to purchase and from whom.

Under the NYOP format, a retailer's threshold price, P_{NYOP}, is not directly observed by consumers. Any bid below this threshold is rejected, while any bid at or above P_{NYOP} is accepted and results in that consumer paying his/her bid. I assume that consumers' expectations of the threshold price are confirmed on average. In particular, the NYOP seller draws the threshold price from a pre-announced distribution and the consumers know this is the process for determining the threshold price. To avoid unnecessary notation, I assume the distribution function is U[0, 1]. I solve the game recursively. First, I identify the profit that results from each possible format combination. Then, I identify the Sub-Game Perfect Nash Equilibrium in format choices for the full game.

2.2 Consumer Demand

Each consumer has a reservation value, $R \equiv 1$, for one unit of the product.[7] There are no frictional costs of purchasing at the posted price. However, consumers incur bidding costs when

[6] Sequential format choices are not required for the core results of this paper. However, with simultaneously format decisions, multiple equilibria may arise – one in which firm *A* selects the NYOP format and firm *B* selects posted prices, and one in which firm *A* selects the posted price format while firm *B* selects the NYOP format. Thus, coordination issues (i.e., which equilibria is played) may arise in a simultaneous-choice setting.

[7] While assuming a common reservation value dramatically simplifies the analysis, it is not essential for the paper's main qualitative results. A more subtle point is that variation in frictional costs is essential for appropriately segmenting consumers. The NYOP mechanism is an effective means of targeting consumers with low frictional costs but not those with low valuations. Thus, to receive the price discrimination effect touted in the literature (e.g., Hann and Terwiesch 2003), variation in frictional costs is essential, but variation in reservation values is not.

interacting with a seller who uses a NYOP format. I assume that the cost to consumer *i* of placing a bid through the NYOP channel, c_i, is drawn from U[0, $\bar{c}$]. I restrict attention to $\frac{1}{4} \leq \bar{c} \leq \frac{1}{2}$, which ensures that the range of bidding costs approximately matches the empirical estimates of these costs (which were discussed in the introduction).

To allow each firm to have some market power, I use a loyal-switcher model. Thus, consumers vary in their proclivity to shop at a given retailer. In particular, a proportion λ of consumers are loyal to retailer *A*. I assume another segment of size λ is loyal to retailer *B*. These consumers are only willing to shop at their favored retailer. The remaining (1 – 2 λ) consumers are "switchers" who will visit either (or both) retailers. In the subsections below, I consider the optimal purchase behavior under the three possible format permutations.

Both Firms Use Posted Prices

The consumers who are loyal to retailer *A* can either purchase the product at a posted price of P_A or forego consuming the product. Purchasing from *A* is optimal if $P_A \leq 1$. The consumers who are loyal to retailer *B* can either purchase the product at a posted price of P_B or forego consuming the product. These consumers purchase from *B* if $P_B \leq 1$.

The switchers can purchase the product from either retailer. They will purchase from the retailer that charges the lowest price, as long as this price does not exceed their reservation values. In particular, the switchers will purchase from *A* if $P_A < P_B$ and $P_A \leq 1$. The switchers will purchase from *B* if $P_B < P_A$ and $P_B \leq 1$. If both retailer charge the same price (and this price does not exceed 1), then the switchers will be evenly divided across the two retailers.

One Firm Uses a Posted Price; One Firm Uses a NYOP Format

Without loss of generality (due to symmetry), let retailer *B* be the firm that uses a NYOP format, while retailer *A* uses a posted price. Recall that consumers cannot observe the actual price threshold employed by the NYOP firm. Thus, consumers instead rely on expectations (i.e., the belief that P_{NYOP} ~ U[0, 1]) in order to decide what to bid. Here, I assume consumers are restricted to a single bid. (As an extension, in Section 3, I allow consumers to bid again if their first bid is rejected.) Each consumer bids to maximize her expected consumer surplus (given the information she possesses).

The consumers who are loyal to retailer *A* can either purchase the product at a posted price P_A or forego consuming the product. Such consumers will purchase from *A* if $P_A \leq 1$.

The consumers who are loyal to retailer *B* can either bid at *B*'s NYOP site or forego bidding. Such a scenario has previously been analyzed by Spann et al. (2004) and Spann and Tellis (2006). The optimal bidding strategy is:

$$(1) \qquad \begin{cases} \text{place a single bid of } \hat{b} & \text{if } c_i \leq \hat{c} \\ \text{do not bid at all} & \text{if } c_i > \hat{c} \end{cases} \qquad \text{where } \hat{b} = \frac{1}{2},\ \hat{c} = \frac{1}{4}$$

The switchers have a more complicated decision. They must decide whether to a) forego bidding and buy the product at the posted price P_A; b) bid at *B*'s NYOP site and then purchase at P_A if that bid is rejected; c) bid at *B*'s NYOP site and then not purchase at *A*'s posted price if that bid is rejected; or d) neither bid at *B*'s NYOP site nor buy at *A*'s posted price. As long as $P_A \leq 1$, only the first and second options can be optimal. This condition, $P_A \leq 1$, will be satisfied in equilibrium since retailer *A* does not make any sales if this condition is violated. I find that the optimal bidding strategy in such an environment is:

$$(2) \qquad \begin{cases} \text{bid at } \hat{b}_1 \text{ and then purchase at } P_A \text{ if rejected} & \text{if } c_i \leq \hat{c}_1 \\ \text{purchase at } P_A \text{ without bidding at all} & \text{if } c_i > \hat{c}_1 \end{cases} \qquad \text{where } \hat{b}_1 = \frac{P_A}{2},\ \hat{c}_1 = \frac{(P_A)^2}{4}$$

<u>Both Firms Use a NYOP Format</u>

As above, I assume consumers are restricted to a single bid on each NYOP site. The consumers who are loyal to retailer *A* can either bid at *A*'s NYOP site or forego bidding. Their optimal bidding strategy is given by (1). The consumers who are loyal to retailer *B* face an isomorphic decision. Thus, their optimal bidding strategy is also given by (1), but for these consumers, retailer *B* receives the bids.

The switchers have the following options: a) to bid at *A*'s site and then bid at *B*'s site if that bid is rejected; b) to bid at *B*'s site and then bid at *A*'s site if that bid is rejected; c) to bid at *A*'s site and then not bid again if that bid is rejected; d) to bid at *B*'s site and then not bid again if that bid is rejected; or e) not to bid at either site. It turns out that the third and fourth options are never optimal. Furthermore, due to symmetry, the first two options yield equivalent expected surplus. The optimal bidding strategy in such an environment is:

$$(3) \qquad \begin{cases} \text{bid at } \hat{b}_{11} \text{ and then bid at } \hat{b} \text{ (on the other site) if rejected} & \text{if } c_i \le \hat{c} \\ \text{do not bid at either site} & \text{if } c_i > \hat{c} \end{cases} \qquad \text{where } \hat{b}_{11} = \frac{3+4c_i}{8}$$

2.3 Prices and Profit for Each Sub-Game

The Appendix contains the derivation of the profit for each of the possible format configurations. The text summarizes the results and provides a brief intuition.

<u>Both Firms Use Posted Prices</u>

To maximize profit from sales to its loyal customers, a retailer would price at 1. But, to maximize profit from switchers, a retailer would want to undercut its competitor's price by epsilon. Due to this discontinuity in demand at $P_A = P_B$, no pure-strategy Nash Equilibrium in prices exists when each retailer sells at a posted price. Instead, there is a mixed-strategy equilibrium in prices. In this equilibrium, both firms earn a profit of:

$$(4) \qquad \Pi_A^{PP,PP} = \Pi_B^{PP,PP} = \lambda$$

Notice that as store loyalty declines, equilibrium profits also fall. Since switchers view the two retailers' products as perfect substitutes, as the magnitude of the switcher segment grows, the firms have less market power and, as a result, prices (on average) are driven closer to marginal cost.

One Firm Uses a Posted Price; One Firm Uses a NYOP Format

Again, I focus on the case in which retailer *B* uses a NYOP format while retailer *A* uses a posted price. Retailer *B* randomly selects P_{NYOP} from U[0, 1]. The expected profit to the firm is:

$$\Pi_B^{PP,NYOP} = \lambda \int_{c_i=0}^{\hat{c}} \int_{P_{NYOP}=0}^{\hat{b}} \hat{b}\ \mathrm{f}\left(c_i\right) \mathrm{d}P_{NYOP}\ \mathrm{d}c_i + \left(1-2\lambda\right) \int_{c_i=0}^{\hat{c}_1} \int_{P_{NYOP}=0}^{\hat{b}_1} \hat{b}_1\ \mathrm{f}\left(c_i\right) \mathrm{d}P_{NYOP}\ \mathrm{d}c_i \tag{5}$$

Retailer *A* sells to its loyal consumers (as long as $P_A \le 1$) and to switchers who do not have a bid accepted (either due to not submitting a bid or due to having their bid rejected). Thus, firm *A* earns a profit of:

$$\Pi_A^{PP,NYOP} = P_A \left[\lambda + \left(1-2\lambda\right) \left(1 - \int_{c_i=0}^{\hat{c}_1} \int_{P_{NYOP}=0}^{\hat{b}_1} \mathrm{f}\left(c_i\right) \mathrm{d}P_{NYOP}\ \mathrm{d}c_i \right) \right] \tag{6}$$

Retailer *A* chooses P_A to maximize this profit.

Both Firms Use a NYOP Format

Retailers *A* and *B* both randomly select P_{NYOP} from U[0, 1]. Sales to each retailer come from their loyal consumers and from switchers (some of whom have had a previous bid rejected at the rival's site). The expected profit to each NYOP seller is:

$$\begin{aligned} \Pi_A^{NYOP,NYOP} = \Pi_B^{NYOP,NYOP} &= \lambda \int_{c_i=0}^{\hat{c}} \int_{P_{NYOP}=0}^{\hat{b}} \hat{b}\ \mathrm{f}\left(c_i\right) \mathrm{d}P_{NYOP}\ \mathrm{d}c_i + \frac{\left(1-2\lambda\right)}{2} \int_{c_i=0}^{\hat{c}} \int_{P_{NYOP}=0}^{\hat{b}_{11}} \hat{b}_{11}\ \mathrm{f}\left(c_i\right) \mathrm{d}P_{NYOP}\ \mathrm{d}c_i \\ &\quad + \frac{\left(1-2\lambda\right)}{2} \int_{c_i=0}^{\hat{c}} \int_{P_{NYOP}=0}^{\hat{b}} \left(1-\hat{b}_{11}\right)\hat{b}\ \mathrm{f}\left(c_i\right) \mathrm{d}P_{NYOP}\ \mathrm{d}c_i \end{aligned} \tag{7}$$

2.4 Format Decision

Now consider the first stage of the duopoly game in which each retailer selects its market format. Without loss of generality, assume retailer *A* chooses its format first and then retailer *B* chooses its format. In the Subgame Perfect Nash Equilibrium, firm *B* chooses the format that is the best response to *A*'s format, and *A* chooses the format that maximizes its profit given firm *B*'s best response. Proposition 1 describes the equilibrium format configuration.

> ***Proposition 1:*** *When there is sufficiently little store loyalty in a market, in the Subgame Perfect Nash Equilibrium, one firm will adopt the NYOP format while the other will use posted prices. Specifically, if* $\lambda < \frac{1}{9}$*, then in the unique Subgame Perfect Nash Equilibrium, retailer A selects a posted price format and retailer B select a NYOP format.*

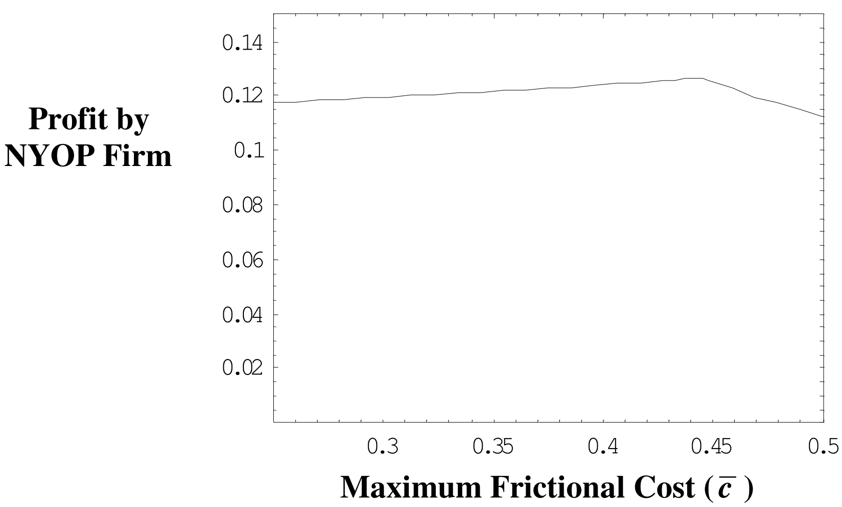
To understand the intuition behind Proposition 1, consider how the size of the loyal segment affects prices and profit when both firms use posted prices. Recall that in this market configuration there is a mixed equilibrium in prices. A firm must balance setting high prices in order to maximize revenue from loyal consumers with setting low prices in order to woo switchers away from a competitor. As the loyal segment grows, each firm puts less emphasis on attracting switchers. Specifically, the lower end of the equilibrium price distribution $\left(\hat{P}\right)$ depends on the degree of store loyalty: $\hat{P} = \frac{\lambda}{1-\lambda}$. As store loyalty increases, the lowest posted price increases (and the firm chooses higher prices with higher probability). At the extreme case where all consumers are loyal $(\lambda = .5)$, each seller always prices at 1. However, at the other extreme in which all consumers are switchers $(\lambda = 0)$, the model converges to the standard Bertrand competition with perfect substitutes in which both firms price at marginal cost.

This suggests that when there is little store loyalty, firms would like to find a mechanism for softening price competition. The NYOP format can serve as such a mechanism. Notice that even though the switchers view the two seller's products as being undifferentiated, the switchers vary in their willingness to bid on a NYOP site since they differ in their frictional costs of bidding. Thus, when one firm adopts the NYOP format, segmentation on the basis of heterogeneous frictional costs occurs. In particular, consumers with low frictional costs are willing to bid at the NYOP site. On the other hand, consumers with high frictional costs or those whose bids the NYOP site rejected, will purchase at the posted-price channel.

Interestingly, such segmentation occurs (and is beneficial to both retailers) even though the posted-price firm can influence how many consumers will bid at the NYOP site. In particular, at a lower posted price, fewer consumers (i.e., only those with sufficiently low frictional costs) will bid at the NYOP site. Thus, lower posted prices lead to higher sales for the posted-price firm, but at the same time reduces margins. In balancing these trade-offs, the posted-price firm may compete for the switchers (i.e., by choosing a price less than one). Even so, the heterogeneity in frictional costs means that competition is not as fierce as it would have been if both firms had used posted prices. This is because a posted price firm does not have the incentive to lower its price so much as to persuade switchers with low bidding costs to forego bidding at the NYOP site. Thus, even though a retailer realizes that if it implements a NYOP format, its posted-price rival will poach some of the switchers, the NYOP format is still advantageous (versus the alternative of facing the fierce competition under posted prices).

Finally, it is interesting to explore how the magnitude of frictional costs affects the profit of the NYOP firm. For instance, one might expect that as costs get larger, the NYOP format becomes less profitable (since bidding on a NYOP site becomes less attractive to consumers). Figure 1 illustrates the NYOP firm's profit as a function of the range of frictional costs (using $\lambda = .1$). Interestingly, profits do not monotonically decrease in frictional costs. When $\bar{c} \in \left[\frac{1}{4}, \frac{4}{9}\right]$, the NYOP firm's profit actually increases in $\bar{c}$. This result occurs because, in this range, an increase in $\bar{c}$ induces the posted-price rival to price less aggressively. Interestingly, this finding implies that the NYOP firm may benefit if the average frictional cost of placing bids on its site rises. Greater inconvenience for some consumers makes segmentation on frictional costs easier and thus increases the profit of both the NYOP firm and its posted-price rival. However, if frictional costs become too large $\left(\bar{c} > \frac{4}{9}\right)$, the NYOP firm's profit decreases in $\bar{c}$. Here, the posted-price retailer is already pricing at each consumer's reservation price and thus price competition cannot be any lower. In this case, a larger $\bar{c}$ simply implies that fewer customers are willing to bid at the NYOP site.

Figure 1 Profit for the NYOP Firm When Its Rival Uses Posted Prices $(\lambda = .1)$



3. Incentive to Allow Re-bids

The preceding section introduced a new motivation for why a firm might employ a NYOP format – namely to reduce price rivalry. In this section, I explore how this new rationale affects the optimal way to structure the NYOP format. I focus on a design aspect that has been a focal point of much past research – whether a NYOP firm should allow rejected bidders to re-bid. Focusing on a monopoly context, the extant literature suggests that allowing re-bids usually improves the profitability of the NYOP channel. For example, Spann et al. (2004) assert that "restricting consumers to a single bid may reduce the seller's revenues." Hann and Terwiesch (2003), in a technical appendix (p. 10), propose a rationale for this result: heterogeneity in frictional costs allows a NYOP firm to price-discriminate between customers and thus increase profit. By allowing consumers to re-bid, the NYOP seller can increase total sales (i.e., capture some sales from consumers whose first bid was rejected) and also price-discriminate (i.e., charge, on average, a higher price to consumers with high frictional costs since such customers increase their bids in larger increments). Additionally, Fay (2004) argues that restricting consumers to a single bid is likely to be undesirable in light of the fact that sophisticated bidders circumvent this restriction while many other bidders cannot.

In this section, I consider the impact of allowing re-bids when the NYOP firm faces a posted-price rival. In the text, I report the main results of my analysis and intuition, relegating the technical details to the Appendix.

First, I find that in the current model, in the absence of any strategic effect, a NYOP firm never benefits from restricting consumers to a single bid. In particular, if the rival firm's posted price is the same when consumers are allowed to re-bid at the NYOP site as when they are restricted to a single bid, then the NYOP firm benefits from allowing consumers to re-bid. This finding is consistent with the literature described above.

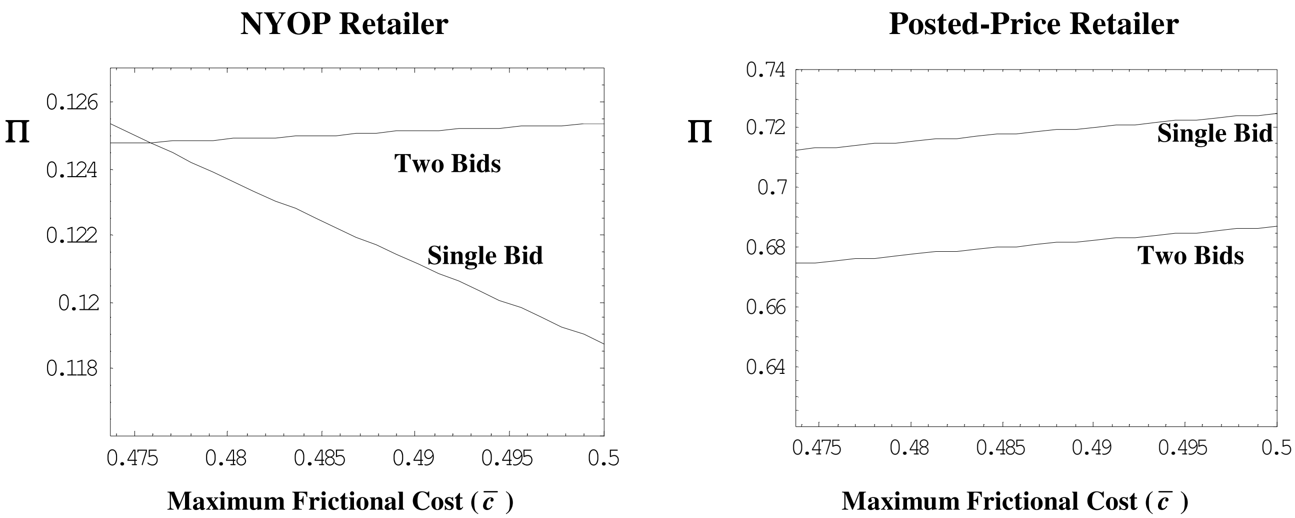
Second, I find that restricting bidders to a single bid can have the strategic benefit of reducing competition. This result is summarized by Proposition 2.

> ***Proposition 2:*** *When facing competition from a posted-price rival, a NYOP firm may benefit from restricting consumers to a single bid. For example, when $\lambda = .05$, restricting consumers to a single bid is more profitable than allowing them to re-bid if $\frac{9}{19} \le \bar{c} < .476$.*

This potential advantage from prohibiting re-bids occurs because re-bidding policies may impact the pricing strategy of a rival. In particular, the posted-price rival may choose a lower price if consumers can re-bid than if they are restricted to a single bid. Allowing re-bids increases the appeal of the NYOP channel to consumers, especially those with relatively low frictional costs. In order to prevent consumers from re-bidding and instead buy at the posted price, the posted price firm must lower its price. But, a lower price in the posted-price channel negatively impacts the NYOP seller's profitability.

Figure 2 illustrates the profits for both firms when re-bidding is or is not allowed (assuming $\lambda = .05$ and $\bar{c} \geq \frac{9}{19}$). Under these parameters, store loyalty is sufficiently small so that in the Subgame Perfect Nash Equilibrium retailer *B* uses the NYOP format, and under the single-bid structure, retailer *A* would set its posted- price equal to 1. Thus, in this situation, the NYOP format is very effective at mitigating price competition when consumers can bid only once at the NYOP retailer's site. However, if the NYOP firm allows re-bids, the NYOP firm is more appealing to consumers. Thus, the posted-price retailer's profit falls. Furthermore, facing this greater competitive threat, the posted-price retailer would lower its price. This, in turn, diminishes the level of bids placed on the NYOP site. Thus, the advantages of allowing re-bids identified above (higher sales and better price discrimination) are counterbalanced by lower bids. When heterogeneity in frictional costs is small, the negative effect from lower bids is sizable because the posted-price rival prices aggressively. Thus, if heterogeneity in frictional costs is sufficiently small $(\bar{c} < .476)$, then the NYOP retailer's profit is higher if it restricts consumers to a single bid. However, as heterogeneity grows, the posted-price rival has less incentive to try to poach the low frictional-cost consumers (since consumers with high frictional costs are willing to pay a high posted price rather than make a costly bid). Thus, if heterogeneity in frictional costs is sufficiently large $(\bar{c} > .476)$, the NYOP retailer finds it advantageous to allow re-bids.

Figure 2 Comparison of Profit with and without Re-bidding $(\lambda = .05)$



Interestingly, these results offer an explanation for an apparent conflict between theory and practice. As noted earlier, much of the past theory suggests that a NYOP retailer would earn higher profits if it allowed consumers to re-bid. Yet, *Priceline* –the most prominent retailer that employs a NYOP format –does in fact restrict consumers to a single bid. The above results suggest that restricting bidders to a single bid may have the strategic benefit of reducing competition. Thus, *Priceline* may benefit from imposing a single-bid restriction in order to mitigate price rivalry with *Hotwire*. However, it is important to note that other factors can affect the desirability of allowing re-bids. In particular, allowing re-bids can increase sales, i.e., rejected bidders continue bidding, but the information rent of the NYOP seller falls if re-bids are allowed since consumers can start their bid sequences at a lower level and raise their bids in smaller increments (Fay 2004). The key insight from Proposition 2 is that the impact on rivals' pricing is another important factor a NYOP firm should consider before allowing re-bids.

4. Concluding Remarks

This paper takes an important step towards modeling the effect of competition on a retailer's choice of whether or not to use a NYOP format. In doing so, it provides one explanation for why a firm would employ a NYOP mechanism rather than posted prices, i.e., the NYOP format provides a mechanism for reducing price competition.

Many issues remain for future research. It would be valuable to extend the theoretical model and to test it empirically in order to assess the robustness of the ideas introduced in this paper. One particularly restrictive assumption in the current paper is that the NYOP retailer is assumed to randomly draw it price threshold from an exogenously determined distribution, namely U[0,1]. Presumably, if a NYOP retailer had the option to commit to any distribution, then the NYOP format would be even more beneficial to a firm. Future research should consider what distribution would be optimal for a NYOP retailer to adopt. And, it would be interesting to explore how a retailer might credibly commit to such a distribution (rather than setting the price threshold which maximizes ex post profits). It would also be useful to explore additional rationales for the NYOP format. Lastly, while the current paper focuses on the policy decision of whether to allow consumers re-bid, future research should explore other design aspects of the NYOP mechanism (e.g., non-uniform price threshold distributions, information to reveal about this distribution, frequency with which to change the actual price threshold, or having consumers "select" rather than "name" a price) with an eye toward understanding how these design issues impact the ability of the NYOP format to fulfill its purpose.

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Appendix

Derivation of consumers' optimal bids when Retailer B uses a NYOP Format

Retailer *B*'s loyal consumers can either bid at *B*'s NYOP site or they can forego bidding. A bid of b is accepted with a probability of b, in which case the consumer gets a net surplus of (1-b). Thus, the consumer's expected value from bidding b is:

(A1) $$\mathrm{EV_L}(b) = (1-b)b - c_i$$

The FOC of this maximization problem is: $\frac{\partial \mathrm{EV_L}(b)}{\partial b} = 1 - 2b \equiv 0$. This FOC is satisfied when $b = \frac{1}{2} \equiv \hat{b}$ and $\mathrm{EV_L}(\hat{b})$ is non-negative (so as to induce bidding rather than abstaining) iff $c_i \le \frac{1}{4} \equiv \hat{c}$.

Suppose retailer *A* sells at a posted price of P_A. A switcher who purchases at the posted price earns a surplus of (1- P_A). A switcher can bid at *B*'s NYOP site if she so chooses. The expected value from placing a bid of b and then purchasing at the posted price if that bid is rejected is:

(A2) $$\mathrm{EV_{S1}}(b) = (1-b)b - c_i + (1-b)(1-P_A)$$

Using the FOC, this expected value is maximized when $b = \hat{b}_1$ and weakly exceeds the surplus from buying at the posted price without bidding iff $c_i \le \hat{c}_1$, where $\hat{b}_1$ and $\hat{c}_1$ are defined in (2).

Now suppose retailer *A* also uses a NYOP format. If a switcher were to not bid on either site, she would earn a surplus of zero. Another alternative bidding strategy would be to place a bid of b at one of the two sites and then not bid at the other site if this bid were rejected. This strategy generates an expected value given by (A1), which is maximized when $b = \hat{b}$, yielding an expected value of $\frac{1}{4} - c_i$. Finally, a switcher could place a bid of b_1 at one of the two sites and then place a bid of b_2 at the other site if the first bid is rejected. This strategy yields an expected value of:

(A3) $$\mathrm{EV_{S2}}(b_1, b_2) = (1-b_1)b_1 - c_i + (1-b_1)\left[(1-b_2)b_2 - c_i\right]$$

Using the resulting FOC's, the consumer's expected value is maximized when $b_1 = \hat{b}_{11}$ and $b_2 = \hat{b}$ where $\hat{b}_{11}$ and $\hat{b}$ are defined in Equations (3) and (1), respectively. This dual-bidding strategy yields a higher expected surplus than the single bidding strategy $\forall\ c_i \le \hat{c}$. This dual-bidding strategy is weakly superior to not bidding at all iff $c_i \le \hat{c}$.

Derivation of Equilibrium Prices and Profit for Each Sub-Game

In accordance with Proposition 1, the remainder of the derivations in the Appendix proceed under the assumptions $\frac{1}{4} \leq \bar{c} \leq \frac{1}{2}$ and $\lambda < \frac{1}{9}$.

Both Firms Use Posted Prices

The loyal-switcher model whereby both firms sell at a posted price is a slightly simplified version of a model which has previously been analyzed by Varian (1980) (using the terms "informed" and "uninformed" to describe the two segments). Rather than replicating that entire analysis, below, I simply report the results.

There is not a pure-strategy equilibrium to this game. Instead, there is a mixed-strategy equilibrium in prices in which each retailer charges price P with a probability f(P). f(P) = 0 if $P < \hat{P}$ or $P > 1$, where $\hat{P} = \frac{\lambda}{1-\lambda}$. On the interval $\left[\hat{P},1\right]$, $\mathrm{f}\left(P\right) = \frac{\lambda}{\left(1-2\lambda\right)P^2}$. Each firm's expected profit is $\Pi_A^{PP,PP} = \Pi_B^{PP,PP} = \lambda$.

Firm A Uses Posted Prices; Firm B Uses a NYOP Format

Retailer A chooses its posted price in order to maximize the expected profit given in Equation (6) (with the profit function for retailer B, $\Pi_B^{PP,NYOP}$, given by Equation (5)). At the interior solution of $P_A^{IS} = \sqrt[3]{\frac{2\bar{c}\left(1-\lambda\right)}{1-2\lambda}}$, profit for the Firm A (who uses a posted price) is $\Pi_A^{PP,NYOP(IS)} = \frac{3\left(1-\lambda\right)}{2}\sqrt[3]{\frac{\bar{c}\left(1-\lambda\right)}{4\left(1-2\lambda\right)}}$. The profit for Firm B is $\Pi_B^{PP,NYOP(IS)} = \frac{\lambda}{16\bar{c}} + \frac{1-2\lambda}{4}\sqrt[3]{\frac{\bar{c}^3\left(1-\lambda\right)^4}{4\left(1-2\lambda\right)^4}}$. There is also a potential corner solution at $P_A^{CS} = 1$. Here, firm A's profit is $\Pi_A^{PP,NYOP(CS)} = 1-\lambda-\frac{1-2\lambda}{8\bar{c}}$ and firm B's profit is $\Pi_B^{PP,NYOP(CS)} = \frac{1-\lambda}{16\bar{c}}$. Firm A chooses the posted price that yields the highest profit:

(A4) $$\Pi_A^{PP,NYOP} = \mathrm{Max}\left[\Pi_A^{PP,NYOP(IS)},\Pi_A^{PP,NYOP(CS)}\right] = \begin{cases} \frac{3\left(1-\lambda\right)}{2}\sqrt[3]{\frac{\bar{c}\left(1-\lambda\right)}{4\left(1-2\lambda\right)}} & \text{if } \bar{c} \leq \frac{1-2\lambda}{2\left(1-\lambda\right)} \\ 1-\lambda-\frac{1-2\lambda}{8\bar{c}} & \text{if } \bar{c} > \frac{1-2\lambda}{2\left(1-\lambda\right)} \end{cases}$$

Both Firms Use a NYOP Format

When both retailers use a NYOP format, profit is given by Equation (7). Taking these integrals,

(A5) $$\Pi_A^{NYOP,NYOP} = \Pi_B^{NYOP,NYOP} = \frac{2-\lambda}{48\bar{c}}$$

Derivation of the Optimal Market Format – Proposition 1

For (PP, NYOP) to be a Subgame-Perfect Nash Equilibrium, then Firm B must earn greater profit by choosing the NYOP format rather than the posted price format. One can calculate the difference in profit under these two formats as:

(A6) $$\Pi_B^{PP,NYOP} - \Pi_B^{PP,PP} = \begin{cases} \frac{1-2\lambda}{4}\sqrt[3]{\frac{\bar{c}^3\left(1-\lambda\right)^4}{4\left(1-2\lambda\right)^4}} - \lambda + \frac{\lambda}{16\bar{c}} & \text{if } \bar{c} \leq \frac{1-2\lambda}{2\left(1-\lambda\right)} \\ \frac{1-\lambda}{16\bar{c}} - \lambda & \text{if } \bar{c} > \frac{1-2\lambda}{2\left(1-\lambda\right)} \end{cases}$$

This difference in the bottom term is positive as long as $1 > \lambda\left(1+16\overline{c}\right)$ or $\lambda < \frac{1}{1+16\overline{c}}$. Note that this condition will be met when $\lambda < \frac{1}{9}$ (since $\overline{c} < \frac{1}{2}$). Furthermore, the top term is decreasing in $\overline{c}$. Thus, on the range, $\overline{c} \in \left[\frac{1}{4}, \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)}\right]$, the difference in profit $\left(\Pi_B^{PP,NYOP} - \Pi_B^{PP,PP}\right)$ is minimized at $\overline{c} = \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)}$. When $\overline{c} = \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)}$, $\Pi_B^{PP,NYOP} - \Pi_B^{PP,PP} = \frac{\left(1-\lambda\right)^2\left(1-5\lambda\right)}{12\left(1-2\lambda\right)^2}$, which is positive for all $\lambda < \frac{1}{5}$. Therefore, $\lambda < \frac{1}{9}$ is a sufficient condition for retailer *B* to prefer the NYOP format over a posted price format.

In addition, for (PP, NYOP) to be a Subgame-Perfect Nash Equilibrium, Firm *A* must earn greater profit by choosing the posted price format rather than the NYOP format. The preceding analysis shows that if firm *A* chooses the posted price format, then firm *B* will select the NYOP format. To determine firm *A*'s profit from selecting the NYOP format instead, one needs to anticipate whether firm *B* would best respond by selecting the posted price format or the NYOP format. Specifically, one can calculate:

$$\text{(A7)} \qquad \Pi_B^{NYOP,PP} - \Pi_B^{NYOP,NYOP} == \begin{cases} \frac{3\left(1\text{-}\lambda\right)}{2}\sqrt[3]{\frac{\overline{c}\left(1\text{-}\lambda\right)}{4\left(1\text{-}2\lambda\right)}} - \frac{2-\lambda}{48\overline{c}} & \text{if } \overline{c} \le \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)} \\ 1-\lambda-\frac{8\text{-}13\lambda}{48\overline{c}} & \text{if } \overline{c} > \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)} \end{cases}$$

Numerical calculations verify that this difference is positive over the entire relevant parameter range. Therefore, firm *B* will choose the posted price format if firm *A* has chosen the NYOP format. For (PP, NYOP) to be a Subgame-Perfect Nash Equilibrium, we must have $\Pi_A^{PP,NYOP} \ge \Pi_A^{NYOP,PP}$. We can show

$$\text{(A8)} \qquad \Pi_A^{PP,NYOP} - \Pi_A^{NYOP,PP} = \begin{cases} \frac{10\overline{c}\left(1\text{-}\lambda\right)\sqrt[3]{2\overline{c}\left(1-\lambda\right)} - \sqrt[3]{1-2\lambda}}{16\overline{c}\sqrt[3]{1-2\lambda}} & \text{if } \overline{c} \le \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)} \\ 1-\lambda-\frac{3\text{-}5\lambda}{16\overline{c}} & \text{if } \overline{c} > \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)} \end{cases}$$

For both the upper and lower expressions of (A8), the difference, $\Pi_A^{PP,NYOP} - \Pi_A^{NYOP,PP}$, is increasing in $\overline{c}$. Thus, the minima over the two ranges are reached at $\overline{c} = \frac{1}{4}$ and $\overline{c} = \frac{1-2\lambda}{2\left(1\text{-}\lambda\right)}$, respectively. At these minimizing points, the difference, $\Pi_A^{PP,NYOP} - \Pi_A^{NYOP,PP}$, are $\frac{5\left(1\text{-}\lambda\right)\sqrt[3]{4\left(1-\lambda\right)} - 4\lambda\sqrt[3]{1-2\lambda}}{16\sqrt[3]{1-2\lambda}}$ and $\frac{\left(1-\lambda\right)\left(5-11\lambda\right)}{8\left(1-2\lambda\right)}$, respectively. These values are positive for all $\lambda < \frac{1}{9}$.

Incentive to Allow Re-Bids

Customers who are loyal to retailer *B* (who uses the NYOP format) can place up to two bids. The optimal bidding strategy is:

$$\text{(A10)} \quad \begin{cases} \text{bid } b_{12}\text{, then bid } b_{22} \text{ if } b_{12} \text{ is rejected} & \text{if } 0 \le c_i \le c_2 \\ \text{place a single bid of } \hat{b} & \text{if } c_2 < c_i \le \hat{c} \\ \text{do not bid at all} & \text{if } c_i > \hat{c} \end{cases} \quad \text{where } b_{12} = \frac{1+2c_i}{3},\ b_{22} = \frac{2+c_i}{3},\ c_2 = \frac{2-\sqrt{3}}{2}$$

For the switchers, the optimal bidding strategy is:

(A11) $$\begin{cases} \text{bid } \hat{b}_{12}\text{, then bid } \hat{b}_{22} \text{ if } \hat{b}_{12} \text{ is rejected; purchase at } P_A \text{ if } \hat{b}_{12} \text{ is rejected} & \text{if } 0 \le c_i \le \hat{c}_2 \\ \text{place a single bid of } \hat{b}_1\text{; purchase at } P_A \text{ if } \hat{b}_1 \text{ is rejected} & \text{if } \hat{c}_2 < c_i \le \hat{c}_1 \\ \text{purchase at } P_A \text{ without bidding at all} & \text{if } c_i > \hat{c}_1 \end{cases}$$

$$\text{where } \hat{b}_{12} = \frac{P_A + 2c_i}{3},\ \hat{b}_{22} = \frac{2P_A + c_i}{3},\ \hat{c}_2 = \frac{3 - P_A - \sqrt{9 - 6P_A}}{2}$$

The following analysis proceeds under the assumption that $\bar{c} \ge \frac{1-2\lambda}{2(1-\lambda)}$ and $\lambda \le \frac{1}{9}$. These restrictions ensure that when retailer *B* (i.e., the NYOP firm) restricts consumers to a single bid, retailer *A* selects a posted price $P_A = 1$. The equilibrium expected profit for each firm is:

(A12) $$\Pi_A^{PP,NYOP(1\text{ bid})} = 1 - \lambda - \frac{1-2\lambda}{8\bar{c}}$$

(A13) $$\Pi_B^{PP,NYOP(1\text{ bid})} = \frac{1-\lambda}{16\bar{c}}$$

If retailer *A* allows consumers to re-bid if their initial bid is rejected, then the profits for the two firms are given by:

(A14) $$\Pi_A^{PP,NYOP(2\text{ bids})} = P_A\left[1 - \lambda - (1-2\lambda)\left(\int_{c_i=0}^{\hat{c}_2}\int_{P_{NYOP}=0}^{\hat{b}_{22}} \mathrm{f}(c_i)\,\mathrm{d}P_{NYOP}\ \mathrm{d}c_i + \int_{c_i=\hat{c}_2}^{\hat{c}_1}\int_{P_{NYOP}=0}^{\hat{b}_1} \mathrm{f}(c_i)\,\mathrm{d}P_{NYOP}\ \mathrm{d}c_i\right)\right]$$

(A15) $$\begin{aligned}\Pi_B^{PP,NYOP(2\text{ bids})} = {} & \lambda\left[\int_{c_i=0}^{c_2}\left(\int_{P_{NYOP}=0}^{b_{12}} b_{12}\mathrm{f}(c_i)\,\mathrm{d}P_{NYOP} + \int_{P_{NYOP}=b_{12}}^{b_{22}} b_{22}\mathrm{f}(c_i)\,\mathrm{d}P_{NYOP}\right)\mathrm{d}c_i + \int_{c_i=c_2}^{\hat{c}}\int_{P_{NYOP}=0}^{\hat{b}} \hat{b}\mathrm{f}(c_i)\,\mathrm{d}P_{NYOP}\mathrm{d}c_i\right] \\ & +(1-2\lambda)\left[\int_{c_i=0}^{\hat{c}_2}\left(\int_{P_{NYOP}=0}^{\hat{b}_{12}} \hat{b}_{12}\mathrm{f}(c_i)\,\mathrm{d}P_{NYOP} + \int_{P_{NYOP}=\hat{b}_{12}}^{\hat{b}_{22}} \hat{b}_{22}\mathrm{f}(c_i)\,\mathrm{d}P_{NYOP}\right)\mathrm{d}c_i + \int_{c_i=\hat{c}_2}^{\hat{c}_1}\int_{P_{NYOP}=0}^{\hat{b}_1} \hat{b}_1\mathrm{f}(c_i)\,\mathrm{d}P_{NYOP}\mathrm{d}c_i\right]\end{aligned}$$

Retailer *A* chooses P_A to maximize (A14). The closed form solution is extremely complex. But, Figure 2 provides an example that verifies the claim in Proposition 2. In particular, when $\lambda = .05$, $\Pi_B^{PP,NYOP(1\text{ bid})} > \Pi_B^{PP,NYOP(2\text{ bids})}$ for $\bar{c} \in \left[\frac{9}{19}, .476\right]$.

Furthermore, one can verify that in the absence of this strategic effect on prices (i.e., that P_A is lower when re-bidding is allowed), the NYOP firm is always more profitable when rebidding is allowed. In particular,

(A16) $$\left(\Pi_B^{PP,NYOP(2\text{ bids})}\middle|P_A = 1\right) - \left(\Pi_B^{PP,NYOP(1\text{ bid})}\middle|P_A = 1\right) = \frac{1605 - 882\sqrt{3} + \left(214 - 156\sqrt{3}\right)\lambda}{6912\bar{c}} \approx \frac{77.3 - 56.2\lambda}{6912\bar{c}} > 0$$