Reverse Pricing: The Impact of Sophisticated Consumers, Seller Commitment, and Competition *

Scott Fay
Department of Marketing
University of Florida
P.O. Box 117155
Gainesville, FL 32611-7155
Phone: 352-392-0161 Ext. 1249
Fax: 352-846-0457
e-mail: scott.fay@cba.ufl.edu

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Abstract:

With a reverse-pricing mechanism (sometimes referred to as a Name-Your-Own Price or NYOP format), a prospective buyer submits a bid for a seller’s product, and a sale occurs only if the bid exceeds a hidden threshold price. This paper models the impact of three factors in such a market: 1) customer sophistication, i.e., whether buyers can correctly anticipate the seller’s procedure for setting the threshold price; 2) seller commitment, i.e., whether the seller commits to randomly selecting the threshold price from a distribution of possible prices; and 3) competition, i.e., whether the seller faces a rival. Some key findings are: in the absence of seller commitment, the seller profits more if customers are less sophisticated; seller commitment can improve profit, but only if customers are sophisticated; a monopolist seller benefits from allowing buyers to re-bid if their previous bid was rejected, but in the presence of both competition and seller commitment, the NYOP seller may benefit from restricting consumers to a single bid. Finally, whereas, the current literature offers little insight into why a firm would employ a NYOP business model rather than simply posting prices, this paper suggests that the NYOP mechanism may offer a way to mitigate price competition with a rival. This finding leads to important new implications for structuring the NYOP channel. For example, a seller may be able to reduce the degree of price rivalry by committing to randomly selecting its price threshold and/or by prohibiting re-bids.

Keywords: Name-Your-Own-Price, Reverse Auctions, Pricing, commitment, consumer learning
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1. Introduction
1.1. The NYOP Business Model

The Name-Your-Own-Price (NYOP) business model offers a non-traditional way of determining market outcomes (prices and distributive allocations). In this scenario, a seller sets a hidden threshold price, and interested consumers place bids for units of this product, where any bid that exceeds the 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. Thus, the NYOP mechanism has drawn the attention of both the popular press and academics (e.g., see Dolan and Moon 2000, Rust and Eisenmann 2000, and the academic literature cited below).

This paper introduces an analytical model that explores the impact of three factors on the profitability of the NYOP business model: 1) customer sophistication, i.e., whether buyers can correctly anticipate the seller’s procedure for setting the threshold price; 2) seller commitment, i.e., whether the seller commits to randomly selecting the threshold price from a set distribution of possible prices and 3) competition, i.e., whether the seller faces a rival. By better understanding the impact of these three factors, one can gauge which market environments are likely to be profitable ones for entry by a NYOP seller and determine the optimal structure of the NYOP mechanism, e.g., whether it is advantageous to allow customers to re-bid if a previous bid is rejected and when seller commitment might be advantageous.

Each of these three factors turns out to have important implications for the profitability of the NYOP business model. Furthermore, there are a number of interesting interactions. For example, if customers are unsophisticated, the NYOP seller earns lower profit with seller commitment than without it. But, if customers are sophisticated, seller commitment can increase profit. The following subsections describe each of these three factors, highlighting their practical importance in actual NYOP markets. In these subsections, I also provide links to the existing literature. Then, I outline the key research questions to be considered by this current paper and summarize the key findings.
1.2 Customer Sophistication

In NYOP markets, the seller’s threshold price \( (P_{NYOP}) \) determines which bids are accepted and which are rejected. Since \( P_{NYOP} \) is the seller’s private information, consumers’ bidding strategies are based on expectations about this threshold price. There is some divergence in the literature on how to model consumers’ expectations in NYOP markets. On the one hand, several papers model consumers’ expectations as being given exogenously, e.g., being drawn from a distribution over the interval \( [P, P] \), where there is no presumed linkage between these expectations and the true threshold (Hann and Terwiesch 2003; Spann, Skiera, and Schafers 2004; Spann and Tellis 2006; Terwiesch, Savin, and Hann 2005). This would be consistent with an environment in which consumers do not have “any knowledge about the supplier’s decision-making process” (Hann and Terwiesch 2003, p. 1571). I refer to such a situation as one with “naïve” customers.

On the other hand, in some NYOP markets, consumers may be better informed about the threshold price. For example, several third-party sites such as biddingfortravel.com, betterbidding.com, and flyertalk.com allow users to post the winning (and losing) bids from Priceline, the most prominent NYOP seller. Over time, consumers may learn across transactions and thus be able to form accurate expectations about \( P_{NYOP} \) (Kannan and Kopalle 2001). Priceline, at one time, even encouraged such third-party sites by paying commissions for referrals from these sites, figuring “[t]he information would be out there whether we had a relationship or not” (Lieber 2002). Thus, one could model consumers as capable of accurately anticipating the NYOP seller’s process for setting the threshold price, as is done in Fay (2004). I refer to such a situation as one with “sophisticated” customers.

1.3 Seller Commitment

Although consumers may believe that the threshold price comes from a distribution, at any given time, it is usually the case that a single threshold price \( (P^*) \) maximizes the NYOP seller’s profit (Terwiesch, Savin, and Hann 2005). However, in practice, the seller may commit to a pricing rule other than \( P^* \). This strategy would be especially plausible if acceptance decisions are computer-automated rather than made by a human. In this case, a computer could be programmed to follow any specified algorithm for accepting/rejecting bids. Furthermore, there is some evidence that existing NYOP sellers do, in fact, engage in such commitment. For
example, Priceline 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.

The current paper models commitment in a very simple manner. The NYOP seller selects a threshold price, $P_{NYOP}$. Any bid below this threshold is rejected, while any bid at or above this threshold is accepted. Under “no commitment”, the NYOP seller can choose $P_{NYOP}$ without regard to expectations about the price threshold. Under “commitment”, the NYOP seller commits to randomly drawing the threshold price from a pre-announced uniform distribution.

1.4 Competition

All extant models of NYOP markets have modeled the NYOP seller as a monopolist. However, in practice, firms often face competition from rivals. For example, Hotwire (www.hotwire.com) is a close rival to Priceline because both travel sites sell “opaque” travel goods. The goods are “opaque” because, prior to purchase, consumers are not told the exact flight itinerary (supplier, connection city, or departure time) or the hotel property. Because of this opacity, even if the ex post product assignment might differ across the two firms, ex ante Priceline and Hotwire offer perfect substitutes, e.g., a flight between two cities anytime on the specified days. Thus, both firms target the same market segment, those most price-sensitive and flexible travelers – a.k.a. the “mercenary traveler” (McGee 2003).

The current paper considers two extreme cases of competition: “no competition”, i.e., a monopoly, and “competition”, i.e., the firms' products are perfect substitutes. This dichotomy helps illustrate the results of the paper in a clean and simple manner.

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1 Segen (2005) asserts that Priceline determines whether a given bid is accepted using a complicated computer formula which includes a random element even for airline tickets and car rentals.
1.5 Research Questions and Key Findings

By integrating the preceding three factors into an analytical model, I am able to address several interesting research questions:

1. Does a NYOP seller profit more when consumers are naïve or when consumers are sophisticated?
2. How does the optimal structure of the NYOP format depend on consumer naïveté or sophistication? For example, at what level should the threshold price be set?
3. Under what conditions, if any, can a NYOP seller benefit when it commits to drawing its threshold price from a pre-announced uniform distribution?
4. What is the impact of competition on the profitability of the NYOP format and on the structure of that format, e.g., whether to commit to randomly selecting the threshold price and whether to allow re-bids?
5. Under what conditions, if any, does a NYOP seller benefit from allowing consumers to re-bid if their previous bid was rejected?
6. When, if ever, can the NYOP format be more profitable than posted prices?

My analysis yields several important insights. First, in the absence of seller commitment, seller profit is higher if customers are naïve rather than sophisticated. If consumers are naïve, the NYOP seller can “fool” customers, i.e., consumers believe that the NYOP firm is randomly selecting its price threshold from a uniform distribution when in fact it chooses the single price threshold that maximizes profit given these (wrong) expectations. For example, consider the numerical example given on p. 349 of Terwiesch et. al. (2005). There are two types of naïve customers. The first type has a reservation value of 101, per-bid frictional costs of .01, and believing the threshold price is drawn from U[0, 101], will bid up to 100.974. The second type has a reservation value of 300, per-bid frictional costs of 50 and, believing the threshold price is drawn from U[0, 300], will begin with a bid of 150. At the suggested optimal price threshold of 100.974, the second type overpays, paying 150 for the product when a bid of 100.974 would have been accepted. However, a sophisticated customer would be able to anticipate the optimal price threshold and thus avoid overpaying. In fact, sophisticated consumers would realize that the NYOP firm has an incentive to accept any bid that exceeds marginal cost. Thus, we have the powerful and interesting result that sophisticated customers can eliminate all profits.
Second, seller commitment diminishes profit if customers are naïve, but improves profit if customers are sophisticated. If customers are naïve, committing to randomize the price threshold reduces the seller’s profit. Return to the preceding example. Notice that if the seller announces and commits to a particular distribution, say \(U[0, 101]\), then it is no longer possible to have heterogeneous expectations across customers (and such heterogeneity can be good from the seller’s perspective because it enhances price discrimination, i.e., high-valuation consumers bid more because they think a high price threshold is likely). Furthermore, if a seller commits to this distribution, then sometimes it will set a high price threshold, so high that it rejects profitable bids. On the other hand, if customers are sophisticated, then seller commitment can be very useful. Recall that without seller commitment, the seller earns zero profit because customers recognize that the firm will accept any bid above marginal cost. If the seller can instead commit to randomly selecting the price threshold from a distribution, the seller can a) commit to setting price above marginal cost, and b) create uncertainty. This first effect induces customers to place bids above marginal cost. The second effect ensures information rent for the seller, i.e., some customers’ bids exceed the actual realized price threshold.

Third, I find that a motivation for using the NYOP format rather than posted prices is to mitigate price competition with a posted price rival. Somewhat surprisingly, very little attention has been paid to why a firm might employ a NYOP format. In fact, posted prices would be more profitable than the proposed NYOP format in nearly every extant model. (See section 2.3 for details.) But, in practice, we do observe some firms, such as Priceline, employing a NYOP format. Thus, it is very important for our field to develop a comprehensive understanding about why the NYOP format may be preferred to alternative selling mechanisms. Such understanding is vital because it allows us to offer insight into when and where such a business model would be desirable from a seller’s perspective. The current paper takes a step in this direction by showing that competition may be an important factor. In the model I propose, a monopolist would prefer posted prices to the NYOP format. However, when facing a posted price rival, a firm prefers to use the NYOP format rather than posted prices. The NYOP format can mitigate price competition because it encourages market segmentation – the NYOP firm will appeal to consumers with low frictional costs (e.g., consumers that find bidding easy or fun) while the posted price firm will appeal to consumers with high frictional costs (e.g., consumers with a high
opportunity cost of time). Thus, each firm has an incentive to target its respective niche, ceding the other niche to its competitor.

Fourth, a monopolist seller benefits from allowing buyers to re-bid if their previous bid was rejected, but in the presence of both competition and seller commitment, the NYOP seller may benefit from restricting consumers to a single bid. Consistent with the literature (e.g., Spann et al. 2004; Hann and Terwiesch 2003), I find that a monopolist benefits from allowing re-bidding. Allowing rejected bidders to re-bid increases the number of winning bids and also allows the NYOP seller to price discriminate according to heterogeneity in frictional costs. However, when the NYOP seller faces competition from a posted price firm, I find that allowing more re-bids increases the competitive threat posed by the NYOP seller to its posted price rival. Thus, the NYOP firm may prefer committing to a single-bid restriction in order to reduce the intensity of price competition.

The remainder of the paper is organized as follows. In Section two, I introduce the model in the absence of competition, i.e., the monopoly model, considering first the case of naïve customers (with and without seller commitment), and then the case of sophisticated customers. In Section three, I extend the model to allow for competition and again analyze both types of consumers (with and without seller commitment). Section 4 offers concluding remarks including managerial implications and directions for future research. Proofs of all propositions are given in the Appendix.

2. Monopoly Model

I normalize the marginal cost of production to zero. Under the NYOP format, the seller selects a threshold price, $P_{NYOP}$. 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 consider two cases: “no seller commitment” and “seller commitment”. Under “no seller commitment”, the NYOP seller can choose $P_{NYOP}$ without regard to expectations about the price threshold. Under “seller commitment”, the NYOP seller commits to randomly drawing the threshold price from a pre-announced uniform distribution. For each of these cases, I also consider two variations on the NYOP format: one where consumers are restricted to a single bid ($J=1$), and one where consumers are allowed an additional bid if their first bid is rejected ($J=2$).

The number of consumers is normalized to one. I assume consumers have a common
reservation value, $R$, for one unit of the product, and further normalize to $R=1$. Following Hann and Terwiesch (2003) and Spann et. al. (2004) who provide evidence that the frictional costs associated with using the NYOP channel vary significantly across consumers, I assume that the cost to consumer $i$ of placing a bid through the NYOP channel, $c_i$, is drawn from $U[0, \bar{c}]$. Since consumers cannot observe the actual price threshold, $P_{NYOP}$, they must instead use expectations in order to decide the level of their bids. The formation of expectations depends on whether consumers are naïve or sophisticated (as outlined below). Each consumer chooses the purchase option that maximizes her expected consumer surplus (given the information she possesses).

The assumption of a common reservation value is obviously an over-simplification of most markets. This assumption simplifies the analysis but is not essential for most of the paper’s main results. To verify this, I also present many of the model’s results using numerical calculations based on the data from Spann et. al. (2004) in which consumers vary both in reservation values and in frictional costs. However, 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.

2.1. Naïve Customers

For the case where customers are naïve, following the previous literature (e.g., Hann and Terwiesch 2003, Spann et. al. 2004, and Ding et. al. 2005), I assume the consumers believe that the price threshold is drawn from a uniform distribution. For simplicity (and to be consistent with the previous assumptions regarding production costs and reservation values), I assume this distribution to be $U[0,1]$. Spann et. al. (2004) and Spann and Tellis (2006) have derived the optimal bidding strategy for a consumer in such an environment. In the case where consumers are restricted to a single bid, the optimal bidding strategy is:

$$
\begin{align*}
&\left\{ \begin{array}{ll}
\text{place a single bid of } b_{i1} & \text{if } c_i \leq c_i \\
\text{do not bid at all} & \text{if } c_i > c_i
\end{array} \right. \\
&\text{where } b_{i1} = \frac{1}{2}, \quad c_i = \frac{1}{4}
\end{align*}
$$
In the case where consumers can place up to two bids, the optimal bidding strategy is:

\[
\begin{align*}
\text{bid } b_{12}, & \text{ then bid } b_{22} \text{ if } b_{12} \text{ is rejected} & \text{if } 0 \leq c_i \leq c_2 \\
\text{place a single bid of } b_{11} & \text{ if } c_2 < c_i \leq c_1 \\
\text{do not bid at all} & \text{ if } c_i > c_1
\end{align*}
\]

(2)

where \( b_{11} = \frac{1}{2}, \ b_{12} = \frac{1 + 2c_i}{3}, \ b_{22} = \frac{2 + c_i}{3}, \ c_1 = \frac{1}{4}, \ c_2 = \frac{2 - \sqrt{3}}{2} \)

**No Seller Commitment**

In the case of no seller commitment, the NYOP seller chooses the price threshold that maximizes expected profit. Suppose consumers are restricted to a single bid. Then, the seller should accept any bid that exceeds marginal costs, i.e., \( P^{\text{NYOP}} = 0 \). This yields a profit of \( \Pi_{j=1}^{NC,NSC} \) (read profit with Naïve Customers, No Seller Commitment, and a limit of 1 bid per customer):

\[
\Pi_{j=1}^{NC,NSC} = b_{11} \text{ Min} \left[ \frac{c_1}{c_i}, 1 \right]
\]

(3)

On the other hand, suppose that re-bidding is allowed. Notice that for all \( c_i \leq c_2 \), \( b_{12} < b_{11} \) and \( b_{22} > b_{11} \). Thus, the NYOP seller should set a price threshold s.t. \( b_{12} < P^{\text{NYOP}} \leq b_{11} \) which ensures that consumers willing to re-bid will pay their second-bid price, while consumers who will only bid once pay their first-bid price. The resulting profit from this strategy is:

\[
\Pi_{j=2}^{NC,NSC} = \int_{c=0}^{\text{Max}[c_2, x]} b_{22} f(c_i) \, dc_i + \int_{c=\text{Max}[c_2, x]}^{\text{Max}[c_1, x]} b_{11} f(c_i) \, dc_i
\]

(4)

Lemma 1 records the profit for both of these scenarios.

**Seller Commitment**

Recall that consumers believe that the price threshold will be drawn from a uniform distribution over \([0,1]\). In this section, I derive the profit when the seller commits to fulfilling these expectations, i.e., randomly selecting \( P^{\text{NYOP}} \) from \( U[0, 1] \). If consumers are restricted to a single bid and the seller follows this policy, then expected profits are:
\[ \Pi_{j=1}^{\text{NC,SC}} = \int_{P_{\text{NYOP}}=0}^{h_1} \int_{c_1=0}^{c_1} f(c_1) h_{1j} dc_1 dP_{\text{NYOP}} \]  

If consumers are allowed to re-bid and the firm commits to this policy, expected profits are:

\[ \Pi_{j=2}^{\text{NC,SC}} = \int_{P_{\text{NYOP}}=0}^{h_2} \left[ \int_{c_1=0}^{\text{Max}[c_2, \pi]} b_{12} f(c_1) dc_1 + \int_{c_1=\text{Max}[c_2, \pi]}^{\text{Max}[c_1, \pi]} b_{11} f(c_1) dc_1 \right] f(P_{\text{NYOP}}) dP_{\text{NYOP}} \]
\[ + \int_{P_{\text{NYOP}}=h_2}^{h_1} \left[ \int_{c_1=0}^{\text{Max}[c_2, \pi]} b_{22} f(c_1) dc_1 + \int_{c_1=\text{Max}[c_2, \pi]}^{\text{Max}[c_1, \pi]} b_{11} f(c_1) dc_1 \right] f(P_{\text{NYOP}}) dP_{\text{NYOP}} \]  

Lemma 1 also records the profit for both of these scenarios.

2.2. Sophisticated Customers

If consumers are sophisticated, they can accurately anticipate the NYOP seller’s process for setting the threshold price, a price that will depend on whether or not the seller commits to randomly selecting its price threshold from \([0, 1]\).

**No Seller Commitment**

If the seller does not commit, then the seller has an incentive to accept any bid that exceeds marginal costs, i.e., \(P^*_{\text{NYOP}} = 0\). This is especially easy to see if consumers are restricted to a single bid. In this case, for any bid, \(b\), that is placed, the seller can either reject it and receive zero profit, or the seller can accept it and receive a profit of \(b\). Thus, the seller will accept any \(b > 0\). A sophisticated customer, anticipating that any positive bid would be accepted, maximizes her consumer surplus by submitting the lowest possible bid, \(\varepsilon\). The seller’s profit, assuming \(\varepsilon \to 0\), is \(\Pi_{j=1}^{\text{SC,NSC}} = 0\).

If repeat bidding is allowed, one might think that a seller may choose to reject a consumer’s first bid in the hope that the consumer would place a second, higher bid. But notice that the seller has an incentive to accept any positive second bid. Recognizing this, a sophisticated consumer maximizes her consumer surplus on the second bid by bidding as low as possible, i.e., equal to \(\varepsilon\). The seller’s profit, assuming \(\varepsilon \to 0\), is \(\Pi_{j=2}^{\text{SC,NSC}} = 0\).
**Seller Commitment**

Now suppose the firm commits to randomly selecting $P_{NYOP}$ from $U[0, 1]$ (and that the consumers know this). Equations (1) and (2) give the optimal bid sequence under the single-bid and repeat-bid policies, respectively. Equations (5) and (6) give the resulting profit functions, respectively. Lemma 1 records the profit: $\Pi_{j=1}^{SC, SC}, \Pi_{j=2}^{SC, SC}$.

2.3. Results

Lemma 1 summarizes the profit for the various cases with and without seller commitment, for naïve and sophisticated customers, and for the single-bid and two-bid models. For comparison purposes, the profit under a simple posted price format is also included in Lemma 1.

**Lemma 1 Profit in the Absence of Competition**

| Commit to | Sophisticated | Posted | NYOP, $J=1$ | NYOP, $J=2$ |
| Price | Price | Threshold | Distribution? | Profit | Distribution? | Profit |
| --- | --- | --- | --- | --- | --- |
| No | No | 1 | $\frac{1}{2}$ if $\tau \leq \frac{1}{4}$, $\frac{1}{8\tau}$ if $\tau > \frac{1}{4}$ | $\frac{4+c}{6}$ if $\tau \leq c_2$ | $\frac{11-6\sqrt{3}+12\tau}{24\tau}$ if $c_3 < \tau \leq \frac{1}{4}$, $\frac{7-3\sqrt{3}}{12\tau}$ if $\tau > \frac{1}{4}$ |
| No | Yes | 1 | $\frac{1}{4}$ if $\tau \leq \frac{1}{4}$, $\frac{1}{16\tau}$ if $\tau > \frac{1}{4}$ | $\frac{1+c}{3} + \frac{(\tau)^2}{9}$ if $\tau \leq c_2$ | $\frac{53-30\sqrt{3}+18\tau}{72\tau}$ if $c_2 < \tau \leq \frac{1}{4}$, $\frac{115-60\sqrt{3}}{144\tau}$ if $\tau > \frac{1}{4}$ |
| Yes | Same profit for both “No” and “Yes” | 1 | $\frac{4}{6}$ if $\tau \leq \frac{1}{4}$, $\frac{9}{16\tau}$ if $\tau > \frac{1}{4}$ | $\frac{1+c}{3} + \frac{(\tau)^2}{9}$ if $\tau \leq c_2$ | $\frac{53-30\sqrt{3}+18\tau}{72\tau}$ if $c_2 < \tau \leq \frac{1}{4}$, $\frac{115-60\sqrt{3}}{144\tau}$ if $\tau > \frac{1}{4}$ |

where $c_2 = 1 - \frac{\sqrt{3}}{2}$

Proposition 1 expresses one important conclusion that can be drawn from Lemma 1.

**Proposition 1:** **In the absence of seller commitment, seller profit is higher if customers are naïve rather than sophisticated.**

Sophisticated consumers recognize that the NYOP seller has an incentive to accept any bid that exceeds marginal costs. Thus, they submit very low bids and as a result the seller earns...
approximately zero profit. However, naïve customers, with inflated expectations about the
threshold price, place larger bids. This leads to much higher profit for the firm.

Proposition 1 appears to be a rather general result since it would also extend to the case in
which consumers have heterogeneous valuations and/or the seller faces capacity constraints.
Notice that when consumers are sophisticated, WTP does not influence the optimal bid level.
Thus, even if consumers have heterogeneous valuations, no consumer has an incentive to bid
above marginal cost and thus the NYOP seller’s profit, assuming sophisticated consumers,
remains at zero. Furthermore, suppose there are capacity constraints. In such a case, the NYOP
seller might want to reject some bids that exceed marginal cost in order to reserve capacity for
potentially larger subsequent bids. Sophisticated consumers could anticipate the price threshold
that would prevail, say \( \hat{P} \), and thus either bid at \( \hat{P} \) or refrain from bidding. The result would be
that the seller would sell all units at a price of \( \hat{P} \). On the other hand, with naïve consumers,
consumers that expect a higher range of threshold prices, say \([\hat{P}, \hat{P} + D]\) would place a bid in
excess of \( \hat{P} \).

Proposition 2 states a second important result that is derived from Lemma 1.

**Proposition 2:** Seller commitment diminishes profit if customers are naïve.

When consumers are naïve, committing to randomize the price threshold reduces the
NYOP seller’s profit. Notice that when consumers are naïve, bid strategies do not depend on
whether the seller has committed to a specific distribution. Holding bids fixed, there will be a
single price threshold, \( P_{NYOP}^* \), that maximizes the seller’s profit. However, if the seller commits
to randomly choosing its price threshold, then it will usually end up employing a suboptimal
price threshold. The seller may set its price too high, i.e., \( P_{NYOP} > P_{NYOP}^* \), and thus reject
profitable bids or, if \( J > 1 \), the seller may set its price too low, i.e., \( P_{NYOP} < P_{NYOP}^* \), and thus
accept some low bids when the customer would have been willing to re-bid.

The above intuition appears to be applicable even in the case in which consumers differ
in their valuations of the NYOP seller’s product or if the seller allows more than two bids. To
verify this conjecture, I use the parameter estimates (e.g., WTP, frictional costs) from Spann et.
al. (2004) for a German NYOP seller of air travel to calculate the profits with and without seller
commitment (assuming naïve customers). These results are reported in Table 1. Details behind
these calculations are reported in the Appendix. The results in Table 1 are perfectly consistent
with Proposition 2, i.e., for any given level of wholesale costs and bidding policy \((J = 1 \text{ or } J = 6)\), profit is higher if the seller does not commit to randomly drawing its price threshold. For example, under the single-bid restriction and wholesale costs of $200, profit is estimated to be $26.44 (per consumer) under seller commitment but is nearly 3 times larger ($64.60) without seller commitment.

**Table 1: Profit Comparisons using Estimated Demand from Spann et. al. (2004) Assuming Naïve Customers**

<table>
<thead>
<tr>
<th>Commit to Price Threshold Distribution?</th>
<th>Wholesale cost (w)</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Posted Price NYOP, J=1</td>
<td>NYOP, J=6</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>264.89</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>165.08</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>82.50</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>28.28</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>2.41</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>264.89</td>
</tr>
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<td>28.28</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>2.41</td>
</tr>
</tbody>
</table>

* Calculations are made assuming that per-bid frictional costs and willingness-to-pay are statistically independent, all variables are uniformly distributed, and each of the means of these distributions match the respective mean reported by Spann et. al. (2004).

Proposition 3 states a third important result derived from Lemma 1.

**Proposition 3:** Seller commitment improves profit if customers are sophisticated.

When there is no seller commitment, the seller earns zero profit because sophisticated customers recognize that the firm will accept any bid above marginal cost. If the seller instead commits to randomly selecting the price threshold from a distribution, then the customers recognize that the threshold price may exceed marginal cost and that the price threshold is uncertain. Thus, seller commitment induces higher bids (relative to the no seller commitment case) and also creates information rent for the NYOP seller, i.e., some consumers’ bids exceed the actual realized price threshold. Combining Propositions 2 and 3, one can see that seller commitment is detrimental to a NYOP seller’s profit if customers are naïve, but can be a useful tool for increasing profit if customers are sophisticated.

Proposition 4 states another important result derived from Lemma 1.
Proposition 4: A monopolist seller benefits from allowing buyers to re-bid if their previous bid was rejected.

The fact that a monopolist in this model benefits from allowing consumers to re-bid is consistent with the literature. For example, Spann et al. (2004) claim, “restricting consumers to a single bid may reduce the seller’s revenues.”2 Hann and Terwiesch (2003), in a technical appendix, propose a rationale for this result: heterogeneity in frictional costs allows the NYOP firm to price discriminate between customers and thus increase profit. Consumers with low frictional costs place a low initial bid, but are willing to place a higher subsequent bid (relative to those consumers with high frictional costs who are only willing to place a single bid). By allowing consumers to re-bid, the NYOP seller can increase its 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 low frictional costs).

The significance of Proposition 4 will become clearer when competition is introduced into the model and we see that allowing re-bids may no longer be advantageous to the NYOP seller.

Proposition 5 states a final result that can be derived from Lemma 1.

Proposition 5: A monopolist would earn higher profit using a posted price format rather than either the single-bid or repeat-bid NYOP format.

The profit for the NYOP seller is strictly less than the profit the seller could obtain by simply using posted prices. There are several main reasons for this. First, the NYOP mechanism increases the costs to consumers of completing a transaction (see Hann and Terwiesch 2003 for empirical evidence that the frictional costs for completing transactions through a NYOP channel are non-trivial). These costs reduce the benefit from purchasing through the NYOP seller and thus lead to lower bid levels. Second, under the NYOP format, consumers may have uncertainty about the price threshold. Thus, the optimal response is for consumers to shade their bids, i.e., submit bids that are less than their reservation values. Finally, if frictional costs vary across consumers, the NYOP format creates heterogeneity in demand which may make it more difficult for the monopolist to extract customer surplus (e.g., consumers with moderate frictional costs place bids at different levels than those with low frictional costs).

2 The profit calculations in Table 1 suggest that for the German NYOP seller studied in Spann et al. 2004, allowing re-bidding is profitable with seller commitment or sufficiently large wholesale costs.
One may be concerned whether Proposition 5 is an artifact of certain specific assumptions made in the model, most notably the assumption that consumers have a common reservation value. However, note from Table 1 (which assumes heterogeneous reservation values based on the data in Spann et. al. 2004) that, for every level of wholesale costs and seller commitment, the estimated profit under posted prices is strictly larger than the profit under either of the NYOP formats. In fact, careful examination of the analytical models and data from the extant literature provides extremely little evidence of situations under which a seller might prefer a NYOP format over posted prices. For example, Fay (2004) acknowledges that posted prices “weakly dominate NYOP in this simple framework” (p. 415). And, Terwiesch et. al. (2005) finds that its German NYOP retailer would have earned higher profit 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). Further details of these and other papers are provided in the Appendix.

Ultimately, the extant models as well as the current model fail to explain why a retailer would choose to employ a NYOP format rather than the simpler, and more common, posted price format. In practice, we observe some retailers, such as Priceline, using a NYOP format. Thus, it would be useful to better understand what might induce a firm to choose this format. The following section provides one such explanation, i.e., that the NYOP format might serve as a way to mitigate price competition.

3. Competition

In this section, I consider a duopoly version of the model. In the duopoly model, a second firm, denoted the “rival” firm, sells an identical product as the focal firm, at the posted price \( P_R \). I assume no frictional costs are associated with purchasing at that price, and the rival firm has the same marginal costs of production, namely zero. Naturally, if the focal firm also were to employ a posted price format, Bertrand competition would drive prices down to marginal cost. This baseline case is compared to one in which the focal firm employs a NYOP format, either restricting consumers to a single bid or allowing a second bid. I assume that both the focal and the rival firm simultaneously and independently choose prices \( P_{NYOP} \) and \( P_R \), respectively. As in section 2, a key factor in the analysis is seller commitment. Under “no seller commitment”, the NYOP seller can choose \( P_{NYOP} \) without regard to expectations about the price threshold.

---

3 The assumption of homogenous products simplifies the analysis and also helps emphasize how the choice of selling formats affects price rivalry. I assume the rival firm employs a posted price format since this is the most common selling format in most markets.
Under “seller commitment”, the NYOP seller commits to randomly drawing the threshold price from $U[0,1]$. I assume both consumers and the rival firm are able to observe whether or not such a commitment has been made.

3.1. Naïve Customers

Consumers must decide on an appropriate bidding strategy. For example, in a case in which consumers are restricted to a single bid, a consumer must decide whether to a) forego bidding and simply buy the product at the posted price $P_R$; b) bid at the NYOP firm and then purchase at $P_R$ if that bid is rejected; c) bid at the NYOP firm and then do not purchase at the posted price if that bid is rejected; or d) neither bid nor buy at the posted price. As long as $P_R \leq R$, only the first and second options can possibly be optimal. This condition, $P_R \leq R$, will be satisfied in equilibrium since the rival does not make any sales if this condition is violated.

The optimal bidding strategy for a naïve consumer in such an environment is:

\[
\begin{cases} 
\text{place a bid of } \hat{b}_{11} \text{ and then purchase at } P_R \text{ if rejected} & \text{if } c_i \leq \hat{c}_i \\
\text{purchase at } P_R \text{ without bidding at all} & \text{if } c_i > \hat{c}_i 
\end{cases}
\]

where
\[
\hat{b}_{11} = \frac{P_R}{2}, \quad \hat{c}_i = \frac{(P_R)^2}{4}
\]

Similarly, in the case in which consumers can place up to two bids, the optimal bidding strategy is:

\[
\begin{cases} 
\text{bid } \hat{b}_{12} \text{, then bid } \hat{b}_{22} \text{ if } \hat{b}_{12} \text{ is rejected; purchase at } P_R \text{ if } \hat{b}_{12} \text{ is rejected} & \text{if } 0 \leq c_i \leq \hat{c}_2 \\
\text{place a single bid of } \hat{b}_{11}; \text{ purchase at } P_R \text{ if } \hat{b}_{11} \text{ is rejected} & \text{if } \hat{c}_2 < c_i \leq \hat{c}_1 \\
\text{purchase at } P_R \text{ without bidding at all} & \text{if } c_i > \hat{c}_1 
\end{cases}
\]

where
\[
\hat{b}_{11} = \frac{P_R}{2}, \quad \hat{b}_{12} = \frac{P_R + 2c_i}{3}, \quad \hat{b}_{22} = \frac{2P_R + c_i}{3}, \quad \hat{c}_1 = \frac{(P_R)^2}{4}, \quad \hat{c}_2 = \frac{3 - P_R - \sqrt{9 - 6P_R}}{2}
\]

No Seller Commitment

Suppose there is no seller commitment and consumers are restricted to a single bid. As shown in Section 2, the NYOP seller should accept any bid that exceeds marginal costs, i.e., $P^*_{NYOP} = 0$. Thus, the rival firm only sells to consumers who do not bid at the NYOP channel, i.e., those consumers with large frictional costs. The rival firm earns a profit of:
\[ \Pi_{R,j=1}^{NC,NSC} = P_R \operatorname{Max} \left[ \frac{\bar{c} - \hat{c}}{c} \right], 0 \] (9)

Profit is maximized at a price:

\[ P_R = \operatorname{Max} \left[ \frac{2}{\sqrt{3}}, 1 \right] \] (10)

Based on this price by the rival, Lemma 2 lists the resulting profit for the focal firm.

On the other hand, suppose that re-bidding is allowed. As shown in Section 2, the NYOP seller will choose its price threshold so that any consumer who places at least one bid will have one of her bids accepted. Thus, the rival firm again only sells to consumers who would not bid at all at the NYOP channel. The RHS of (9) gives the expression for profits and (10) lists the profit-maximizing price. Lemma 2 records the resulting profit for the focal firm.

**Seller Commitment**

Suppose the focal NYOP firm commits to randomly selecting \( P_{NYOP} \) from \( U[0, 1] \). If consumers are restricted to a single bid and the NYOP firm follows this policy, then expected profits to the NYOP seller are:

\[ \Pi_{E,J=1}^{NC,SC} = \int \int f(c_i) dP_{NYOP} \] (11)

The rival firm sells to all consumers who do not have a bid accepted (either due to not submitting a bid or due to having their bid rejected). Thus, the rival firm earns a profit of:

\[ \Pi_{R,j=1}^{NC,SC} = P_R \left[ 1 - \int \int f(c_i) dP_{NYOP} \right] \] (12)

The rival firm maximizes expected profit by choosing a posted price of:

\[ P_R = \begin{cases} \sqrt{2\bar{c}} & \text{if } \bar{c} \leq \frac{1}{2} \\ 1 & \text{if } \bar{c} > \frac{1}{2} \end{cases} \] (13)

Lemma 2 records the equilibrium expected profit for the focal firm when the rival firm chooses the price given in (13).

If consumers are allowed to re-bid and the focal firm commits to randomly selecting \( P_{NYOP} \) from \( U[0, 1] \), then the rival firm will sell to any consumer that chooses not to bid at the NYOP channel and to any consumer with no accepted bids. The Appendix gives the precise
profit functions for the rival firm and the focal firm, and the derivations for the posted price which maximizes the rival firm’s expected profit. This optimal price, $P_{R^*}$, is illustrated in Figure 1.

**Figure 1 The Rival Firm’s Posted Price With Seller Commitment and Repeat Bidding**

![Graph showing the rival firm's posted price with seller commitment and repeat bidding]

When all consumers have very low frictional costs ($\bar{c} < \alpha$), the rival firm would have to choose a very low price in order to get consumers to forego bidding on the NYOP channel. Thus, the rival firm maximizes its profit by setting its price equal to the consumers’ reservation value, i.e., $P_{R^*}=1$, and only making sales if the realized price threshold turns out to be high. In this case, all consumers bid twice at the NYOP channel before resorting to purchasing at the posted price.

If some consumers have very high frictional costs ($\bar{c} > \beta$), the rival firm also sets $P_{R^*}=1$. But, in this case, the rival firm makes sales both to consumers whose bids are rejected (such rejections only occur if the realized price threshold is sufficiently large) and to those with high frictional costs ($c_i > \bar{c}$). Finally, if the upper limit of frictional costs is in the moderate region ($\alpha < \bar{c} < \beta$), the rival firm chooses $P_{R^*}<1$. Here, the rival firm lowers its price in order to increase its expected market share, i.e., induce some consumers with moderate frictional costs to forego bidding at the focal firm. Lemma 2 records the profit the focal firm earns when the rival firm adopts this pricing strategy.
3.2. Sophisticated Customers

Below, I outline the impact of seller commitment when consumers are sophisticated, i.e., able to anticipate accurately the NYOP seller’s process for setting the threshold price.

**No Seller Commitment**

If the focal firm does not commit to randomizing its threshold price, then, as in the case without competition, it has an incentive to set the threshold price such that it sells to all consumers that place at least one bid at the NYOP channel. Following the same intuition as in section 2.2, this leads to zero profit in equilibrium.

**Seller Commitment**

Now suppose the focal firm commits to randomly selecting $P_{NYOP}$ from $U[0, 1]$ (and that the consumers know this). The analysis is equivalent to the case of seller commitment with naïve customers. Regardless of whether or not consumers are sophisticated, in the seller commitment case, consumers believe that $P_{NYOP}$ is randomly drawn from $U[0, 1]$ and the focal firm actually randomly draws $P_{NYOP}$ from $U[0, 1]$. Lemma 2 records the focal firm’s equilibrium profit.

3.3. Results

Lemma 2 lists the equilibrium profit for the focal firm when it faces a posted price rival for the various cases with and without seller commitment, for naïve and sophisticated customers, and for posted price, single-bid NYOP and two-bid NYOP models.

**Lemma 2** Profit for the Focal Firm in the Presence of Competition

<table>
<thead>
<tr>
<th>Commit to Price Threshold Distribution?</th>
<th>Sophisticated Customers?</th>
<th>Posted Price</th>
<th>NYOP, $J=1$</th>
<th>NYOP, $J=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>0</td>
<td>$\frac{1}{3} \sqrt{3} \frac{c}{3}$ if $c \leq \frac{3}{4}$</td>
<td>$\frac{27 - 9\sqrt{9 - 4\sqrt{3c}} - 6\sqrt{3c} - 2c + 4\sqrt{3} (\frac{c}{3})^3}{36c}$ if $c \leq \frac{3}{4}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\frac{1}{8c}$ if $c &gt; \frac{3}{4}$</td>
<td>$\frac{7 - 3\sqrt{3}}{12c}$ if $c &gt; \frac{3}{4}$</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>Same profit for both “No” and “Yes”</td>
<td>0</td>
<td>$\frac{1}{4} \sqrt{c}$ if $c \leq \frac{4}{27}$</td>
<td>$\frac{1}{3} + \frac{c}{6} + \frac{(\frac{c}{3})^3}{9}$ if $c \leq \alpha$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\frac{1}{4} \sqrt{c}$ if $\frac{4}{27} &lt; c \leq \frac{1}{2}$</td>
<td>$\frac{1}{3} + \frac{c}{6} + \frac{(\frac{c}{3})^3}{9}$ if $\alpha &lt; c \leq \beta$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\frac{1}{16c}$ if $c &gt; \frac{1}{2}$</td>
<td>$\frac{115 - 60\sqrt{3}}{144c}$ if $c &gt; \beta$</td>
</tr>
</tbody>
</table>

18
From Lemma 2, we can confirm that several of the key results for the monopoly model extend to the case of competition. In particular, Propositions 1 and 3 continue to hold when the NYOP seller faces competition from a posted price seller, i.e., in the absence of seller commitment, the NYOP seller earns more profit if customers are naïve rather than sophisticated, and seller commitment enhances profit if customers are sophisticated. The Appendix contains detailed calculations that verify these statements.

However, competition does introduce several new and interesting results. One such result is stated in Proposition 6.

**Proposition 6:** When facing competition from a posted price rival, a firm can earn more profit using a NYOP format rather than posted prices. In particular, the NYOP format is more profitable than the posted price format if either consumers are naïve or the NYOP seller commits to randomly selecting its price threshold (or both).

A key result from this paper is that a posted price competitor provides a strong impetus for using a NYOP mechanism. When facing a rival, the focal firm earns zero profit if it uses posted prices, whereas it obtains strictly positive profits if it employs a NYOP mechanism (as long as either consumers are naïve or there is seller commitment). This is an especially important and interesting result in light of Proposition 5. In the monopoly model, posted prices dominate the NYOP format in terms of seller profitability. The existing literature pays little attention to the issue of when, if ever, the NYOP format might be preferable to simply posting prices. The available evidence strongly indicates that the NYOP format is less profitable. However, in practice, we do observe some firms, such as Priceline, using the NYOP format. Proposition 6 suggests one rationale for this divergence is that previous models have ignored competitive reactions. Once competitive reaction is accounted for, the NYOP format can be preferred to posted prices since it softens price competition.

In the current model, the NYOP mechanism creates consumer heterogeneity in a market for otherwise undifferentiated products. Consumers with low frictional costs will find the NYOP channel an attractive option. On the other hand, consumers with high frictional costs, or those whose bids the NYOP site rejected, will purchase at the posted price channel. The NYOP firm finds it very difficult and costly to attract consumers with high frictional costs since a very low distribution of price thresholds would be required to get such consumers to bid (or to place additional bids) at the NYOP channel. The posted price firm finds it very difficult to attract
consumers with low frictional costs since such consumers can easily try the NYOP channel first, and reducing the posted price to attract such consumers means sacrificing the firm’s margins on high-frictional cost consumers. Thus, each firm has an incentive to focus on its respective segment.

This reasoning does not hold if consumers are sophisticated AND there is no seller commitment. In this case, consumers recognize that the NYOP seller has an incentive to accept any bid that exceeds marginal costs. Thus, they submit very low bids and as a result the seller earns approximately zero profit. Notice that this also drives the rival firm’s profit to zero. Thus, if consumers are sophisticated, both the focal firm and the rival firm benefit if the focal firm commits to randomizing its price threshold.

The role of the NYOP format in mitigating price competition has important implications for how to structure the NYOP mechanism optimally. One such implication is stated in Proposition 7.

**Proposition 7:** When facing competition from a posted price rival, a firm employing the NYOP format may benefit from seller commitment even if consumers are naïve.

Proposition 7 is particularly interesting in light of Proposition 2. In a monopoly model (Proposition 2), if consumers are naïve, seller commitment is detrimental to the NYOP seller since such commitment does not impact bidding behavior but does cause the seller to reject profitable bids or accept bids that are too low. However, when the NYOP seller faces competition, seller commitment can be beneficial even if consumers are naïve. This is because seller commitment impacts the rival’s pricing strategy. The rival realizes that without seller commitment, the NYOP firm has an incentive to sell to any consumer that bids at the NYOP channel. Thus, the rival will only be able to sell to consumers who choose not to bid at all. If all consumers have very low bidding costs (i.e., \( \bar{c} \) is small), the rival firm must set a low posted price in order to keep any consumers from bidding (See Equation (10)). Notice from Equation (7) and (8) that the lower \( P_R \) is, the lower the bids will be. Therefore, aggressive pricing behavior by the rival reduces the NYOP seller’s profit. Committing to randomize one’s price threshold can mitigate this price competition. Under seller commitment, the rival firm will also sell to consumers who have all their bids rejected by the NYOP seller, which happens at some positive probability. Thus, the posted price rival does not compete as hard to keep consumers from bidding at the NYOP channel, but instead raises its price to extract higher margins from the
“left-out” consumers.

Another implication for how competition may impact the optimal structure of the NYOP format is stated in Proposition 8.

**Proposition 8:** When facing competition from a posted price rival, a firm employing the NYOP format may benefit from restricting consumers to a single bid. In particular, if there is seller commitment, the single-bid format is more profitable than the two-bid format when there is a relatively small amount of heterogeneity in frictional costs \( \alpha < \bar{c} < \frac{4}{27} \).

Proposition 8 contrasts sharply with Proposition 4. A monopolist finds it advantageous to allow re-bidding, but a NYOP firm facing competition may benefit from restricting consumers to a single bid. The reason for this is that re-bidding policies can impact the pricing strategy of a rival. Consider the seller commitment case studied in section 3.1. If the focal firm restricts consumers to a single bid, then the rival firm follows the pricing strategy given in (10). However, if the focal firm allows re-bids, the rival firm follows the pricing strategy described by Figure 1. For \( \bar{c} \) that are just larger than \( \alpha \), the rival firm would choose a lower price if consumers could re-bid than if they were restricted to a single bid. Allowing re-bidding increases the appeal of the NYOP channel to consumers, especially those with low frictional costs. The rival firm must lower its price in order to sell to such consumers. But a lower price in the posted price channel negatively impacts the NYOP seller’s profitability. Thus, to reduce price rivalry, the NYOP seller can adopt a single-bid restriction.

If one considers a more general model (e.g., any distribution of consumer valuations and bid costs), it is likely that the impact of re-bidding on a monopolist’s profits is ambiguous. On the one hand, more opportunities to bid may increase sales, i.e., rejected bidders whose reservation values exceed the threshold price continue bidding and thus increase their probability of submitting a winning bid (Fay 2004). On the other hand, the information rent of the NYOP seller declines if re-bidding is allowed, i.e., consumers may start their bid sequences at a lower level and thus reduce how much in excess of the price threshold they bid. In the current model and Spann et. al. (2004), this first effect dominates. In Fay (2004), the two effects exactly offset (when \( c_i = 0 \) for all consumers) so that the firm earns the same profit with a single-bid restriction as it does without such a restriction. In the field data collected by Hann and Terwiesch (2003), the first effect is insignificant but the second effect is strong, thus suggesting that allowing re-
bidding reduces the profit of a NYOP seller.

The key insight from Proposition 8 is that competition adds another factor which impacts how re-bidding affects profit. In particular, allowing consumers to re-bid may intensify competition with a posted price rival. Ignoring this strategic effect, giving consumers the opportunity to re-bid may appear advantageous. However, once it recognizes the impact of re-bidding policies on rivals’ pricing decisions (and thus on its own profit), the NYOP seller may prefer to disallow re-bidding.

4. Concluding Remarks

4.1 Managerial Implications

The current paper has several important implications for sellers who use or intend to use the NYOP format. First, it is critical to assess the information available to one’s customers and how they use it to make bidding decisions. For instance, if consumers lack information about the process used to set price thresholds (or do not incorporate such knowledge into their decision-making), then a NYOP seller may be able to profit from fooling customers, e.g., trying to inflate consumers’ expectations of the price threshold, but then setting a low price threshold in order to capture a large market share.

On the other hand, if consumers know more about the process for setting price thresholds and are able to correctly set expectations, a much different policy may be optimal. In this case, the NYOP seller may benefit from “tying its hands”, e.g., committing to randomly choosing prices. Although this commitment may lead to the seller rejecting profitable bids, in the long run, it may have the positive effect of raising bid levels. Notice that this reasoning may help explain why Priceline chooses to use the “randomizer” program described in Section 1.3.

Due to the ease with which word-of-mouth spreads on the Internet, consumers may easily obtain information about the distribution of price thresholds in an online setting. For instance, numerous web forums, e.g., biddingfortravel.com, betterbidding.com, and flyertalk.com, allow consumers to discuss their experiences at Priceline. In such an environment, the NYOP seller may want to commit to randomly selecting its price and/or limiting consumers to a single bid (if there is competition). Fortunately, the online environment may facilitate such commitment. An automated platform can easily be augmented to include a random component and can also ensure that the stated bidding restrictions are enforced (e.g., no counter-offers, no more than one bid per customer). In contrast, in the off-line world of human agents (who are inherently more flexible
than computer algorithms), committing to reject an “extra” bid that exceeds one’s reservation price may be more difficult. In addition, web forums which report accept/reject outcomes can demonstrate the unpredictable nature of the acceptance decision, i.e., that the NYOP seller truly has committed to its stated policy.

Second, a firm that faces a competitor who offers a close substitute may want to adopt the NYOP format rather than posted prices. Because they buy from the same manufacturers, retailers may find themselves selling a product that is undifferentiated from their rival’s product. This hazard is especially compounded in online markets since the lack of physical locations makes it impossible to have geographically-based differentiation. In such settings, the NYOP format may be a valuable tool for creating differentiation and thus relaxing price competition. Section 1.4 provides one such example involving the competition between Hotwire (which uses posted prices) and Priceline (which uses a NYOP format) in the travel market (predominantly in the U.S.). The opacity of their product offerings results in close substitutability. If both firms offered posted prices, price competition would likely be very fierce. But since Priceline uses the NYOP format rather than posted prices, there is less price rivalry.

Third, a NYOP seller should carefully consider the strategic impact of its policies. For instance, committing to randomize its price threshold and/or restricting bidders to a single bid may be a tool for mitigating price competition. Such strategic considerations may help bridge a gap between previous theory and practice. For instance, Fay (2004) argues that it is very difficult for Priceline to enforce its single-bid restriction and that this policy is likely to be unprofitable in light of the fact that a segment of sophisticated bidders can circumvent the single-bid restriction while many other bidders cannot. Yet, in fact, Priceline does have a policy limiting consumers to a single bid, which it strives to enforce. The intuition from the current paper suggests that Priceline may be better off attempting to enforce this single-bid restriction (even though enforcement is costly and incomplete) in order to mitigate its price rivalry with Hotwire.

4.2 Future Research

There are a number of directions in which this research should be extended. The modeling assumptions could be relaxed in a number of directions in order to explore the robustness of these results. For example, one may want to consider heterogeneous reservation values, risk aversion, per-bid costs that vary with the number of bids, and other, more complicated market environments, e.g., more than one rival, imperfect product substitutability,
capacity-constrained firms. Also notice that the current paper examines several baseline cases (e.g., sophisticated vs. naïve consumers, full seller commitment vs. no seller commitment). Intermediate cases, especially when coupled with dynamic considerations, might also be interesting. For instance, if consumers become more knowledgeable over time, what is the optimal pricing strategy and/or structure of the NYOP format? Furthermore, the current paper assumes that the NYOP seller can only commit to drawing its price threshold from $U[0,1]$. Is there a better distribution to commit to? And, how does the optimal distribution depend on the sophistication of consumers and/or the degree of competition in the market?

Ultimately, one would like to develop a richer understanding of the situations under which the NYOP model is advantageous. The current paper suggests that the NYOP mechanism is very useful for a firm that has a product or service that is otherwise undifferentiated from the competition. Future research should also explore additional rationale for the NYOP format. Some alternative explanations are currently being developed. For example, a working paper by Wang, Gal-Or, and Chatterjee (2006) suggests that adding an additional NYOP channel may provide pricing flexibility to help a service provider better manage its scarce capacity when that service provider faces demand uncertainty. Terwiesch et. al. (2005) hypothesize that the NYOP format may allow a supplier to “price discriminate across channels” (p. 349). It would be interesting to formally model a consumer’s choice between channels and how that impacts the supplier’s profit.

Lastly, this paper provides some insight into how to structure the NYOP mechanism, focusing on the policy decisions of whether to allow consumers a second bid and whether to randomize the price threshold. Future research should explore other design aspects of the NYOP mechanism (e.g., allowing more than two bids, using non-uniform price threshold distributions, setting the frequency at which to change the actual price threshold, having consumers “select” rather than “name” a price) with an eye towards understanding how these design issues impact the ability of the NYOP format to fulfill its purpose. For instance, in addition to considering how a non-uniform price threshold distribution impacts bid levels and revenue of the NYOP firm, it would also be important to consider how a non-uniform distribution impacts the pricing decisions of rivals.
Appendix

Monopoly Model

Proof of Proposition 1
From Lemma 1, for both the single-bid and two-bid cases, compare the profit with naïve customers and no seller commitment to the profit with sophisticated customers and no seller commitment:

\[
\Pi_{J=1}^{NC,NSC} - \Pi_{J=1}^{SC,NSC} = \begin{cases} 
\frac{1}{2} > 0 & \text{if } \bar{c} \leq \frac{1}{4} \\
\frac{1}{8\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4}
\end{cases} \tag{A1}
\]

\[
\Pi_{J=2}^{NC,NSC} - \Pi_{J=2}^{SC,NSC} = \begin{cases} 
\frac{4 + \bar{c}}{6} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{6\sqrt{3} - 11 + 12\bar{c}}{24\bar{c}} > 0 & \text{if } c_2 < \bar{c} \leq \frac{1}{4} \\
\frac{7 - 3\sqrt{3}}{12\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4}
\end{cases} \tag{A2}
\]

Proof of Proposition 2
From Lemma 1, for both the single-bid and two-bid cases, compare the profit with naïve customers and no seller commitment to the profit with naïve customers and seller commitment:

\[
\Pi_{J=1}^{NC,SC} - \Pi_{J=1}^{NC,NSC} = \begin{cases} 
\frac{1}{4} > 0 & \text{if } \bar{c} \leq \frac{1}{4} \\
\frac{1}{16\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4}
\end{cases} \tag{A3}
\]

\[
\Pi_{J=2}^{NC,SC} - \Pi_{J=2}^{NC,NSC} = \begin{cases} 
\frac{3 - \bar{c}^2}{9} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{6\sqrt{3} - 10 + 9\bar{c}}{36\bar{c}} > 0 & \text{if } c_2 < \bar{c} \leq \frac{1}{4} \\
\frac{24\sqrt{3} - 31}{144\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4}
\end{cases} \tag{A4}
\]

Proof of Proposition 3
From Lemma 1, for both the single-bid and two-bid cases, compare the profit with sophisticated customers and no seller commitment to the profit with sophisticated customers and seller commitment:
Proof of Proposition 4

From Lemma 1, compare the profit under two-bids to the profit under a single bid for each of the various configurations:

\[
\Pi_{J=1}^{SC,SC} - \Pi_{J=1}^{SC,NSC} = \begin{cases} 
\frac{1}{4} > 0 & \text{if } \bar{c} \leq \frac{1}{4} \\
\frac{1}{16\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4} 
\end{cases} \quad (A5)
\]

\[
\Pi_{J=2}^{SC,SC} - \Pi_{J=2}^{SC,NSC} = \begin{cases} 
\frac{1 + \bar{c} + \bar{c}^2}{3} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{53 - 30\sqrt{3} + 18\bar{c}}{72\bar{c}} > 0 & \text{if } c_2 < \bar{c} \leq \frac{1}{4} \\
\frac{115 - 60\sqrt{3}}{144\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4} 
\end{cases} \quad (A6)
\]

Proof of Proposition 5

From Lemma 1, compare the profit under posted prices to the profit for each of the various configurations:

\[
\Pi_{J=2}^{NC,NSC} - \Pi_{J=1}^{NC,NSC} = \begin{cases} 
\frac{1 + \bar{c}}{6} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{11 - 6\sqrt{3}}{24\bar{c}} > 0 & \text{if } \bar{c} > c_2 
\end{cases} \quad (A7)
\]

\[
\Pi_{J=2}^{SC,NSC} - \Pi_{J=1}^{SC,NSC} = 0 
\]

\[
\Pi_{J=2}^{NC,SC} - \Pi_{J=1}^{NC,SC} = \Pi_{J=2}^{SC,SC} - \Pi_{J=1}^{SC,SC} = \begin{cases} 
\frac{3 + 6\bar{c} + 4(\bar{c})^2}{36} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{53 - 30\sqrt{3}}{72\bar{c}} > 0 & \text{if } \bar{c} > c_2 
\end{cases} \quad (A8)
\]

\[
\Pi_{J=2}^{PP} - \Pi_{J=1}^{NC,NSC} = \begin{cases} 
\frac{1}{2} > 0 & \text{if } \bar{c} \leq \frac{1}{4} \\
\frac{8\bar{c} - 1}{8\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4} 
\end{cases} \quad (A9)
\]

\[
\Pi_{J=2}^{PP} - \Pi_{J=2}^{NC,NSC} = \begin{cases} 
\frac{2 - \bar{c}}{6} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{6\sqrt{3} - 11 + 12\bar{c}}{24\bar{c}} > 0 & \text{if } c_2 < \bar{c} \leq \frac{1}{4} \\
\frac{12\bar{c} - 7 + 3\sqrt{3}}{12\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4} 
\end{cases} \quad (A10)
\]
\[ \Pi^{PP} - \prod_{j=1}^{\text{SC,NSC}} = \Pi^{PP} - \prod_{j=2}^{\text{SC,NSC}} = 1 > 0 \] (A12)

\[ \Pi^{PP} - \prod_{j=1}^{\text{NC,SC}} = \Pi^{PP} - \prod_{j=1}^{\text{SC,SC}} = \begin{cases} 
\frac{3}{4} > 0 & \text{if } \bar{c} \leq \frac{1}{4} \\
\frac{16\bar{c} - 1}{16\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4}
\end{cases} \] (A13)

\[ \Pi^{PP} - \prod_{j=2}^{\text{NC,SC}} = \Pi^{PP} - \prod_{j=2}^{\text{SC,SC}} = \begin{cases} 
\frac{2}{3} - \frac{\bar{c}}{6} - \frac{\bar{c}^2}{9} > 0 & \text{if } \bar{c} \leq c_2 \\
\frac{30\sqrt{3} - 53 + 54\bar{c}}{72\bar{c}} > 0 & \text{if } c_2 < \bar{c} \leq \frac{1}{4} \\
\frac{29 + 60\sqrt{3}}{144\bar{c}} > 0 & \text{if } \bar{c} > \frac{1}{4}
\end{cases} \] (A14)

**Details for the Construction of Table 1**

Table 2 of Spann et al. (2004) reports parameter estimates of consumers’ WTP, expected lower and upper bounds of threshold prices, and per-bid frictional cost for bidders at a German NYOP seller of air travel. Based on these estimates, I calculate profit assuming that WTP is distributed U[264.89, 441.25], costs are distributed U[0, 12.46], and the price thresholds are expected to be distributed over U[177.94, 441.25]. These specifications ensure that frictional costs are non-negative, that all consumers have a WTP that is no greater than the maximum threshold price (as assumed by Spann et al. 2004), and that the means match the estimated means of these variables. Table 1 records the results. “Posted Price” profit is calculated by solving the maximization problem: \( \max_{p} (P - w) \text{prob}(WTP \geq P) \). “NYOP, J=1” records the profit when consumers are restricted to a single-bid. Profit is:

\[
\int_{WTP} \int_{c} (B - w) \psi f(c) f(WTP) dc dWTP \quad \text{where} \quad \psi = 1 \text{ if } B \geq P_{NYOP} \text{; else } \psi = 0.
\]

Without commitment, the firm optimally chooses to accept any bid above costs, i.e., \( P_{NYOP} = w \). With commitment, the NYOP firm employs the estimated distribution of price thresholds, i.e., randomly chooses \( P_{NYOP} \text{ from } U[177.94, 441.25] \). “NYOP, J=6” records the profit when consumers can place up to six bids. Each consumer selects the bid-sequence length (as outlined in Table B.1. of Spann et al. 2004) that maximizes her expected surplus.

**Posted-Prices versus NYOP: Evidence from the Literature**

Below, I examine the existing literature on the NYOP format and consider how the NYOP format performs relative to posted prices for each of these papers.

Terwiesch et al. (2005): As mentioned in the text, using data from a German NYOP retailer for three electronic products, this paper finds 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). Thus, the actual profit under the NYOP format reaches only 57.5 percent to 90 percent of the profit that would have been obtained with posted prices. Terwiesch
et. al. (2005) argue that the NYOP firm has set price thresholds at a suboptimal level and that if the thresholds were adjusted to the levels proposed by their Proposition 2, this gap would have been narrowed for two of the three products, and even reversed for the third. But, even in this third case, the estimated profit advantage of the NYOP format (relative to posted prices) is extremely small (less than 1 percent). Notice this advantage also requires naïve customers.

With the exception of Terwiesch et. al. (2005), none of the other papers listed in Section 1 explicitly compare profit under NYOP to the profit a firm could earn from posted prices. However, sometimes there is enough evidence to make this comparison for oneself. Below, I present this analysis.

Fay (2004): As mentioned in the text, this paper acknowledges that posted prices “weakly dominate NYOP in this simple framework” (p. 415). In this analytical model (with no bidding costs), the firm could replicate the profit earned by either “Single-Bid” and “All-Repeat-Bid” by simply posting prices of \( P_0 \) and \( P_1 \), depending on the supply realization \( q_i \), rather than using a NYOP format with concealed threshold prices. Furthermore, profitability of the NYOP format is diminished once one adds more realistic assumptions of strictly positive bidding costs and/or circumvention of a single-bid restriction by sophisticated consumers (see Fay 2004). But, a posted price format would be unaffected by such extensions and thus would be strictly more profitable in such settings.

Spann, Skiera, and Schafers (2004): This paper derives the optimal bidding behavior (when repeat bidding is or is not allowed). Table 1 (p. 28) provides an example with a single consumer who has a willingness-to-pay of 350 and who expects the NYOP firm to select its threshold price from \( U[150, 500] \). Notice that a posted price firm could earn a revenue of $350 by setting a price equal to this willingness-to-pay. However, using a NYOP format and restricting the consumer to a single bid would lead to a bid of 250. Under no seller commitment, the NYOP seller could generate a revenue of $250, i.e., 71.4 percent of the revenue achieved from the posted price format. Under seller commitment, i.e. the NYOP seller randomly chooses its price from the expected distribution, the bid would be accepted with probability 28.6% of \( \frac{250 - 150}{500 - 150} = .286 \). Thus, under a single-bid policy, the NYOP retailer earns an expected revenue of 71.43 (250 * .286) or 20.4% of the level achieved by posted prices. With repeat bidding, the consumer places at most four bids (starting at 199, then 243, then 282, then 316). With no seller commitment, this generates a revenue that is 90.3 percent of the level under posted prices \( \frac{316}{350} \). Using seller commitment, the NYOP retailer earns an expected revenue that is 34.4 percent of the level achieved by posted prices \( \frac{316 - 282}{500 - 150} = .344 \).

My Table 1 extends this comparison to heterogeneous consumers. Each of the various NYOP formats is strictly dominated by the posted price format. The dominance of posted prices is particularly evident if the seller faces significant wholesale costs. For instance, \( w = \$200 \) represents a gross margin of over 35 percent for the average price threshold from the estimated distribution (in line with the reported gross margins for the NYOP retailer studied in Hann and Terwiesch 2003). At this level of wholesale cost, all NYOP formats obtain less than 80 percent of the profit that would be obtained with posted prices (and as little as 32 percent for the case with a single-bid restriction and seller commitment). Notice that this table only considers naïve
consumers. The profit under the NYOP format would be even lower if I had assumed that consumers were sophisticated.

*Ding et. al. (2005):* In this experimental study, subjects have a uniform reservation value of $1100 for the NYOP package. Thus, the optimal posted price would generate a profit of $1100. Two scenarios using the NYOP format are considered, Scenario 1, where the NYOP firm chooses a bid threshold that ranges from $100 to $1100, and scenario 2 where the NYOP chooses a bid threshold that ranges from $800 to $1100. According to this analysis, the optimal consumer bid would be $600 in scenario 1 and $950 in scenario 2. Under no commitment, the seller could generate a revenue of $600 per consumer under scenario 1 and a revenue of $950 per consumer under scenario 2, or 54.5 percent and 86.4 percent or the revenue under posted prices, respectively. Under seller commitment, i.e., if the NYOP firm followed the acceptance pattern prescribed for it (given in Table 1b of Ding et. al. 2005), 43 percent and 14 percent of these optimal bids would be accepted for these two scenarios, respectively. This results in a per-subject profit of $258 ($600 * .43) and $133 ($950 * .14), respectively. Thus, the NYOP format generates approximately 18 percent ($258 + $133) / 2 = .178 of the per-subject revenue obtainable under posted prices.

*Hann and Terwiesch (2003):* This paper demonstrates that frictional costs are non-trivial. Therefore, the NYOP format reduces the willingness-to-pay of consumers versus a posted price format in which such frictional costs would not be incurred. Furthermore, this paper asserts that consumers shopping at a firm that employs a NYOP format are likely to be concerned about bidding above the unknown threshold price. This leads to the prediction that consumers “are likely to either suggest extremely low prices, so that a transaction often does not occur, or abstain from submitting offers completely.” Their evidence is consistent with this conjecture, with first and second round bids averaging 118 and 142 Euros respectively whereas the average threshold prices are significantly higher for the three product categories in their data set (EUR 204 for CD-RW and DVD drives, EUR 153 for MP3 players, and EUR 281.55 for PDAs). This leads to very low acceptance rates, e.g., their Figure 2 shows acceptance rates at a magnitude of about 5 percent.

**Duopoly Model**

*Derivation of Equilibrium with Seller Commitment for the Two-Bid Model (Consumers are either Naïve or Sophisticated)*

Consumers follow the bidding strategy given in (8). Profit for the focal firm is given by:

\[
\Pi_{F,i=2}^{NC,SC} = \Pi_{F,i=2}^{SC,SC} = \int_{P_{NYOP}=b_2} \left[ \int_{c_i=0}^{\hat{b}_{i2} f(c_i) dc_i} \left( \hat{b}_{i2} f(c_i) dc_i + \int_{c_i=\max[c_i,\pi]} \hat{b}_{i1} f(c_i) dc_i \right) f(P_{NYOP}) dP_{NYOP} \right]
\]

\[
+ \int_{P_{NYOP}=b_2} \left[ \int_{c_i=0}^{\hat{b}_{i2} f(c_i) dc_i} \left( \hat{b}_{i2} f(c_i) dc_i + \int_{c_i=\max[c_i,\pi]} \hat{b}_{i1} f(c_i) dc_i \right) f(P_{NYOP}) dP_{NYOP} \right]
\]

\[
+ \int_{P_{NYOP}=b_1} \left[ \int_{c_i=0}^{\hat{b}_{i2} f(c_i) dc_i} f(P_{NYOP}) dP_{NYOP} \right]
\]

The rival firm’s profit is given by:
For a given price, $P_R$, one of three scenarios will result: a) $\bar{c} \leq \hat{c}_2$, i.e., all consumers bid twice at the NYOP channel; b) $\hat{c}_2 < \bar{c} \leq \hat{c}_1$, i.e., all consumers bid at the NYOP channel but some only bid one time at most; and c) $\bar{c} > \hat{c}_1$, i.e., some consumers do not place any bid at the NYOP channel. Under scenarios a) and c), the profit-maximizing price for the rival is $P_R=1$. Here, the profit function is strictly increasing in $P_R \left( \frac{d\Pi_{NC,SC}^{NC,SC}}{dP_R} > 0 \text{ if } \bar{c} \leq \hat{c}_2 \text{ or } \bar{c} > \hat{c}_1 \right)$. Thus, the rival earns the highest profit by selling at the highest possible margin to those consumers who do not purchase from the NYOP firm (either because they do not bid at all or because their bids have been rejected).

However, if $\hat{c}_2 < \bar{c} \leq \hat{c}_1$, then the profit-maximizing price is less than 1. The rival firm can lower its price in order to discourage some consumers from bidding at all and encourage others (with lower costs) to place a single bid rather than two bids. In particular, one can numerically solve the optimization problem: $\max_{P_R} \Pi_{NC,SC}^{NC,SC}$ s.t. $\hat{c}_2 < \bar{c} \leq \hat{c}_1$. Let $\hat{P}$ be this solution. Thus, the rival maximizes profit by either selecting $P_R=1$ or $P_R=\hat{P}$. Figure 1 illustrates this solution where $\alpha = 0.0703$ and $\beta = 0.4137$. The focal firm’s profit when $P_R=\hat{P}$ is $\hat{\Pi}$, can be calculated numerically using (A15).

**Confirmation of Consistency of Monopoly Results for Propositions 1 and 3**

The text asserts that Propositions 1 and 3 extend to the case of competition. The following calculations based on Lemma 2 confirm this assertion:

**Proposition 1**

\[
\Pi_{NC,SC}^{NC,SC} - \Pi_{SC,SC}^{SC,SC} = \begin{cases} 
\frac{1}{3\sqrt{3}} > 0 & \text{if } \bar{c} \leq \frac{3}{4} \\
\frac{1}{8\bar{c}} > 0 & \text{if } \bar{c} > \frac{3}{4}
\end{cases}
\]

\[
\Pi_{NC,SC}^{NC,SC} - \Pi_{SC,SC}^{SC,SC} = \begin{cases} 
\frac{27 - 9\sqrt{9 - 4\sqrt{3\bar{c}}} - 6\sqrt{3\bar{c}} - 2\bar{c} + 4\sqrt{3} (\bar{c})^\frac{3}{2}}{36\bar{c}} > 0 & \text{if } \bar{c} \leq \frac{3}{4} \\
\frac{7 - 3\sqrt{3}}{12\bar{c}} > 0 & \text{if } \bar{c} > \frac{3}{4}
\end{cases}
\]
Proposition 3

\[
\Pi^{SC,SC}_{F,j=1} - \Pi^{SC,NSC}_{F,j=1} = \begin{cases} 
\frac{1}{4} > 0 & \text{if } \bar{c} \leq \frac{4}{27} \\
\frac{3\sqrt{c}}{4} > 0 & \text{if } \frac{4}{27} < \bar{c} \leq \frac{1}{2} \\
\frac{1}{16c} > 0 & \text{if } \bar{c} > \frac{1}{2} 
\end{cases} \quad (A19)
\]

\[
\Pi^{SC,SC}_{F,j=2} - \Pi^{SC,NSC}_{F,j=2} = \begin{cases} 
\hat{\Pi} > 0 & \text{if } \bar{c} \leq .0703 \\
\frac{1 - \frac{c}{3} + \frac{c^2}{9}}{3} > 0 & \text{if } .0703 < \bar{c} \leq .4137 \\
\frac{115 - 60\sqrt{3}}{144c} > 0 & \text{if } \bar{c} > .4137 
\end{cases} \quad (A20)
\]

Proof of Proposition 6

From Lemma 2, compare the profit of the focal firm under the various NYOP configurations to the profit the focal firm would have earned using a posted price:

\[
\Pi^{SC,SC}_{F,j=1} - \Pi^{pp}_F = \begin{cases} 
\frac{1}{3\sqrt{3}} > 0 & \text{if } \bar{c} \leq \frac{3}{4} \\
\frac{1}{8c} > 0 & \text{if } \bar{c} > \frac{3}{4} 
\end{cases} \quad (A21)
\]

\[
\Pi^{NC,NSC}_{F,j=2} - \Pi^{pp}_F = \begin{cases} 
\frac{27 - 9\sqrt{9 - 4\sqrt{3\bar{c}}} - 6\sqrt{3\bar{c}} - 2\bar{c} + 4\sqrt{3}(\bar{c})^{\frac{3}{2}}}{36c} > 0 & \text{if } \bar{c} \leq \frac{3}{4} \\
\frac{7 - 3\sqrt{3}}{12c} > 0 & \text{if } \bar{c} > \frac{3}{4} 
\end{cases} \quad (A22)
\]

\[
\Pi^{NC,SC}_{F,j=1} - \Pi^{pp}_F = \Pi^{SC,SC}_{F,j=1} - \Pi^{pp}_F = \begin{cases} 
\frac{1}{4} > 0 & \text{if } \bar{c} \leq \frac{4}{27} \\
\frac{3\sqrt{c}}{4} > 0 & \text{if } \frac{4}{27} < \bar{c} \leq \frac{1}{2} \\
\frac{1}{16c} > 0 & \text{if } \bar{c} > \frac{1}{2} 
\end{cases} \quad (A23)
\]
\[\Pi_{F,j=2}^{NC,SC} - \Pi_F^{PP} = \Pi_{F,j=2}^{SC,SC} - \Pi_F^{PP} = \begin{cases} 
\frac{1 + \frac{\bar{c}}{3} + \left(\frac{\bar{c}}{9}\right)^2}{6} > 0 & \text{if } \bar{c} \leq .0703 \\
\hat{\Pi} > 0 & \text{if } .0703 < \bar{c} \leq .4137 \\
\frac{115 - 60\sqrt{3}}{144 \bar{c}} > 0 & \text{if } \bar{c} > .4137 
\end{cases} \tag{A24}\]

**Proof of Proposition 7**

From Lemma 2, for both the single-bid and two-bid cases, compare the profit of the focal firm with naive customers and seller commitment, to the profit with naive customers and no seller commitment:

\[\Pi_{j=1}^{NC,SC} - \Pi_{j=1}^{NC,NSC} = \begin{cases} 
\frac{9 - 4\sqrt{3\bar{c}}}{36} > 0 & \text{if } \bar{c} \leq \frac{4}{27} \\
\frac{(9\bar{c} - 32\sqrt{3})^{1/2}}{288} > 0 & \text{if } \frac{4}{27} < \bar{c} \leq \frac{1}{2} \\
\frac{1}{16\bar{c}} - \frac{1}{3\sqrt{3}} < 0 & \text{if } \frac{1}{2} < \bar{c} \leq \frac{3}{4} \\
\frac{-1}{16\bar{c}} < 0 & \text{if } \bar{c} > \frac{3}{4} 
\end{cases} \tag{A25}\]

\[\hat{\Delta} > 0 \quad \text{if } \bar{c} \leq .0703 \]

\[\hat{\Delta} > 0 \quad \text{if } .0703 < \bar{c} \leq .4137 \]

where \(\hat{\Delta} = \hat{\Delta} \left(\frac{27 - 9\sqrt{9 - 4\sqrt{3\bar{c}}} - 6\sqrt{3\bar{c}} - 2\bar{c} + 4\sqrt{3}(\bar{c})^{3/2}}{36\bar{c}}\right) \tag{A26}\]

**Proof of Proposition 8**

From Lemma 2, compare the profit under one-bid with seller commitment to the profit under two-bids with seller commitment:
\[
\Pi_{F,J=1}^{SC,SC} - \Pi_{F,J=2}^{NC,SC} = \Pi_{F,J=1}^{SC,SC} - \Pi_{F,J=2}^{SC,SC} = \begin{cases} 
\frac{3 + 6\bar{c} + 4(\bar{c})^2}{36} < 0 & \text{if } \bar{c} \leq 0.0703 \\
\Delta_1 > 0 & \text{if } 0.0703 < \bar{c} \leq \frac{4}{27} \\
\Delta_2 < 0 & \text{if } \frac{4}{27} < \bar{c} \leq 0.4137 \\
\frac{120\sqrt{3} + 9\bar{c}^{5/2} - 230}{288\bar{c}} < 0 & \text{if } 0.4137 < \bar{c} \leq \frac{1}{2} \\
\frac{30\sqrt{3} - 53}{72\bar{c}} < 0 & \text{if } \bar{c} > \frac{1}{2}
\end{cases}
\]

where \( \Delta_1 = \frac{1}{4}\hat{\mu} \) and \( \Delta_2 = \frac{1}{4}\sqrt{\frac{\bar{c}}{4} - \hat{\mu}} \)

References


33