

Commitment and Cheap Talk in Search Deterrence: Exploding Offer vs Buy-Now Discount

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Abstract

This paper theoretically and experimentally investigates two prevailing search deterrence tactics, exploding offer and buy-now discount, under various commitment conditions. An exploding offer is a take-it-or-leave-it offer that expires if the recipient does not accept before a given deadline. A buy-now discount is a high-pressure tactic that specifies a higher buy-later price so as to encourage early transactions. In an experimental setting where the two tactics are predicted to generate the same equilibrium outcome under full commitment, we find exploding offers are implemented more optimally and are more effective in search deterrence. Consistent with the theory, the removal of the seller's power to commit sharply decreases the frequency of exploding offers while leaving the use of buy-now discounts largely unaffected. Allowing a seller to cheap talk can significantly influence the buyer's search and return decisions. Cheap talk is most used to deter search in the exploding offer game but to induce return in the buy-now discount game. Such a different cheap talk strategies can be largely explained by our behavioral model, where we introduce a behavioral type of buyers who naively believe the seller's cheap talk.

1 Introduction

Search deterrence tactics are used in both consumer goods markets and labor markets to create high pressure that discourages search and leads to early transactions. When a seller meets a buyer, the seller is often eager to secure an immediate sale while the buyer may want to check more options before purchase; when an employer makes an offer to its top job candidate, the employer often prefers an immediate acceptance while the candidate may want to hold the

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offer and search for more opportunities. In these scenarios, two tactics are commonly used to deter search: exploding offer and “buy-now” discount (or “accept-now” bonus). An exploding offer is a take-it-or-leave-it offer that expires if the recipient does not accept before a given deadline. A buy-now discount (or an accept-now bonus) is a high-pressure tactic that specifies a lower buy-now price (or a salary bonus) so as to encourage early transactions.

The literature has documented many real-world examples of these two search deterrence tactics. In the matching market between judges and law clerks in the US, described in Roth and Xing (1994), judges send exploding offers that expire in a couple of hours or even over the phone call of making the offer. Lippman and Mamer (2012) document that some consulting firms include in their job offers a signing bonus that drops by a certain amount each week until acceptance.¹ Neale and Bazerman (1991) mention when recruiting graduates of management schools, some firms make the salary drop every day until acceptance. In consumer goods markets, “flash sales”—a typical form of buy-now discount—is common on online shopping platforms. As a variant of exploding offer, some sellers allow pre-orders for their popular products before the official release date.

The implementation of search deterrence, however, requires commitment power, which is often absent in real-world markets. Approaching the end of “limited-time-only” sales in marketplace, sellers often “surprise” consumers by extending the sales period. In many labor markets including the economics job market, it is not uncommon for employers to extend an exploding offer especially when the candidate expresses reluctance to accept the offer before the original deadline. In fact, some online career platforms including the Muse, JobHero, AngelList advice job seekers faced with exploding offers to try to negotiate more time instead of being blindsided by announced deadlines. This is because search deterrence claims are rarely formally contracted or legally binding: they are often communicated through vague advertisements in public sales or orally in private negotiations.

Despite the extensive application of exploding offer and buy-now discount in various real-world markets, it is largely unexplored, from a behavioral perspective, the role of commitment in these two search deterrence tactics. In this paper, we theoretically and experimentally investigate the tactics of exploding offer and buy-now discount under different commitment conditions with the intention to answer the following questions. Are these two tactics equally effective in deterring search when the proposer can fully commit to her claims? How does the lack of commitment power affect the performance of the two tactics? Does cheap talk—a search deterring claim without commitment power—affect the receiver’s decision to search? The current paper studies these questions in the context of consumer search. The main conclusions should carry over to the labor market environment.

¹A signing bonus, also known as a sign-on bonus, is a lump-sum payment from an employer to its new hire when they sign an employment contract. It is a traditional strategic recruitment device used by employers to attract talents.

To theoretically analyze the two search deterrence tactics under various commitment conditions, we consider a dynamic model of consumer search adapted from Armstrong and Zhou (2016). In the games with exploding offers, the seller proposes a transaction price and specifies a date that the offer expires. In the games with buy-now discounts, the seller proposes a buy-now price and a buy-later price for the transaction. If the seller can fully commit to her search deterring claims, a buy-now discount can generate equivalent outcomes to an exploding offer if the buy-later price is sufficiently high. However, removing the seller’s commitment power has different consequences under the two tactics: it effectively removes the seller’s ability to deter search using exploding offers; while for buy-now discounts, it does not induce the seller to adopt a more lenient pricing scheme that increases the buyer’s incentive to seek an alternative option.

We adopt two settings to study the games without commitment power. In the first setting named “no commitment,” the seller does not announce to the buyer the future price/availability of the item at their initial encounter. In the second setting named “cheap talk,” the seller announces the future price/availability via (costless and non-contractible) cheap talk; such a setting mimics the commitment condition of many real-life scenarios and is also prevailing in the discussion of commitment in principal-agent models. Although the standard theory provides the same equilibrium predictions for these two approaches, behaviorally cheap talk has been found to be effective in various environments.

Since search deterrence in practice often occur in private negotiations, it is hard to obtain empirical evidence that captures market participants’ behavioral patterns. The laboratory provides us with an ideal environment to study this form of price discrimination. Our lab experiment has a three-by-two treatment design; varying the search deterrence tactics of *Exploding Offer* or *Buy-Now Discount* and the commitment condition of *Full Commitment*, *No Commitment*, or *Cheap Talk*.

First, to examine how subjects use and respond to the two search deterrence strategies differently under full commitment, we choose an experimental setting such that the seller in equilibrium sends an exploding offer in the exploding-offer game and uses a buy-now discount strategy in the game of buy-now discount; the equilibrium outcomes in these two games are identical. Such a theoretical prediction, however, is not fully supported by our experimental data from the two full-commitment treatments. Compared to buy-now discounts, we find that exploding offers are implemented more optimally by sellers and are more effective in deterring buyers from search. We mainly attribute such a result to a better understanding of the environment with exploding offers by both seller and buyer subjects: with two adjustable prices, the buy-now discount setting is cognitively more challenging.

Next, we investigate the role of commitment power in search deterrence by comparing the conditions of full commitment and no commitment for the two tactics respectively. Theoretically speaking, under no commitment, the seller in the exploding-offer game can only make

an open offer that keeps the transaction price constant over time, while the outcome of the buy-now discount game is the same as that with full commitment. Our experimental results largely confirm such a prediction. However, although removing a seller's power of committing to an exploding offer effectively removes her ability to deter search, we observe no effect on the payoffs of sellers or buyers due to a drastic increase in cooperation: both sellers and buyers choose sub-optimal strategies that lead to an equal split of surplus. This result is surprising because cooperation is also an option under the full commitment condition: both sides switch to cooperation once the seller can no longer effectively deter the buyer from search.

Lastly, we discuss subjects' strategic behaviors in the cheap talk environment. We find strong evidence that sellers' cheap talk affects buyers' search and return decisions, while cheap talk is not as effective as credible claims under full commitment. In our opinion, one of the most intriguing experimental results lies in the cheap talk strategies adopted by our seller subjects. In the exploding offer game, a majority of sellers use cheap talk to deter search: they claim exploding offers and later revise to open offers. In the buy-now discount game, a majority of sellers use cheap talk to induce return: they claim uniform prices or even buy-later discounts and then revise to a higher buy-later price to exploit returning buyers.

We rationalize the experimental results in the cheap talk environment by introducing a behavioral type of buyer into the theory model, who naively believes that the seller fully commits to her pricing claim. Under the two search deterrence tactics, the presence of the naive buyer has different effects on the strategy of the seller. In the exploding offer game, facing a naive buyer, the seller chooses the offer that is optimal under the full-commitment condition, that is, she sends the optimal exploding offer when it is profitable to deter search. In the buy-now discount game, compared with the optimal pricing under the full-commitment condition, it is more profitable for the seller to charge a lower buy-later price and a higher buy-now price, so as to take the chance of altering the buy-later price to exploit returning buyers. We show that the incentives of the seller to exploit the naivety of some buyers induce the optimal strategies of the seller in the cheap-talk games deviate from the optimal strategies of the seller in the no-commitment games in the ways consistent with the experimental observations.

Our findings on cheap talk echo the conclusions of Brown et al. (2017). In an exploding-offer game with full commitment, Brown et al. (2017) show that buyers may have negative behavioral responses towards exploding offers: they tend to reject them more often than rational buyers would. This greatly reduce the gains from using high-pressure search deterrence tactics, which may induce sellers to adopt a less aggressive approach. They use this to explain why we do not see more search deterrence in the field given the theoretically predicted profitability. Our results, on the other hand, point to the explanation of the lack of commitment power in real-life scenarios. Although cheap talk can influence buyers' decision making, the lack of true commitment power still weakens the effects of an exploding offer. With buy-now discounts, a standard model that assumes full rationality predicts no effect of removing a

seller's ability to commit and has no prediction on her cheap talk strategy. Our behavioral model and experimental results, however, suggest that a seller without commitment power should announce a less aggressive claim due to the added incentive to encourage return, which also explains the departure of real-life observations from theoretical predictions.

The rest of this paper is organized as follows. In Section 2, we lay out a general two-period model and make theoretical predictions under standard assumptions. Section 3 describes the laboratory experiment and presents experimental results. A behavioral model is introduced in Section 4 to analyze the key experimental findings on cheap talk. Section 5 concludes the paper.

2 Model

We consider a two-period model of consumer search, which is adapted from Armstrong and Zhou (2016). There are one buyer (he) and one seller (she). The seller has a single object to sell and gets 0 payoff from retaining the object. The buyer's value for the object u is a random draw from distribution F with support $[\underline{u}, \bar{u}]$ and density f , and is privately known to the buyer. In the first period, the seller makes an offer to the buyer. The buyer can choose to purchase the seller's item immediately, or by incurring a search cost $s \geq 0$ to enter the second period and search for an alternative option. The search yields a random net surplus v to the buyer. The value of v is only privately observable to the buyer after he conducts search, and is randomly drawn from distribution G with support $[\underline{v}, \bar{v}]$ and density g . Once the buyer observes his alternative option after search, he chooses whether to get the alternative option or to return to purchase the seller's item if it is still available. If the buyer returns but fails to reach a deal with the seller, he receives v with probability δ , where $\delta \in [0, 1)$ is the probability that the outside option stays available during the period of return. The decrease in the expected payoff, $(1 - \delta)v$, can be interpreted as the value-dependent cost of return for the buyer. Throughout the analysis, we assume that v is independent of u , and \underline{v} and \underline{u} are both positive.

In this setting, we want to examine how the *dynamic* pricing scheme of the seller affects the *intertemporal* purchasing decision of the buyer, which is to choose between buying the seller's item in period 1 or making the purchasing decision after search. Thus, for the purpose of this study, we impose Assumption 1 to exclude two uninteresting scenarios: (1) the buyer neither purchases the seller's item nor searches for an alternative option; (2) the buyer always conducts search regardless of the pricing scheme of the seller. For expositional purpose, we define

$$S(x) = E_v[\max\{v, x\}] - x = \int_x^{\bar{v}} (1 - G(v))dv, \quad (1)$$

which is the payoff gain of the buyer from search when his payoff from buying the seller's item

is constantly x across periods. It is intuitive that $S(x)$ is decreasing in x , i.e., the gain for the buyer from search is smaller when the payoff from the seller's item is higher.

Assumption 1. *The search cost s and the distributions F and G satisfy*

$$S(\bar{u}) < s < S(0) - \underline{u}. \quad (2)$$

The second inequality in (2) means that if the value of the object to the buyer is \underline{u} , the buyer would like to search even he cannot return to get the seller's object after the search. This inequality implies

$$s < E[v]. \quad (3)$$

With condition (3), searching for an alternative option makes the buyer better off than leaving the market without buying anything. The first inequality in (2) means that if the buyer values the seller's item most, he will not search for an alternative option when the price charged by the seller in the first period is sufficiently low. Thus, making the purchase decision after search is not a dominant strategy for the buyer regardless of the price in period 1.

The most natural pricing scheme for the seller in this setup is to make the item available for purchase at the same price across the two periods. This pricing scheme is named *free recall* in Armstrong and Zhou (2016). In the current paper, we refer this scheme more often as *(intertemporal) uniform price* or *open offer* interchangeably depending on the context. Under a uniform price, the buyer is not discriminated based on the time that he makes the purchase; he can choose to buy the seller's item at the same price after search. However, the search of the buyer hurts the seller, as it reduces the probability of transaction. Two dynamic pricing schemes are commonly employed by sellers to create high pressure for early transaction and deter the buyers from search: buy-now discount and exploding offer. A buy-now discount is a sales tactic under which a seller specifies a lower period-1 price and a higher period-2 price to discourage a buyer from making the purchase decision in period 2. An exploding offer is a take-it-or-leave-it offer that expires at the end of period 1 if the buyer does not accept it. In essence, both of these tactics creates high pressure for the buyer to transact early by endogenously increasing the cost of search. However, they are different in the way of increasing search cost: a buy-now discount raises the cost of search by manipulating the buy-later price, while an exploding offer arguments the search cost by manipulating the availability of the seller's item in period 2. We show that they can achieve similar outcomes when the seller has full commitment power, but perform very differently when the seller has no power to commit to them.

We use sequential equilibrium as our solution concept for the rest of the analysis.

2.1 Search Deterrence with Full Commitment

In this subsection, we assume that the seller can fully commit to her dynamic pricing scheme, and study how the seller uses the two search deterrence tactics, buy-now discount and exploding offer, differently. For the sake of comparison, we consider two games. In the first game, which we call the *buy-now-discount game*, the seller can flexibly choose the prices of her object in period 1 and period 2. In the second game, which we call the *exploding-offer game*, the seller chooses the price of the object and determines whether the object is available or not at the price in period 2. These two games mainly differ in the strategy space of the seller, with the buy-now-discount game offering the seller a larger strategy space. In particular, any strategy of the seller in the exploding-offer game can be replicated by a strategy in the buy-now discount game. We discuss under what conditions the seller optimally adopts search deterrence strategies in these two games and characterize the equilibria.

To begin, we lay out the timing of the buy-now-discount game:

1. Nature draws the value of u according to distribution F .
2. The seller chooses the prices of selling the object in the first period and the second period. Let p_1 and p_2 denote the period-1 and period-2 prices, respectively.
3. Upon observing the value of u and the price pair (p_1, p_2) , the buyer decides whether to purchase the seller's item at price p_1 or to search for an alternative option in period 2 by incurring a search cost s . The game ends if the buyer purchases the seller's item at price p_1 .
4. If the buyer decides to search for an alternative option, he privately observes an option v , which is randomly drawn from distribution G , then decides whether to accept the alternative option, which gives him payoff v , or to return to purchase the seller's item, which gives him payoff $u - p_2$. The game ends after the decision.

The timing of the exploding-offer game is the same as that of the game of buy-now discount, except that (1) instead of announcing a price pair (p_1, p_2) at the beginning of the game, the seller chooses the price p of selling the object and the expiration date of the offer, which is either period 1 or period 2; (2) if the buyer searches and the offer expires in period 1, the buyer cannot return to the seller in period 2, in which case the buyer keeps his outside option v and the seller gets payoff 0.²

²In these two games, by assuming that the games end when the buyer chooses to purchase the seller's item in period 1, we rule out the possibility that the buyer *both* purchases the seller's item *and* searches for an outside option, then consumes the one giving him the higher payoff. For many situations, this assumption is innocuous. For example, (1) the budget of the buyer does not allow him to purchase two items; (2) the seller's object is a perishable good, the consumption of which cannot be delayed; (3) in the labor market setting, a potential employee cannot accept two offers. With this assumption, the decision problem faced by the buyer is greatly simplified, without losing the tradeoffs that we are interested in. The simplified game structure makes the experiments designed based on these games much more accessible to the subjects.

We first analyze the game of buy-now discount. In this game, given (p_1, p_2) , the buyer will purchase the seller's item without search if

$$u - p_1 \geq E_v[\max\{v, u - p_2\}] - s,$$

the left-hand side (LHS) of which is the payoff of the buyer from buying the seller's item in period 1, and the right-hand side (RHS) is the expected payoff of the buyer from search. This inequality can be reformulated as

$$(p_2 - p_1) + s \geq S(u - p_2), \quad (4)$$

the RHS of which is decreasing in $(u - p_2)$. Given Assumption 1, there exists a cutoff $\hat{u}(p_1, p_2) > \underline{u}$ of u satisfying (4) with equality, such that the buyer does not search if $u \geq \hat{u}(p_1, p_2)$. Thus, the buy-now demand and buy-later demand for the seller's item are respectively

$$x_1(p_1, p_2) = 1 - F(\hat{u}(p_1, p_2)), \quad x_2(p_1, p_2) = \int_{\underline{u}}^{\hat{u}(p_1, p_2)} G(u - p_2) f(u) du. \quad (5)$$

The expected payoff of the seller is

$$\pi_B(p_1, p_2) = p_1 x_1(p_1, p_2) + p_2 x_2(p_1, p_2). \quad (6)$$

At optimum, there are three possible scenarios: (1) $x_1(p_1, p_2) = 0$, (2) $x_2(p_1, p_2) = 0$, and (3) $x_1(p_1, p_2), x_2(p_1, p_2) > 0$. The first scenario means that p_1 in period 1 is prohibitively high such that all types of the buyer choose to search. The second scenario corresponds to the case that p_2 is prohibitively high such that no buyer returns to the seller in period 2. In the current paper, since we focus on search deterring pricing schemes, we impose the following assumption to rule out the possibility of $x_1(p_1, p_2) = 0$ at optimum. We will show that in the case that there is no fixed cost of search, the assumption below ensures that it is optimal for the seller to adopt a search deterring strategy in the buy-now-discount game and the exploding-offer game.

Assumption 2. Let p_2^* denote the period-2 price maximizing the profit of the seller when every type of the buyer searches, i.e., p_2^* solves

$$\max_{p_2} p_2 \cdot x_2(\infty, p_2),$$

where $x_2(\infty, p_2) = \int_{\underline{u}}^{\bar{u}} G(u - p_2) f(u) du = E_v[1 - F(v + p_2)]$ is the buy-later demand for the

seller's item when p_1 is prohibitively high. We assume that the value of p_2^* satisfies

$$1 - F(E[v] + p_2^*) > E_v[1 - F(v + p_2^*)]. \quad (7)$$

Condition (7) is satisfied when (1) $\bar{u} - p_2^* > \bar{v}$, which means that the buyer that values the seller's item most always returns at p_2^* , and (2) the function $1 - F(u)$ is strictly concave for $u < \bar{u}$. We briefly illustrate why this assumption ensures that $x_1(p_1, p_2) = 0$ is not optimal. If the seller adopts a pricing scheme with $x_2(p_1, p_2) = 0$, then $\hat{u}(p_1, p_2) = E[v] - s + p_1$, and the expected profit of the seller is $p_1(1 - F(E[v] - s + p_1))$. Under Assumption 2, the optimal pricing scheme with no buy-later demand outperforms the optimal pricing scheme with no buy-now demand, because

$$\max_{p_1} p_1(1 - F(E[v] - s + p_1)) \geq p_2^*(1 - F(E[v] - s + p_2^*)) \geq p_2^*(1 - F(E[v] + p_2^*)) > p_2^* E_v[1 - F(v + p_2^*)],$$

where the second inequality is based on that $s \geq 0$ and $1 - F(u)$ is decreasing in u , and the third inequality is directly from (7).

In the case that the buy-later demand $x_2(p_1, p_2) = 0$ at optimum, the optimal buy-later price is not unique. For the convenience of analysis, we can without loss restrict that the buy-later price is the minimum p_2 inducing 0 buy-later demand given the optimal p_1 .

Proposition 1. *Under Assumptions 1 and 2, the optimal prices (p_{B1}, p_{B2}) maximizing the expected payoff $\pi_B(p_1, p_2)$ of the seller in the buy-now-discount game satisfy*

$$\begin{aligned} \frac{d\pi_B(p_1, p_2)}{dp_1} &= x_1(p_{B1}, p_{B2}) + p_{B1} \frac{dx_1}{dp_1} + p_{B2} \frac{dx_2}{dp_1} = 0, \\ \frac{d\pi_B(p_1, p_2)}{dp_2} &= p_{B1} \frac{dx_1}{dp_2} + x_2(p_{B1}, p_{B2}) + p_{B2} \frac{dx_2}{dp_2} = 0. \end{aligned} \quad (8)$$

When there is no fixed cost of search, i.e., $s = 0$, we have $p_{B1} < p_{B2}$, namely the seller uses a buy-now discount to deter the buyer from search.

Proof. Conditions in (8) are obviously the first order necessary conditions satisfied by (p_{B1}, p_{B2}) when $x_1, x_2 > 0$ at optimum. Thus, we only need to show that they are satisfied when $x_1(p_{B1}, p_{B2}) > 0, x_2(p_{B1}, p_{B2}) = 0$. Since the buy-now demand is positive, p_{B1} is an interior solution of $\max_{p_1} \pi_B(p_1, p_{B2})$, given the second inequality of Assumption 1 which implies $\hat{u}(p_1, p_2) > \underline{u}$.³ The interiority of p_{B1} directly implies that the first equality of (8) holds. To prove the second condition of (8) holds with equality, we show that the right derivative and left derivative of $\pi_B(p_{B1}, p_2)$ with respect to p_2 at $p_2 = p_{B2}$ are both equal to 0. Since

³Without Assumption 1, it can be that at optimum, depending on the shape of function $1 - F(u)$, no buyer chooses to search for an alternative option, i.e., $p_{B1} = \underline{u} - (E_v[v] - s) > 0$ (given $x_2(p_{B1}, p_{B2}) = 0$) and the right derivative of $\pi_B(p_1, p_{B2})$ at p_{B1} is negative.

p_{B2} is defined to be the minimum p_2 inducing $x_2 = 0$ given $p_1 = p_{B1}$, it is obvious that $\pi_B(p_{B1}, p_2) = \pi_B(p_{B1}, p_{B2})$ for any $p_2 > p_{B2}$. Thus, the right derivative of $\pi_B(p_{B1}, p_2)$ at $p_2 = p_{B2}$ is equal to 0. To calculate the left derivative of $\pi_B(p_{B1}, p_2)$ at $p_2 = p_{B2}$, one should note that $x_2(p_{B1}, p_{B2}) = 0$ implies $\hat{u}(p_{B1}, p_{B2}) - p_{B2} = \underline{v}$, given Assumption 1. We have, according to L'Hopital's rule,

$$\lim_{p_2 \rightarrow p_{B2}^-} \frac{\pi_B(p_{B1}, p_2) - \pi_B(p_{B1}, p_{B2})}{p_2 - p_{B2}} = \lim_{p_2 \rightarrow p_{B2}^-} \frac{d\pi_B(p_{B1}, p_2)}{dp_2}.$$

According to the definition of $\hat{u}(p_1, p_2)$, we have

$$\frac{dx_1}{dp_2} = f(\hat{u}) \frac{G(\hat{u} - p_2)}{1 - G(\hat{u} - p_2)}, \quad \frac{dx_2}{dp_2} = -\frac{G(\hat{u} - p_2)^2}{1 - G(\hat{u} - p_2)} f(\hat{u}) - \int_{\underline{u}}^{\hat{u}} g(u - p_2) f(u) du. \quad (9)$$

Thus, we obtain

$$\lim_{p_2 \rightarrow p_{B2}^-} \frac{d\pi_B(p_{B1}, p_2)}{dp_2} = p_{B1} \lim_{p_2 \rightarrow p_{B2}^-} \frac{dx_1}{dp_2} + p_{B2} \lim_{p_2 \rightarrow p_{B2}^-} \frac{dx_2}{dp_2} = 0, \quad (10)$$

given that $\hat{u}(p_{B1}, p_{B2}) - p_{B2} = \underline{v}$. This completes the proof that $d\pi_B(p_1, p_2)/dp_2 = 0$ at (p_{B1}, p_{B2}) .

When $s = 0$, we can without loss focus on price pairs with $p_1 \leq p_2$ in characterizing the optimal pricing scheme, because any price pair with $p_1 > p_2$ generates the same profit for the seller as does the uniform price p_2 , as the buyer always searches when $p_1 > p_2$. Under a uniform price $p_1 = p_2$, it is without loss to assume that all types of the buyer chooses to search and make a purchase decision in period 2. Thus, the optimal uniform price is p_2^* . Assumption 2 ensures that the optimal uniform price is outperformed by a buy-now discount. \square

Now we look at the exploding-offer game. In this game, the strategy space of the seller is greatly simplified, and she chooses only between exploding offers and open offers. The optimal open offer maximizing the seller's expected payoff has price p_O solving

$$\max_p p \cdot (x_1(p, p) + x_2(p, p)). \quad (11)$$

The optimal exploding offer has price p_E solving

$$\max_p p \cdot x_1(p, \infty). \quad (12)$$

The problem for the seller is to choose either the exploding offer with price p_E or the open offer with price p_O . The proposition below provides sufficient conditions under which sending an exploding offer is optimal.

Proposition 2. *In the exploding-offer game,*

1. *if $x_1 > 0$ under the optimal open offer with price p_O , it is optimal for the seller to send the exploding offer with price p_E if the function $1 - F(u)$ is concave for $u < \bar{u}$;*
2. *if $x_1 = 0$ under the optimal open offer with price p_O , which is true when $s = 0$, it is optimal for the seller to send the exploding offer with price p_E if Assumption 2 holds.*

Part 1 of the above proposition is directly obtained from Proposition 2 of Armstrong and Zhou (2016). We sketch only the proof of part 2 of the proposition. If under the optimal open offer the buy-now demand $x_1 = 0$, then the expected payoff of the seller under the optimal open offer is no larger than $p_2^* \cdot x_2(\infty, p_2^*)$. Given Assumption 2, sending an exploding offer with price p_2^* gives the seller a payoff higher than $p_2^* \cdot x_2(\infty, p_2^*)$, so makes the seller better than sending the optimal open offer. Thus, sending the optimal exploding offer is better than sending any open offer.

2.2 Search Deterrence with No Commitment

If it is common knowledge that the seller has no power to commit to her dynamic pricing scheme, then the two search deterrence tactics, exploding offer and buy-now discount, generate very different outcomes. In this subsection, we first analyze that games corresponding to these two tactics in which the seller makes no claim about her period-2 action in period 1. These games provide a clean benchmark for examining the consequences of removing the seller's commitment power.

Before elucidating the heterogeneous performances of the two tactics in this no-commitment case, we spell out the timing of the games. For simplicity, we ignore the move of Nature at the beginning of the games. The timing of the buy-now discount game in this case is as follows:

1. The seller chooses the price p_1 of selling the object in the first period.
2. Given the value of u and price p_1 , the buyer decides whether to purchase the seller's object at price p_1 or to search for an alternative option in period 2 by incurring a search cost s . The game ends if the buyer chooses to make a purchase at price p_1 .
3. If the buyer decides to search for an alternative option, an option v is randomly drawn from the distribution G . The buyer then decides whether to accept the alternative option or to return to purchase the item of the seller. The game ends if the buyer chooses not to return.
4. If the buyer chooses to return to the seller, then the seller chooses price p_2 of selling her item. The two parties *automatically* transact if the new price p_2 satisfies $u - p_2 \geq \delta v$, otherwise the transaction fails, and the seller gets payoff 0 and the buyer receives expected payoff δv .

Different from the full-commitment game, the seller makes no claim about the future transaction price p_2 in period 1. He chooses p_2 only until the buyer returns after search for an alternative option.

Proposition 3. *The game of buy-now discount with no commitment has a unique equilibrium outcome in which the buyer either accepts the seller's offer in period 1 or searches without return. That is, the equilibrium outcome of the buy-now-discount game with no commitment is as if the seller makes an exploding offer with full commitment.*

Proof. We prove this proposition by contradiction. Suppose that in equilibrium the new price set by the seller in period 2 is \tilde{p}_2 such that some value- u buyer will search and return when his outside option is v satisfying $u - \tilde{p}_2 \geq v \geq \underline{v}$. Remember that returning to the seller costs the buyer $(1 - \delta)v$, and the transaction will be completed as long as $u - \tilde{p}_2 \geq \delta \underline{v}$ once the buyer returns. Thus, the seller, upon observing a returning buyer, has an incentive to increase the new price to at least $\tilde{p}_2 + (1 - \delta)\underline{v}$. This contradicts the supposition that \tilde{p}_2 is the equilibrium buy-later price. Therefore, there is no sequential equilibrium with returning buyers in the second period. Given that the buyer will never return to the seller once he conducts search, the unique equilibrium p_1 should be p_E solved from (12).⁴ \square

The order of play in the exploding-offer game is similar to that of the buy-now discount game. To emphasize the differences in the strategies of the seller in these two games, we describe the details of the exploding-offer game, but ignore the stage 3 of the game that is identical to the stage 3 of the buy-now discount game.

1. The seller chooses the price p of selling the object.
2. Given the value of u and the price p , the buyer decides whether to purchase the seller's object at price p or to search for an alternative option in period 2 by incurring a search cost s . The game ends if the buyer chooses to make a purchase at price p .
4. If the buyer chooses to return to the seller after search, the seller decides to make the item available to the buyer or not at price p . If the item is still available and $u \geq \delta v$, the transaction is *automatically* completed, and the seller and buyer get p and $u - p$, respectively. Otherwise, the seller and buyer get 0 and δv , respectively.

The major difference between the exploding-offer game and the buy-now-discount game lies in the flexibility of the seller in choosing the price of selling item when the buyer returns after search: in the buy-now discount game, she has full flexibility, while in the exploding offer game, she can only choose to sell the item at the initially announced price p or not. The difference generates very different equilibrium predictions in the two games.

⁴The equilibrium p_1 is not unique if we consider solution concepts weaker than sequential equilibrium.

Proposition 4. *For the game of exploding-offer with no commitment, the equilibrium outcome of the exploding-offer game with no commitment is as if the seller makes an open offer under the full commitment condition, which sets the uniform price p_O across periods for the buyer to purchase the item.*

Proof. Upon observing the return of the buyer, it is a dominant strategy for the seller to make the initial offer available, regardless of the initial price p , as making the item available for purchase always gives the seller positive payoff p , while refusing transaction gives the seller 0. In equilibrium, the buyer forms correct belief about the strategy of the seller upon observing a returning buyer, so will treat the offer of the seller as an open offer. Therefore, the equilibrium response of the seller in choosing p is to set $p = p_O$ to maximize her expected payoff. \square

The two propositions above demonstrate that removing the commitment power of the seller has heterogeneous impact on the two search deterrence tactics. For the buy-now discount tactic, the lack of commitment power makes the outcome equivalent to a more aggressive search deterrence tactic in equilibrium, while for the exploding-offer tactic, no power to commit to the future price essentially removes the ability of the seller to strategically deter search.

2.3 Search Deterrence with Cheap Talk

In the economics literature, a common approach of modeling an agent's lack of commitment power is to assume that the agent can freely act without following his/her promised actions that are announced earlier via (costless and non-contractible) cheap talk. In this subsection, we follow this prevailing approach to model the search deterrence tactics under the no-commitment condition.

We briefly describe the differences of the games from the no-commitment case when we allow the seller to make a cheap-talk announcement in the play. For the buy-now-discount tactic, the timing of the game with cheap talk is similar to that with no commitment, except that (1) at the first encounter with the buyer, the seller announces a price pair (p_1, p_2) for the transactions in period 1 and period 2, instead of a single price p_1 for the period-1 transaction; (2) upon observing a returning buyer, the seller is free to choose a new period-2 price, \tilde{p}_2 , different from the initially announced p_2 . For the exploding-offer tactic, the game with cheap talk differs from the one with no commitment in the following aspects: (1) at the initial encounter with the buyer, the seller announces the price of the item and the expiration date of the price; (2) if the buyer returns after search, the seller may revise the expiration condition of her initial offer.

One should note that the role of cheap talk is only to communicate the intended action of the seller in period 2. However, the seller has no power to commit to her claim; she can

freely adjust her action in period 2 to best serve her personal interests. For a rational buyer, he can foresee the *opportunistic* response of the seller to his return, thus may not trust the initial cheap-talk claim of the seller. In fact, as shown in the proposition below, the buyer will completely disregard the seller’s announcement about her intended action in period 2.

Proposition 5. *When the seller has no commitment power, her ability to make a cheap-talk announcement about her intended play in period 2 has no impact on the equilibrium outcome of a search-deterrence game. Specifically,*

1. *for the buy-now-discount tactic, the game with cheap talk has the same unique equilibrium outcome as the game with no commitment, which is as if the seller makes the optimal exploding offer under the full-commitment condition;*
2. *for the exploding-offer tactic, the game with cheap talk has the same unique equilibrium outcome as the game with no commitment, which is as if the seller makes the optimal open offer with full commitment.*

Proof. We first look at the buy-now-discount game with cheap talk. Suppose that in equilibrium the seller announces (p_1, p_2) in period 1 and chooses \tilde{p}_2 upon observing a returning buyer on the equilibrium path, and there are some types of the buyer that search and return to the seller with positive probabilities in period 2. Following the proof of Proposition 3, it is clear that the seller has an incentive to raise \tilde{p}_2 given that some buyers return, which contradicts the supposition. Thus, no buyers will return on the equilibrium path, and the equilibrium p_1 must be p_E that maximizes the expected payoff of the seller given that there is no buy-later demand. The equilibrium outcome is therefore independent of the announced p_2 .

In the exploding-offer game with cheap talk, the same as in the game with no commitment, it is a dominant strategy for the seller to make her offer available to a returning buyer. Thus, the buyer in equilibrium treat the offer of the seller as an open offer, regardless of her initially claimed expiration condition. The seller therefore optimally chooses $p = p_O$, which makes the equilibrium outcome the same as that of making the optimal open offer under the full-commitment condition. □

3 A Laboratory Experiment

It is hard to obtain empirical evidence on search deterrence since in practice it often occurs in private negotiations and involves private information. The laboratory provides us with an ideal environment to study this form of price discrimination. In Section 3.1, we introduce an experimental design that allows us to compare search deterrence tactics under various commitment conditions. Theoretical predictions and hypotheses under the experimental setting are provided in Section 3.2. Section 3.3 describes the experimental procedure and Section 3.4 discusses the results.

3.1 Experimental Design

The dynamic nature of the search deterrence problem makes the general setting described in Section 2 very challenging for subjects to solve. To capture the key insights of the theory without creating too much noise in our experimental data, we adopt the following discrete version of the model.

In each experimental market, a seller costlessly supplies a product to a buyer. The price, including the buy-now price p_1 and buy-later price p_2 in the buy-now discount game and the price p in the exploding offer game, can only be chosen from the set $\{10, 20, 30\}$. The buyer has either a high or low value for the product: u equals 20 with probability 0.25 or 40 with probability 0.75. If the buyer chooses to search for an outside option v , he receives 9 or 29 with equal probability.⁵ To further simplify the environment, we set $s = 0$ (zero fixed cost of search) and $\delta = 0$ (outside option becomes unavailable for a returning buyer). The high cost of return also serves as a stress test on the effectiveness of cheap talk, which is further explained in Section 3.4.

The experiment has a three-by-two treatment design (Table 1); varying the search deterrence tactics of *Exploding Offer* (EO) or *Buy-Now Discount* (BND) and the commitment conditions of *Full Commitment* (FC), *No Commitment* (NC), or *Cheap Talk* (CT). All treatments are implemented between-subject.

Table 1: Treatment Design

	Exploding Offer	Buy-Now Discount
Full Commitment	EO-FC	BND-FC
No Commitment	EO-NC	BND-NC
Cheap Talk	EO-CT	BND-CT

As previously described in Section 2, under *Full Commitment*, the seller is asked to announce the future availability (in treatment EO-FC) or price (in treatment BND-FC) in Period 1 and cannot renege on her claims; under *No Commitment*, the seller makes no announcement about the second-period availability or price; and under *Cheap Talk*, the seller announces the future price or availability but can later revise her decision in Period 2.⁶ Although the standard theory makes the same equilibrium prediction for *No Commitment* and *Cheap Talk*

⁵The difference $|40 - 29| = |20 - 9| = 11$ is chosen to avoid situations in which the buyer is indifferent between returning to the seller and keeping the outside option after search.

⁶One detail of our design is that in treatments BND-NC and BND-CT, if the second-period price is even higher than the value of a returning buyer, the sale does not occur and both players receive zero. This is only an off-equilibrium scenario; but we add this constraint so that the seller cannot simply choose the highest price possible to exploit a returning buyer.

conditions, the former provides us with a clean baseline to study the role of commitment power, while the latter allows us to observe strategic behaviors in a setting closer to many real-life scenarios.

We use the strategy method on both sides: a buyer is asked to respond to each possible offer a seller can make, before knowing the seller’s actual choice; in no commitment and cheap talk treatments, a seller is asked to choose her availability or second-period price supposing that the buyer has chosen to search and return under the initial offer.⁷ Such a design provides us with enough observations on buyer decisions under each possible offer, which are later used in Section 3.4.5 to analyze the profitability of offer types and the optimality of seller behaviors in the experiments.

3.2 Theoretical Prediction

3.2.1 Full Commitment

We first focus on the strategic environment where the seller is fully committed to her dynamic pricing scheme. The proposition below shows that in our experimental setting, the buy-now discount and exploding offer games have the same equilibrium outcome, in which the seller employs a search deterrence strategy to prevent a high-value buyer from seeking an alternative option. We use a price pair (p_1, p_2) to denote a seller strategy in BND-FC; in EO-FC, (p, EO) and (p, OP) refer to an exploding offer and an open offer with price p , respectively.

Hypothesis 1. *Treatments BND-FC and EO-FC have the same equilibrium outcome, in which the seller adopts search deterrence strategies. Specifically,*

- (1) *in the equilibrium of BND-FC, the seller offers the price pair $(p_1, p_2) = (20, 30)$;*
- (2) *in the equilibrium of EO-FC, the seller offers $(20, EO)$, that is, an exploding offer with price $p = 20$;*
a low-value buyer searches without return, while a high-value buyer purchases the seller’s product without search.

In general, the optimal buy-now discount, given its flexibility in choosing the buy-later price, often outperforms exploding offers. To capture the potential behavioral differences in subjects’ use and response to these two search deterrence tactics, we choose the current setting with theoretically equivalent equilibrium outcomes.

The seller’s sub-optimal strategies in these two games are also equivalent: $(30, 30)$ in BND-FC and $(30, OP)$ in EO-FC. They set a uniform price for purchasing the product across periods, which means search cannot be deterred.

⁷The restriction on the seller’s choice of prices greatly simplifies the strategy space, thus allowing us to use the strategy method without overwhelming subjects with decisions. The seller can choose from a total of 9 possible offers in treatments BND-FC and BND-CT, 6 possible offers in EO-FC and EO-CT, and 3 possible offers in BND-NC and EO-NC.

There are other search deterrence strategies that induce a high-value buyer to purchase immediately: $(10, 20)$ and $(10, 30)$ (or simply $(10, 20/30)$) in BND-FC, both equivalent to $(10, EO)$ in EO-FC.⁸ These strategies yield the same expected payoff for the seller as two equivalent non-search-detering offers: $(20, 20)$ in BND-FC and $(20, OP)$ in EO-FC. However, compared with optimal (search deterrence) strategy in these two games, these pricing schemes leave the high-value buyer too much surplus. Table 2 summarizes the strategic equivalence between EO-FC and BND-FC, which will be the focus of our subsequent analysis.⁹

Table 2: Equivalent Strategies in EO-FC and BND-FC

Treatment		High-Value	Seller's
EO-FC	BND-FC	Buyer	Expected Payoff
$(20, EO)$	$(20, 30)$	Buy Now	15
$(30, OP)$	$(30, 30)$	Search	11.25
$(10, EO)$	$(10, 20/30)$	Buy Now	7.5
$(20, OP)$	$(20, 20)$	Search	7.5

3.2.2 No Commitment and Cheap Talk

In the general model, we have shown that with a cost of return, removing the seller's commitment power has heterogeneous impacts on the tactics of buy-now discount and exploding offer. Moreover, whether or not to allow the seller to make a costless and non-contractible announcement, i.e., cheap talk, about her future action will not lead to different outcomes, because the buyer will disregard any claim of the seller in response. These theoretical predictions directly carry over to the simplified experimental setting.

Hypothesis 2. *Treatments BND-NC, BND-CT, and BND-FC have the same equilibrium outcome. Specifically, in equilibrium the seller chooses $p_1 = 20$ and sets $p_2 = 30$ following the history of $p_1 = 20$; a high-value buyer accepts p_1 without search, while a low-value buyer searches without return.*

Therefore, the lack of commitment power has no impact on the search deterring effect of a buy-now discount. However, we conclude the contrary for the tactic of exploding offer, due to the seller's limited flexibility in choosing the buy-later price.

⁸In the current setting, an exploding offer with $p = 30$ is not a search-deterrence strategy: even a high-value buyer will search under this offer as the price is too high.

⁹Here we exclude another pair of equivalent strategies, $(10, 10)$ in BND-FC and $(10, OP)$ in EO-FC, from our discussion on search deterrence because it leaves a high-value buyers indifferent between search and purchasing immediately.

Hypothesis 3. *In treatments EO-NC and EO-CT, the equilibrium outcome is the same as the outcome of an open offer with $p = 30$ in EO-FC. Specifically, on the equilibrium path, the seller chooses $p = 30$ and makes her offer available when the buyer chooses return after search; a high-value buyer always searches but returns if and only if he receives a low outside option, and a low-value buyer searches without return.*

As we discussed above in the general model, since it is a dominant action for the seller to make the item available when the buyer returns, any offer made by the seller is essentially an open offer. Thus, the equilibrium offer is the optimal open offer, which is the one with $p = 30$ in our setting. Naturally, compared with the exploding-offer game under full commitment, the seller is worse off in the game with no commitment or cheap talk.

3.3 Experimental Procedure

Each session of the experiment consists of two parts. The first part elicits risk attitudes using a variation of the lottery game from Holt and Laury (2002).¹⁰ The second part is the main experiment. Instructions are read aloud, followed by a quiz on the key components of the experimental setting. If a subject answers a question wrong, a hint shows up on the screen and the subject is asked to answer again. Subjects can also ask for help from the experimenters by raising their hands. The session does not proceed until every participant has answered all questions correctly.

At the beginning of the experiment, every participant is randomly assigned a role as a seller or a buyer, which stays the same throughout the entire experiment. Subjects are anonymously and randomly divided into different markets; each market consists of one seller and one buyer. The experiment consists of 22 rounds, with buyers and sellers randomly rematched at the beginning of every round. Full feedback is provided after each round, including both players' realized actions and payoffs of the round, the buyer's value, and the buyer's outside option if he has chosen to search. At the end of the experiment, three rounds are randomly chosen for payment.¹¹

The experiment was conducted in October 2018 at the Experimental Economics Laboratory at the University of Melbourne (E^2MU) and programmed using z-Tree (Fischbacher, 2007). There were 12 sessions with 22 to 30 subjects in each session. A total of 314 participants were recruited using ORSEE (Greiner, 2015). Each session lasted approximately 120

¹⁰Subjects are asked to make 20 choices between paired lotteries; each pair consists of a “safe” option and a “risky” option. Following Holt and Laury (2002), the total number of safe choices (ranging from 0 to 20) is used as an indicator of risk aversion. A majority of subjects chose the safe option when the probability of the higher payoff was small, and then crossed over to the risky option without ever going back to the safe option. 40 out of 314 subjects exhibited back-and-forth behavior.

¹¹We choose to pay three rounds instead of one because sellers are likely to end up with zero payoff in a round, which may lead to highly unfair earnings between the two roles.

minutes. Every 2 units of the experimental currency, named “points,” are equivalent to 1 AUD. The average payment, including a show-up fee of 10 AUD, was about 42.66 AUD.

3.4 Experimental Results

Below in Section 3.4.1, we first discuss the two search deterrence tactics under full commitment. Section 3.4.2 then examines the role of commitment power by comparing the full-commitment with the no-commitment condition. In Sections 3.4.3 and 3.4.4, we discuss sellers’ cheap talk strategies and buyers’ responses to them in the exploding offer and the buy-now discount game respectively. Lastly in Section 3.4.5, we ask whether buyers’ decision making in the lab is consistent with the theoretical prediction, and based on the experimental data on buyers, we conduct a best-response analysis on the behaviors of sellers.

3.4.1 Search Deterrence with Full Commitment

Recall that Hypothesis 1 predicts the same equilibrium outcome that involves search deterrence for the exploding offer and the buy-now discount game under full commitment. The seller’s equilibrium strategy is $(20, EO)$ in EO-FC and $(20, 30)$ in BND-FC. We collectively call these strategies “optimal” because they are the most profitable according to the theory as well as buyer subjects’ actual responses in the experiment (See Section 3.4.5).

The seller’s sub-optimal strategies in these two games are also equivalent: $(30, 30)$ in BND-FC and $(30, OP)$, in EO-FC; they cannot deter search due to the uniform pricing scheme. Thus, in our experimental setting with full commitment, search deterrence with exploding offers or with buy-now discounts is equally more profitable than uniform prices.

Result 1. (EO-FC vs BND-FC; Sellers) *Under full commitment, experienced sellers use exploding offers more optimally than buy-now discounts: compared to BND-FC, the optimal strategy of search deterrence is more frequently adopted by experienced sellers in EO-FC while the total proportion of search deterrence offers does not differ.*

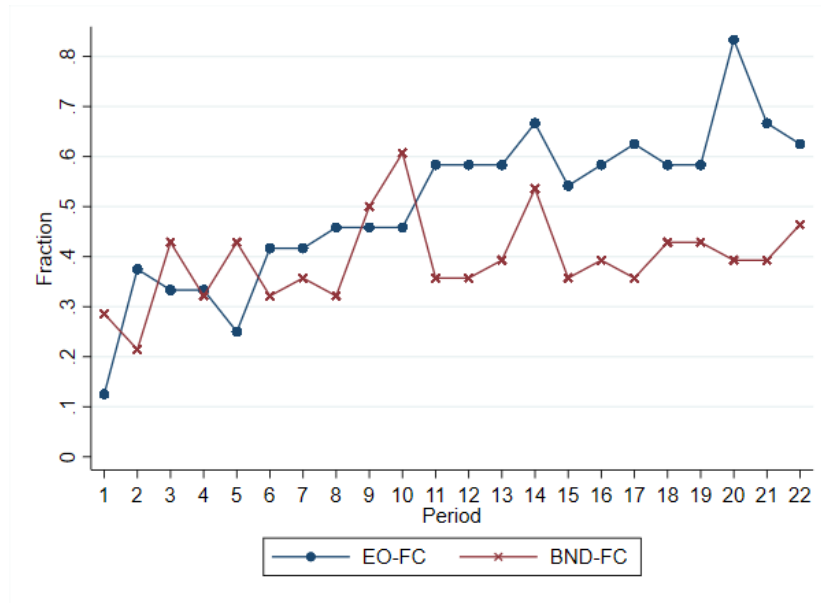


Figure 1: Optimal Strategy of Search Deterrence under Full Commitment

Figure 1 presents, in each round, the proportion of sellers who use the optimal strategy of search deterrence: $(20, EO)$ in EO-FC and $(20, 30)$ in BND-FC. We can see a much clearer upward trend in EO-FC than in BND-FC, leading to a separation of the two plots around round 11. We define *OptimalSD* as a dummy variable that equals 1 for an optimal search-detering offer in these two treatments and 0 otherwise. Table 3 displays the results from logit regressions of *OptimalSD* for (1) all rounds, (2) rounds 1-11, and (3) rounds 12-22, with the data clustered by subject. The dummy variable for treatment BND-FC is significant in regression (3) but not in (1) or (2), which means Result 1 is mainly driven by the difference in sellers' learning process when using the tactics of exploding offer and buy-now discount. According to the marginal effects displayed in Table 8, on average an experienced seller in BND-FC is 22.65% less likely to use search deterrence optimally than an experienced seller in EO-FC.

Table 3: Optimal Strategy of Search Deterrence under Full Commitment

Dep. Var.	<i>OptimalSD</i>		
	(1) All Rounds	(2) Rounds 1-11	(3) Rounds 12-22
<i>BND-FC</i>	-0.514 (0.399)	-0.086 (0.372)	-0.923** (0.469)
<i>Round</i>	0.053*** (0.012)	0.107*** (0.031)	0.025 (0.019)
<i>RiskAverse</i>	-0.068 (0.065)	-0.084 (0.064)	-0.054 (0.071)
Constant	0.367 (0.930)	0.047 (0.887)	0.841 (1.124)
Observations	1,144	572	572

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. In the regression, *BND-FC* is the dummy variable for the corresponding treatment; *Round* is the round number in the experiment, ranging from 1 to 22; *RiskAverse* is the total number of safe choices made by a subject during risk attitude elicitation.

Importantly, the above result is not driven by sellers' overall tendency to deter search. In terms of other search deterrence strategies, we observe more (10, 20/30) offers in BND-FC than (10, *EO*) in EO-FC ($p = 0.023$), while all three are theoretically equivalent.¹² Consequently, the total fraction of search deterrence offers do not significantly differ between these two treatments. The key difference is that exploding offers are implemented in a more optimal way than buy-now discounts.

Next, we examine how buyers make search decisions in response to different sales tactics. For ease of comparison, we mainly discuss the following two pairs of equivalent strategies: (1) the optimal search-detering offers: (20, *EO*) in EO-FC and (20, 30) in BND-FC; and (2) the suboptimal uniform-price offers: (30, *OP*) in EO-FC and (30, 30) in BND-FC. The result does not change if we also include the following equivalent strategies: (1) (10, *EO*) in EO-FC and (10, 20/30) in BND-FC as search-detering offers; and (2) (20, *OP*) in EO-FC and (20, 20) in BND-FC as uniform-price offers. Also, we focus on high-value buyers since in the current setting, a low-value buyer should always search regardless of the offer he receives.

Result 2. (EO-FC vs BND-FC; Buyers) *Under full commitment, the tactics of exploding*

¹²Unless otherwise specified, the p -values in Section 3.4 are obtained from logit regressions that control for round and risk attitude, with the data clustered by subject.

offer and buy-now discount have different search deterring effects: buyers in EO-FC are more responsive to search deterrence than those in BND-FC.

Table 4: Effects of Search Deterrence in EO-FC and BND-FC

Dep. Var.	<i>Search</i>		
	Coef.	Robust Std. Err.	Marginal Effect
<i>SD</i>	-6.548***	(0.778)	-0.886
<i>BND-FC</i>	-2.907***	(0.829)	-0.500
<i>SD</i> × <i>BND-FC</i>	3.647***	(0.896)	0.448
<i>Round</i>	0.042***	(0.015)	0.008
<i>RiskAverse</i>	-0.019	(0.058)	-0.004
Constant	4.706***	(1.099)	
Observations	1,740		

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. In the regression, *SD* is a dummy variable that equals 1 for an optimal search-detering and 0 for a sub-optimal uniform-price offer; *SD* × *BND-FC* is the interaction term between *SD* and *BND-FC*.

We define *Search* as a dummy variable that equals 1 if a high-value buyer chooses to search and 0 if he chooses to buy now, and run a logit regression of *Search* with the data clustered by subject. The regression and corresponding marginal effects are displayed in Table 4. According to the results, an optimal search-detering offer leads to less search than a sub-optimal uniform-price offer in both EO-FC and BND-FC. However, the search-detering effect of buy-now discounts are significantly smaller in magnitude. Specifically, relative to uniform pricing, on average an exploding offer decreases search by 88.6% while a buy-now discount decreases by only 43.8%.

Result 3. (EO-FC vs BND-FC; Payoffs) *There is no significant difference in the payoffs of sellers or buyers between EO-FC and BND-FC.*

Importantly, Figure 2a and the coefficient for *BND-FC* in the regression suggest that Result 2 is not only driven by less search under an exploding offer than under a buy-now discount, but also driven by more search under uniform pricing in EO-FC than in BND-FC. Hence, no significant difference in the payoffs of sellers ($p = 0.557$) or buyers ($p = 0.630$) is observed between two treatments.

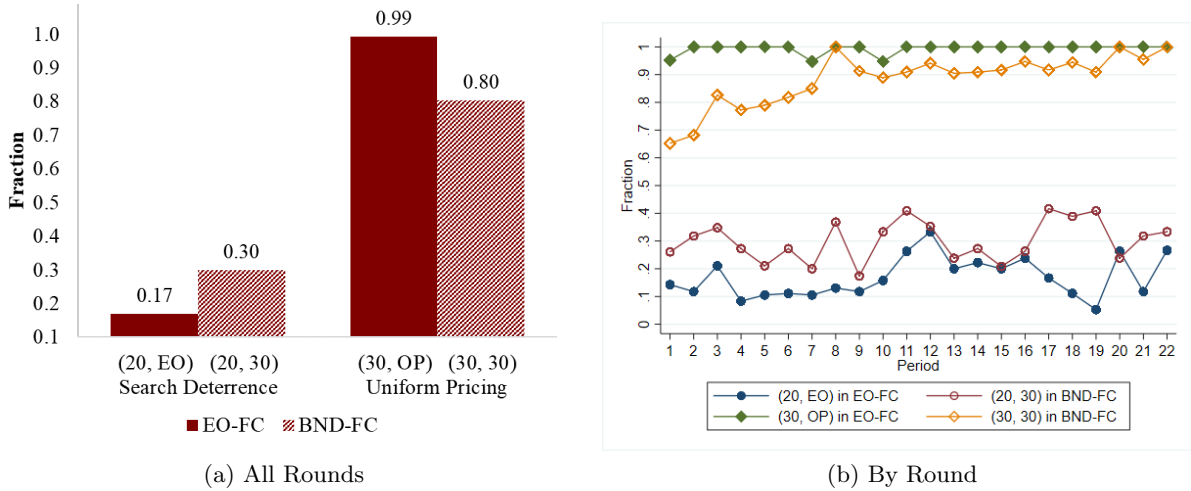


Figure 2: Search by High-Value Buyers in EO-FC and BND-FC

One plausible explanation is that compared to the exploding offer game, buyer subjects find the buy-now discount game with two adjustable prices more complicated, thus less likely to identify a buy-now discount as a search deterrence tactic. As shown in Figure 2b, there is a clear learning process in the first 8 rounds for those who receive (30, 30) in BND-FC. Recall in Result 1, seller subjects also exhibit a better understanding of exploding offers than of buy-now discounts through more optimal decision-making, which is consistent with our interpretation of Results 2 and 3.

The above explanation is also supported by the behaviors of low-value buyers: 11.84% of them choose to buy immediately under (20, 20) in BND-FC, as opposed to 0% under (20, OP) in EO-FC. This extreme behavior, leading to zero payoff, cannot be easily justified with factors other than limited cognitive ability, such as social preferences or risk attitudes.

3.4.2 Effects of Commitment

To cleanly identify the effects of commitment power, in this section we analyze the other baseline where the seller makes no announcement about the second-period availability or price. According to Hypotheses 2, the lack of commitment power in BND-NC does not affect search deterrence, since any offer should be considered as a buy-now discount with the same first-period price. On the other hand, Hypotheses 3 predicts the opposite for EO-NC: search can no longer be deterred since any offer should be considered as an open offer with the same price.

Result 4. (BND-FC vs BND-NC)

1. The removal of commitment power has no significant effect on sellers' use of buy-now discounts.
2. Buyers respond similarly to an offer in BND-NC and a buy-now discount in BND-FC with the same first-period price.
3. The removal of commitment power in the buy-now discount game does not significantly affect payoffs.

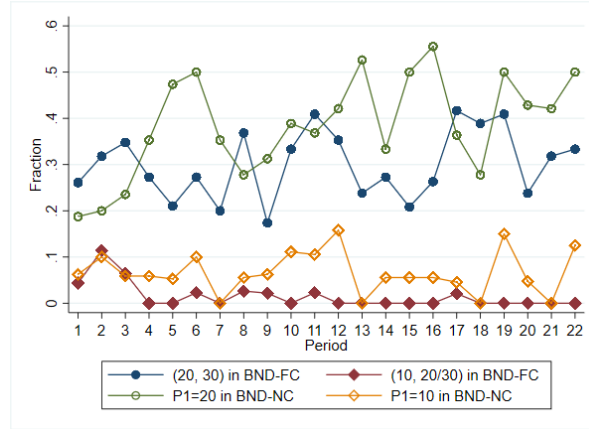


Figure 3: Search by High-Value Buyers in BND-FC and BND-NC

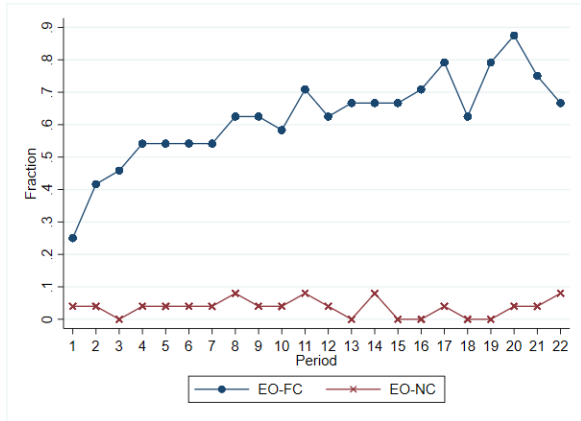
The experimental evidence on sellers is consistent with the theoretical prediction: compared to BND-FC, the lack of commitment power in BND-NC does not significantly change the proportion of buy-now discounts, either for (20, 30) ($p = 0.556$) or for (10, 20/30) ($p = 0.303$). Figure 3 summarizes a high-value buyer's likelihood of search in BND-NC and BND-FC. Generally speaking, we observe similar responses to an offer in BND-NC and a buy-now discount in BND-FC with the same first-period price: although $p_1 = 10$ in BND-NC leads to more search than (10, 20/30) in BND-FC, the magnitude is only 4.23%; search likelihood is not significantly different for $p_1 = 20$ in BND-NC and (20, 30) in BND-FC (Table 9). Moreover, offers in BND-NC leads to less search than uniform prices in BND-FC ($p < 0.001$). Lastly, the removal of commitment power in the buy-now discount game does not significantly affect the payoffs of sellers or buyers. This is not surprising given the little effects on their strategic behaviors.

Result 5. (EO-FC vs EO-NC)

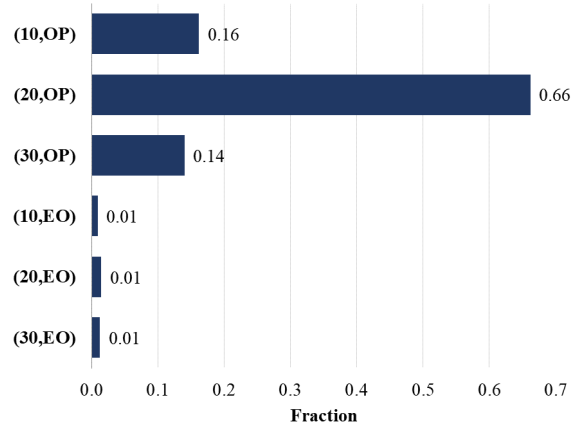
1. The removal of commitment power significantly decreases the proportion of exploding offers.

2. An offer in EO-NC leads to less search than an open offer in EO-FC with the same price.
3. The removal of commitment power in the exploding offer game does not significantly affect payoffs due to increased cooperation between sellers and buyers in EO-NC.

Consistent with the theoretical prediction, we observe a sharp decrease in the proportion of exploding offers with the removal of commitment power ($p < 0.001$). Only 3.64% of sellers in EO-NC choose to let their offers expire for returning buyers in Period 2, as opposed to 62.12% in EO-FC (Figure 4a).



(a) Exploding Offers in EO-FC and EO-NC



(b) Seller Strategies in EO-NC

Figure 4: Offers in EO-FC and EO-NC

In terms of buyers, we confirm that the removal of sellers' commitment power significantly decreases their ability to deter search, since high-value buyers in EO-NC search significantly more than those under search-detering offers in EO-FC ($p < 0.001$). However, as shown in Figure 5, the equivalence between an offer in EO-NC and an open offer in EO-FC with the same price is not fully supported by experimental data. Offers under no commitment tend to result in less search than the corresponding open offers under full commitment. Such an effect holds for both $p = 30$ and $p = 20$ but is much larger in magnitude for $p = 20$. By logit regressions (Table 10), on average the search likelihood for high-value buyers receiving $p = 30$ in EO-NC is 6.13% smaller than those receiving $(30, OP)$ in EO-FC; while the difference is 36.84% between $p = 20$ offers in EO-NC and $(20, OP)$ in EO-FC.

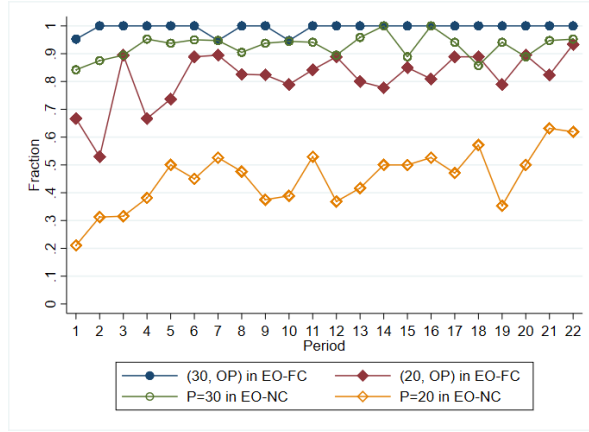


Figure 5: Search by High-Value Buyers in EO-FC and EO-NC

Our interpretation of Result 3.2 has two different aspects: uncertainty and social preferences. First, compared to full commitment, the environment of no commitment involves more uncertainty. Although a seller in EO-NC should never let an offer explode in Period 2, a buyer may still assign a positive probability to such an event, as opposed to zero probability for an open offer in EO-FC. Therefore, a buyer with a very pessimistic belief about the seller’s rationality may choose the safe option of buying immediately, and the incentive to do so is stronger for $p = 20$ since it secures higher surplus for the buyer than $p = 30$.

Secondly, an early transaction at $p = 20$ means an equal payoff of 20 for a seller and a high-value buyer. Such an outcome may be attractive for buyers with fairness concerns. Similarly, we also identify significant cooperative behaviors on sellers. Since sellers rarely make exploding offers in EO-NC, the standard model predicts that $p = 20$ is the least profitable choice of price while $p = 30$ is the optimal. In contrast, Figure 4b shows that $p = 20$ is chosen by as high as 68% of sellers. As we will later discuss in Section 3.4.5, these sellers are in fact best responding to buyers’ cooperative behaviors in the experiment.

Such a significant increase in cooperation, as a result of removing the possibility of credible search deterrence, leads to a surprising finding on welfare. According to the theoretical prediction for the exploding offer game, a seller without commitment power should receive a lower payoff since search can no longer be deterred. However, we observe no significant effect on the payoffs of sellers or buyers.

Overall, the predicted effects of commitment are mostly confirmed by our experimental results: the removal of sellers’ power to commit has a detrimental effect on search deterrence in the exploding offer setting, but has little effect in the buy-now discount environment. Interestingly, although cooperation between the seller and buyer is feasible regardless of the commitment condition, it is substantially facilitated by the fact that exploding offers can no

longer be used for credible search deterrence under no commitment.

3.4.3 Cheap Talk and Exploding Offers

Although the standard theory makes the same equilibrium prediction for *No Commitment* and *Cheap Talk* conditions, behaviorally the seller’s ability to make costless and non-contractible claims can make substantial differences, which has important implications for many real-world scenarios. In the following two sections, we discuss the effects of cheap talk on exploding offers and buy-now discounts respectively. In treatment EO-CT, the seller chooses a price and announces the future availability of this offer in Period 1; then she is given the opportunity to revise whether the offer indeed expires in Period 2. We use a “claimed” offer to refer to a offer made by the seller as cheap talk, which is not necessarily the same as his revised and final decision.

Result 6. (EO-CT; Sellers) *In EO-CT, a majority of sellers use cheap talk of exploding offers to deter search but later revise to open offers, while a significant proportion of sellers truthfully claim open offers.*

Table 5: Cheap Talk and Revised Offers in EO-CT

Claimed Offer	Revised Offer		Total
	EO	OP	
(10, EO)	4.22%	9.25%	13.47%
(20, EO)	3.73%	38.64%	42.37%
(30, EO)	0.97%	6.33%	7.31%
(10, OP)	0.32%	5.03%	5.36%
(20, OP)	1.30%	19.32%	20.62%
(30, OP)	1.14%	9.74%	10.88%
<i>Total</i>	<i>11.69%</i>	<i>88.31%</i>	<i>100.00%</i>

Table 5 summarizes sellers’ strategies in EO-CT. Overall, 54.22% of sellers claim exploding offers in Period 1 but then choose to remain available in Period 2. After eliminating the 6.33% of sellers who claim (30, EO), which is not a search-detering strategy, we can conclude that about 47.89% of sellers use cheap talk to deter search. Among these sellers, 38.64% claim (20, EO) offers, which is also the most frequently played strategy. A notable proportion of sellers, on the other hand, choose to truthfully claim open offers. No significant trend with experience is observed in sellers’ cheap talk strategy.

Next, we discuss buyers’ responses to cheap talk. We pool together claimed exploding offers that can deter search under full commitment and compare them with claimed open offers.¹³ We also analyze the role of commitment power in search deterrence by comparing treatments EO-FC and EO-CT.

Result 7. (EO-FC vs EO-CT; Buyers) *For the tactic of exploding offer,*

1. *cheap talk affects search: claimed exploding offers lead to less search on average than claimed open offers in EO-CT;*
2. *commitment power affects search: credible exploding offers in EO-FC can more effectively deter search than claimed exploding offers in EO-CT.*

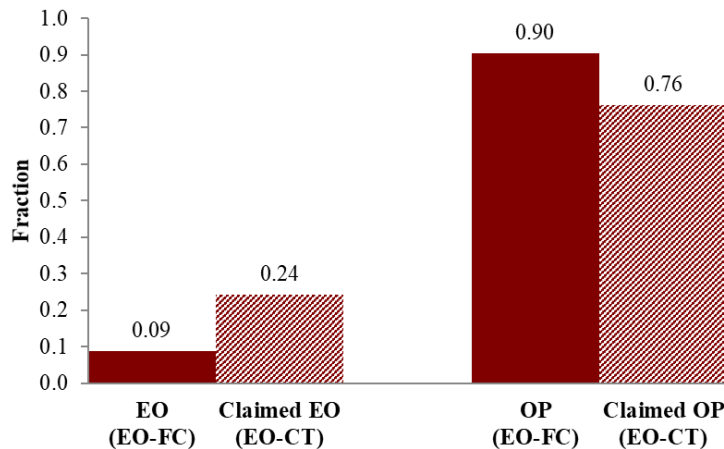


Figure 6: Search by High-Value Buyers in EO-FC and EO-CT

Figure 6 summarizes the search decisions of high-value buyers under different offer types in EO-FC and EO-CT. It is evident that search deterrence is effective even in cheap talk. According to the regression results (Table 11), relative to a claimed open offer, a claimed exploding offer in EO-CT decreases search by 52.36% on average. Evidence of learning is observed on buyers: the proportion of search under claimed exploding offers increases with experience ($p = 0.047$).

¹³There is a slight abuse of terminology here because (30, EO) is excluded from “exploding offers” since it does not deter search, while (10, OP) is excluded from “open offers” since it leads to indifference between search and immediate purchase. Our main results do not change if we only focus on claimed (20, EO) and (30, OP) offers.

On the other hand, more search is observed under claimed exploding offers in EO-CT than under credible exploding offers in EO-FC ($p < 0.001$). High-type buyers who receive search deterrence in cheap talk is 10.33% more likely to search than those who receive search deterrence with full commitment (Table 12). We also observe less search under claimed open offers in EO-CT than credible open offers in EO-FC ($p < 0.001$). Similar to Results 3.2 and 4.2, such an effect could be attributed to more uncertainty involved in the cheap talk condition.

Result 8. (EO-FC vs EO-CT; Payoffs) *There is no significant difference in the payoffs of sellers or buyers between EO-FC and EO-CT.*

Theoretically speaking, sellers in EO-CT should receive a lower payoff than those in EO-FC, since they can no longer adopt credible search deterrence. However, we find no difference in the payoffs of sellers ($p = 0.331$) or buyers ($p = 0.619$) between these two treatments. Such a result can be explained by buyers' search behaviors, which, contrary to the theoretical prediction, are affected by sellers' cheap talk. Although on average an exploding offer in cheap talk still result in more search than that under full commitment, an open offer in cheap talk leads to less search than that under full commitment. Overall, there is no significant difference in subjects' payoffs between two conditions.

3.4.4 Effects of Cheap Talk on Buy-Now Discounts

We now investigate the effects of cheap talk on buy-now discounts. Similar to the previous section, since a seller in treatment BND-CT first announces a buy-later price and is then given the opportunity to revise his decision in Period 2, the "claimed" offer, meaning the offer made by the seller as cheap talk, is not necessarily the same as his revised and final decision on the buy-later price.

An distinguishing feature of the buy-now discount environment is that without the power to commit, a seller can exploit a returning buyer due to the flexibility in choosing the second-period price. In this case, not only can a seller benefit from search deterrence like in the exploding offer setting, but she may also profit by inducing return. Since the cheap talk that induces return also tend to encourage search, the seller faces a trade-off when choosing her cheap talk strategy. Such a complication can explain the heterogenous strategic choices by sellers in BND-CT (Table 6).

Result 9. (BND-CT; Sellers) *In BND-CT, a majority of sellers use cheap talk of buy-later discounts or uniform prices to induce return and later increase the second-period prices, while a significant proportion of sellers truthfully claim buy-now discounts or uniform prices.*

Table 6: Cheap Talk and Revised Offers in BND-CT

Claimed Offer	Revised Buy-Later Price			Total
	Decreased	Unchanged	Increased	
<i>Buy-Now Discount</i>	11.04%	16.88%	0.97%	<i>28.90%</i>
<i>Uniform Price</i>	3.25%	16.72%	12.82%	<i>32.79%</i>
<i>Buy-Later Discount</i>	0.65%	8.12%	29.55%	<i>38.31%</i>
<i>Total</i>	<i>14.94%</i>	<i>41.72%</i>	<i>43.34%</i>	<i>100.00%</i>

A claimed buy-later discount, combined with a higher revised second-period price, is the most frequently played strategy. Among sellers who choose such a strategy, 87.26% claim (20, 10) and then revise to (20, 30) or (20, 20) in Period 2. The announcement of a low second-period price is intended to attract return, and a higher revised price is used to exploit a returning buyer who naively believes cheap talk. A similar strategy of inducing return with cheap talk of uniform prices is chosen by 12.82% of sellers, among whom about 80% claim (20, 20) and then revise to (20, 30). We also observe a significant proportion of honest sellers: 16.88% truthfully claim buy-now discounts and 16.72% truthfully claim uniform prices.

To analyze the effects of cheap talk, we summarize in Figure 7 the search decisions of high-type buyers and the return decisions of all buyers under different offer types in BND-CT and BND-FC. BND, UP, and BLD in the figure respectively refer to buy-now discount, uniform price, and buy-later discount.¹⁴

Result 10. (BND-FC vs BND-CT; Buyers) *For the tactic of buy-now discount,*

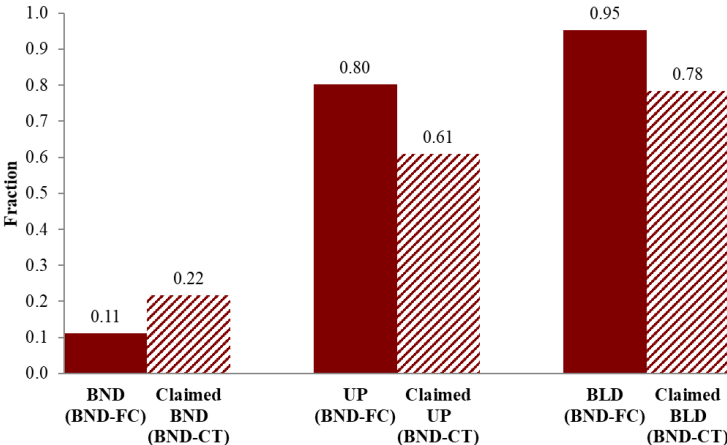
- cheap talk affects search and return: claimed buy-later discounts lead to more search and more return (conditional on search) than claimed buy-now discounts or uniform prices in BND-CT;*
- commitment power affects search and return: credible buy-later discounts in BND-FC are more effective than claimed buy-later discounts in BND-CT in increasing search and inducing return.*

From Figure 7a, we can see that sellers' cheap talk has significant impacts on high-value buyers' search decisions, especially the search-encouraging effect of claimed buy-later discounts in BND-CT ($p < 0.001$). According to the regression results (Table 13), on average a claimed

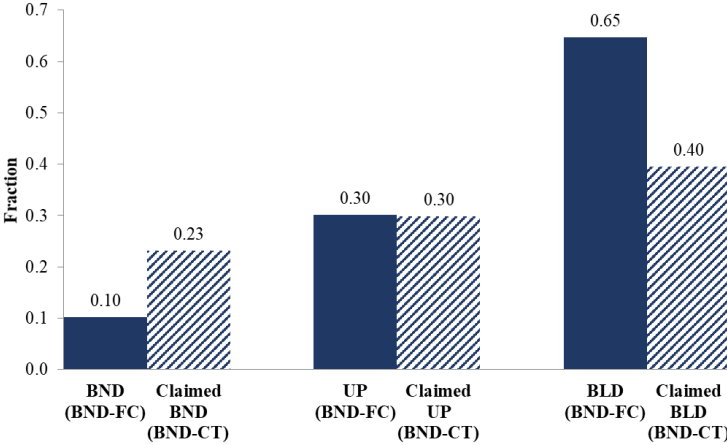
¹⁴There is a slight abuse of terminology because (10, 10) is excluded from "uniform prices" since it leads to indifference between search and immediate purchase.

buy-later discount increases the search of high-value buyers by 56.99% relative to a claimed search-detering offer, and increases by 17.50% relative to a claimed uniform-price offer.

Since the intention of a claimed buy-later discount is mainly to induce return, next we examine buyers' return decisions under cheap talk and full commitment. According to the standard theory, a buyer in BND-CT can predict that the seller would always set the price to 30 in the second period, thus not affected by the claimed buy-later price when making return decisions. However, as shown in Figure 7b, the proportion of return in BND-CT clearly depends on sellers' cheap talk. By a logit regression controlling for a buyer's value and outside option (Table 14), on average a claimed buy-later discount induces 14.50% more return than a search-detering offer, and 12.32% more than a uniform-price offer. We also find evidence of learning on buyers: the proportion of return under claimed buy-later discounts decreases with experience ($p = 0.013$).



(a) Search (High-Value Buyers)



(b) Return (All Buyers)

Figure 7: Search and Return in BND-FC and BND-CT

The fact that cheap talk can effectively induce return is especially surprising given the our choice of a high return cost: since the buyer has to completely give up his outside option in order to return, it can be rather costly for him to believe the seller’s cheap talk. Such a setting is a stress test for the effectiveness of cheap talk since in many real-life scenarios, a returning buyer may lose his outside option with only a small probability.

Lastly, the seller’s power to commit also plays a role: claimed buy-later discounts in BND-CT lead to less search and less return than credible buy-later discounts in BND-FC ($p < 0.001$). From the logit regressions in Table 15, we can calculate the marginal effect of cheap talk is a decrease of 12.54% on search and a decrease of 33.64% on return. Similarly, uniform-price offers in cheap talk result in less search than those under full commitment ($p = 0.005$; Table 16). We also observe more search under claimed search-detering offers in BND-CT than under credible search deterrence in BND-FC ($p = 0.013$), which could be attributed to more uncertainty involved in the cheap talk condition.

Table 7: Effects of Claimed Buy-Later Discounts on Return in BND-CT

Dep. Var.	<i>Return</i>			
	(1)		(2)	
<i>Claimedp₂</i>	-0.052***	(0.018)	-0.058***	(0.020)
<i>BND-FC</i>			3.705***	(0.715)
<i>Claimedp₂ × BND-FC</i>			-0.157***	(0.030)
<i>Value</i>	0.125***	(0.024)	0.144***	(0.020)
<i>OutsideOption</i>	-0.137***	(0.029)	-0.150***	(0.023)
<i>Round</i>	-0.035**	(0.014)	-0.017	(0.011)
<i>RiskAverse</i>	0.021	(0.029)	0.014	(0.021)
Constant	-1.472*	(0.850)	-1.965***	(0.721)
Observations	3,042		2,378	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. In the regression, *Claimedp₂* is the announced second-period price; *Claimedp₂ × BND-FC* is the interaction term between *Claimedp₂* and *BND-FC*.

While we have been focusing on offer types in our discussion, a buyer’s return decision is more directly related to the claimed second-period price since the first-period price is no longer relevant once search is chosen. The logit regressions in Table 7 confirm that (1) when a

seller announces a lower buy-later price, even via cheap talk, a buyer is more likely to return after search; (2) such an effect is stronger for credible claims in BND-FC compared to cheap talk in BND-CT; (3) evidence of learning is observed since return in BND-CT decreases in later rounds.

Result 11. (BND-FC vs BND-CT; Payoffs) *Buyer payoffs in BND-CT are lower than BND-FC on average.*

Cheap talk in BND-CT has impacts on payoffs. According to the regressions in Table 17, on average buyers under cheap talk receive a lower payoff than those under full commitment and the marginal effect of the cheap talk treatment is -1.368. Cheap talk also has a positive effect of 1.096 on seller payoff. However, the effect is not significant due to a higher variance in sellers' payoffs.

As we can clearly see from Results 6-11, subjects exhibit very different behavioral patterns in the cheap talk games of exploding offer and buy-now discount. However, the standard theory is silent about cheap talk strategies because a rational buyer always ignores a seller's cheap talk, and thus any cheap talk strategy can be justified in equilibrium. To better understand this rather realistic commitment setting, in Section 4 we introduce a behavioral model that includes a type of buyers who *naively* believe that the seller will fully commit to her cheap talk claims.

3.4.5 Profitability of Market Tactics and Sellers' Best Response

The strategy method produces relatively rich data on buyers' responses to each possible offer, which allows us to ask the following questions. What is the most profitable marketing tactic in each treatment according to buyers' actual responses in the lab? Are they consistent with the theoretical predictions? Are sellers in the experiment best responding to buyers' behaviors?

Result 12. (Best Response)

1. *The experimentally most profitable strategy is consistent with the theoretical prediction in EO-FC, BND-FC, BND-NC, and BND-CT, but inconsistent in EO-NC and EO-CT.*
2. *In every treatment, the majority of sellers best respond to buyers by choosing the experimentally most profitable strategy.*

For each possible offer in a treatment, we calculate a seller's expected payoff based on buyers' actual responses in the experiment, and then compare it to the theoretically-predicted expected payoff. Those, together with the distribution of seller strategies in each treatment, are summarized in Figure 8. The results confirm that the experimentally most profitable strategy is consistent with the standard theory in treatments EO-FC, BND-FC, BND-NC,

and BND-CT. However, such consistency is not present in EO-NC and EO-CT, which can be attributed to the increase in cooperation in EO-NC (Result 5.3) and the search-detering effect of cheap talk in EO-CT (Result 7.1).

As also shown in Figure 8, the majority of sellers successfully choose the experimentally most profitable strategy in every treatment. Such a conclusion suggests that most sellers in our experiment take buyers' irrational behaviors into consideration when choosing their strategies, thus maximizing their experimental expected payoff even when it does not coincide with the theoretical prediction.

4 Search Deterrence with Naive Buyer

In the standard model in Section 2, given that the buyer is fully rational, allowing the seller to make a cheap-talk promise about her future actions will not alter the equilibrium outcomes under the no-commitment condition, as the buyer completely disregards her promise. However, evidences in our experimental outcomes (Results 7 and 10) and the experimental literature on cheap talk show that some listeners *naively* believe what the speakers communicate via cheap talk. The presence of naive buyers in our setting allows the cheap-talk communication to make a big difference. In this section, we modify the standard model by assuming that (1) the buyer is of *naive* type, who naively trusts whatever the seller says, with probability $\beta \in (0, 1]$, while with probability $1 - \beta$, the buyer is fully rational as before, and (2) it is common knowledge among the seller and the rational buyers that there is β fraction naive buyers in the game. We use this behavioral model to explain the experimental outcomes (Results 6 and 9) in the games with cheap talk.

To elucidate how the seller exploits the naivety of the buyer differently under the two search deterrence tactics, we first consider the case where $\beta = 1$, i.e., the buyer is of the naive type for sure. Encountering a naive buyer, who believes that the seller has full commitment power, does not necessarily induce the seller to choose the optimal pricing scheme under the full commitment condition, especially under the buy-now-discount tactic. The basic intuitions carry over to the cases where β is close to 1.

Consider the buy-now-discount game. Suppose that the seller announces a price pair (p_1, p_2) in period 1. Believing that the seller will commit to her claimed pricing scheme, the naive buyer behaves as if in the full-commitment game with prices (p_1, p_2) . That is, he chooses to buy in period 1 if $u \geq \hat{u}^n(p_1, p_2)$, where $\hat{u}^n(p_1, p_2)$ is the minimum type of the buyer that does not search and satisfies

$$(p_2 - p_1) + s = S(\hat{u}^n(p_1, p_2) - p_2).$$

The buy-now demand for the seller's item under (p_1, p_2) is thus

$$x_1^n(p_1, p_2) = 1 - F(\hat{u}^n(p_1, p_2)),$$

which is the same as the buy-now demand function $x_1(p_1, p_2)$ under the full-commitment condition. The naive buyer chooses to search when $u < \hat{u}^n(p_1, p_2)$ and then returns to the seller if

$$u - p_2 \geq v. \quad (13)$$

Note that different from the full-commitment case, the fraction of returning buyers is *not* equivalent to the buy-later demand for the seller's item in period 2, because whether a returning buyer finally purchases the seller's item or not depends on the new buy-later price chosen by the seller. Let \tilde{p}_2 denote the new buy-later price set by the seller upon observing a returning buyer. A returning buyer purchases the seller's item if

$$u - \tilde{p}_2 \geq \delta v, \quad (14)$$

the RHS of which is the expected payoff of the returning buyer from revisiting his outside option. From a quick comparison between (13) and (14), one could realize that in equilibrium there should be

$$\tilde{p}_2 \geq p_2 + (1 - \delta)\underline{v}, \quad (15)$$

namely \tilde{p}_2 should be higher than the announced buy-later price p_2 by at least $(1 - \delta)\underline{v}$. This is because once the buyer chooses to return, his outside option $v \geq \underline{v}$ will depreciate by $(1 - \delta)v$. The seller can exploit the depreciation of the buyer's outside by increasing the buy-later price by at least $(1 - \delta)\underline{v}$. If (15) holds with strict inequality, some returning buyers will not transact with the seller. Let $\tilde{x}_2(p_1, p_2, \tilde{p}_2)$ denote the actual buy-later demand under the announced prices (p_1, p_2) and the altered buy-later price \tilde{p}_2 . According to the analysis above, we have

$$\begin{aligned} \tilde{x}_2^n(p_1, p_2, \tilde{p}_2) &= \int_{\underline{u}}^{\hat{u}^n(p_1, p_2)} G(\min\{u - p_2, \frac{u - \tilde{p}_2}{\delta}\}) f(u) du \\ &= \int_{\underline{u}}^{\tilde{u}^n(p_2, \tilde{p}_2)} G(\frac{u - \tilde{p}_2}{\delta}) f(u) du + \int_{\tilde{u}^n(p_2, \tilde{p}_2)}^{\hat{u}^n(p_1, p_2)} G(u - p_2) f(u) du, \end{aligned} \quad (16)$$

in which the cutoff value $\tilde{u}^n(p_2, \tilde{p}_2)$ defined as

$$\tilde{u}^n(p_2, \tilde{p}_2) = \max\{u \leq \hat{u}^n(p_1, p_2) : u - p_2 \geq \frac{u - \tilde{p}_2}{\delta}\}.$$

The expected payoff of the seller under the pricing scheme (p_1, p_2, \tilde{p}_2) is

$$\pi_B^n(p_1, p_2, \tilde{p}_2) = p_1 x_1^n(p_1, p_2) + \tilde{p}_2 \tilde{x}_2^n(p_1, p_2, \tilde{p}_2).$$

It is clear that if $\tilde{p}_2 = p_2 + (1 - \delta)\underline{v}$, then $\tilde{x}_2^n(p_1, p_2, \tilde{p}_2)$ is equal to the buy-later demand $x_2(p_1, p_2)$ in the full-commitment case. This implies that the optimal $\pi_B^n(p_1, p_2, \tilde{p}_2)$ in the cheap-talk game is strictly higher than that in the game with full commitment.

Proposition 6. *Under the buy-now-discount tactic, given Assumptions 1 and 2, if the seller can communicate with the buyer about her dynamic pricing scheme via cheap talk, and the buyer naively believes the seller's claim and responds optimally, then announcing a price pair (p_1, p_2) with $p_1 > p_{B1}$ and $p_2 < p_{B2}$ can be more profitable than sticking to the optimal prices (p_{B1}, p_{B2}) under the full commitment condition.*

Proof. Evaluating the first order derivatives of $\pi_B^n(p_1, p_2, \tilde{p}_2)$ with respect to p_1 and p_2 at $\tilde{p}_2 = p_2 + (1 - \delta)\underline{v}$ and $(p_1, p_2) = (p_{B1}, p_{B2})$, we obtain

$$\begin{aligned}\frac{d\pi_B^n(p_1, p_2, \tilde{p}_2)}{dp_1} &= \frac{d\pi_B(p_1, p_2)}{dp_1} + (1 - \delta)\underline{v} \cdot \frac{dx_2}{dp_1}, \\ \frac{d\pi_B^n(p_1, p_2, \tilde{p}_2)}{dp_2} &= \frac{d\pi_B(p_1, p_2)}{dp_2} + (1 - \delta)\underline{v} \cdot \frac{dx_2}{dp_2},\end{aligned}$$

given that $\tilde{x}_2^n(p_1, p_2, \tilde{p}_2) = x_2(p_1, p_2)$ under $\tilde{p}_2 = p_2 + (1 - \delta)\underline{v}$, where $d\pi_B(p_1, p_2)/dp_1$ and $d\pi_B(p_1, p_2)/dp_2$ are the first order derivatives of $\pi_B(p_1, p_2)$ in Proposition 1, thus are equal to 0. In the case of $x_2(p_{B1}, p_{B2}) > 0$, we have $dx_2/dp_1 > 0$ and $dx_2/dp_2 < 0$, thus choosing $p_1 > p_{B1}$ and $p_2 < p_{B2}$ are more profitable to the seller than (p_{B1}, p_{B2}) . In the case of $x_2(p_{B1}, p_{B2}) = 0$, both $d\pi_B^n(p_1, p_2, \tilde{p}_2)/dp_1$ and $d\pi_B^n(p_1, p_2, \tilde{p}_2)/dp_2$ are equal to 0. However, when $(1 - \delta)\underline{v}$ is sufficiently large, which means that the seller has a relatively large gain from exploiting returning buyers, we can have $d\pi_B^n(p_1, p_2, \tilde{p}_2)/dp_1 > 0$ and $d\pi_B^n(p_1, p_2, \tilde{p}_2)/dp_2 < 0$ in the left neighborhood of $(p_1, p_2) = (p_{B1}, p_{B2})$, given that $dx_2/dp_1 > 0$ and $dx_2/dp_2 < 0$ in the left neighborhood of $(p_1, p_2) = (p_{B1}, p_{B2})$. In this case, choosing $p_1 > p_{B1}$ and $p_2 < p_{B2}$ are more profitable to the seller than (p_{B1}, p_{B2}) .¹⁵ \square

The intuition behind this result is simple. Since the buyer naively believes the claim of the seller in period 1, the seller may have an incentive to announce a lower p_2 , and then increases the buy-later price to \tilde{p}_2 to take advantage of the decreased outside option of the buyer and get higher surplus. This effect also increases the gain from allowing a marginal buyer to search, thus the seller has an incentive to charge a higher p_1 . The incentives to decrease p_2 and increase p_1 may lead the seller to announce in period 1 a pricing scheme with a buy-later discount, i.e., $p_1 > p_2$. This is exactly the case in our discrete experiment setting, where announcing a buy-later discount (20, 10) or (30, 10) is optimal.

¹⁵Our experimental setting provides a good example for the case of $x_2(p_{B1}, p_{B2}) = 0$. In our setting, we have $x_2(p_{B1}, p_{B2}) = 0$ in the full-commitment game. In the cheap-talk game, the seller optimally announces a buy-later discount, either (20, 10) or (30, 10), to induce the naive buyers to return, because he can have a large gain from charging $\tilde{p}_2 = 30$ to a returning buyer.

In the exploding-offer game, the seller can manipulate only the availability of her offer in period 2. The lack of flexibility in adjusting the buy-later price makes the seller unable to exploit a returning buyer by cheating on the buy-later price. As a result, the seller just chooses her optimal strategy in the full-commitment case, given the buyer naively believes her strategy. We omit the proof of the following proposition, given its straightforwardness.

Proposition 7. *Under the exploding-offer tactic, given Assumptions 1 and 2, if the seller can communicate with the buyer about her dynamic pricing scheme via cheap talk, and the buyer naively believes the seller's claim and responds optimally, the seller behaves as if under the full-commitment condition, that is, she sends the buyer an exploding offer with $p = p_E$.*

Given the intuitions in Propositions 6 and 7, we illustrate below how the presence of naive buyers, with $\beta \in (0, 1)$, and the ability of the seller to make cheap-talk announcements can make the equilibrium outcomes deviate from the ones of the no-commitment games. Still, we start the analysis from the buy-now-discount tactic.

To study how the seller uses cheap talk to improve her surplus, we need to clarify first in a sequential equilibrium how the seller forms her belief about the type of a returning buyer, including the behavioral type and the values of u and v , under a history (p_1, p_2) off the equilibrium path. Let $\tilde{p}_2(p_1, p_2)$ denote the rational buyer's *expected* new buy-later price under history (p_1, p_2) . The strategy of the buyer can be represented by $\tilde{p}_2(p_1, p_2)$. Sequential rationality requires that the strategy of a rational buyer under history (p_1, p_2) be the optimal response to the *actual* buy-later price chosen by the seller. Thus, the actual buy-later price should be the same as $\tilde{p}_2(p_1, p_2)$. The consistent condition of sequential equilibrium requires that the belief of the seller about the buyer's type under (p_1, p_2) , which corresponds to a strategy of the buyer, be consistent with the true strategy of the buyer *whenever* (p_1, p_2) *induces some naive buyers to return*. Therefore, the belief of the seller can be uniquely represented by $\tilde{p}_2(p_1, p_2)$, and her optimal response to the belief represented by $\tilde{p}_2(p_1, p_2)$ is to choose $\tilde{p}_2(p_1, p_2)$ as the buy-later price when a fraction of naive buyers return under the history (p_1, p_2) . When there is no naive buyer returning to the seller, we have more flexibility in specifying the belief of the seller.

In the game of buy-now discount with no commitment, we have shown in Proposition 3 that the equilibrium outcome is the same as using the optimal exploding offer under the full-commitment condition. In the game with cheap talk, the seller can generate the same outcome by announcing $p_1 = p_E$ and $p_2 = \underline{p}_2$ solving $\hat{u}(p_E, p_2) - p_2 = \underline{v}$, and choosing \tilde{p}_2 solving $\hat{u}(p_E, p_2) - p_2 = \delta \underline{v}$ upon observing a returning buyer. It is clear that $\tilde{p}_2 > \underline{p}_2$. The proposition below shows that the seller has an incentive to deviate from this strategy by announcing a lower p_2 to induce some naive buyers to return.

Proposition 8. *In the game of buy-now discount with cheap talk, under Assumptions 1 and 2, the presence of naive buyers can make it more profitable to announce a pricing scheme (p_1, p_2)*

that induces some naive buyers to return than to announce the price pair $(p_1, p_2) = (p_E, \underline{p}_2)$ that induces no buyer to return.

Proof. Suppose that the seller announces $p_1 = p_E$ and $p_2 = p'_2$ which is marginally lower than \underline{p}_2 . Then, some buyers will return to the seller after search. The altered buy-later price $\tilde{p}_2(p_1, p'_2)$ should be higher than $p'_2 + (1 - \delta)v$. Since p'_2 is marginally lower than \underline{p}_2 , then \tilde{p}_2 is strictly higher than \underline{p}_2 . Therefore, no rational buyer will return, as $\hat{u}(p_E, \tilde{p}_2) - \tilde{p}_2 < v$ given the continuity of $\hat{u}(p_E, p_2) - p_2$ in p_2 . This implies that changing to prices $p_1 = p_E$ and $p_2 = p'_2$ will not change the profit of the seller from rational buyers. However, it increases the profit of the seller from naive buyers. Evaluating the derivative of $\pi_B^n(p_1, p_2, \tilde{p}_2(p_1, p_2))$ at $p_1 = p_E$ with respect to p_2 in the left neighborhood of \underline{p}_2 , we have

$$\begin{aligned} \frac{d\pi_B^n(p_1, p_2, \tilde{p}_2(p_1, p_2))}{dp_2} &= p_E \frac{dx_1^n}{dp_2} + \tilde{x}_2^n(p_E, p_2, \tilde{p}_2) + \tilde{p}_2 \left(\frac{\partial \tilde{x}_2^n}{\partial p_2} + \frac{\partial \tilde{x}_2^n}{\partial \tilde{p}_2} \frac{d\tilde{p}_2}{dp_2} \right) + \frac{d\tilde{p}_2}{dp_2} \tilde{x}_2^n \\ &= p_E \frac{dx_1^n}{dp_2} + \tilde{x}_2^n(p_E, p_2, \tilde{p}_2) + \tilde{p}_2 \frac{\partial \tilde{x}_2^n}{\partial p_2} \\ &= p_E \frac{dx_1^n}{dp_2} + \tilde{x}_2^n(p_E, p_2, \tilde{p}_2) + p_2 \frac{\partial \tilde{x}_2^n}{\partial p_2} + (\tilde{p}_2 - p_2) \frac{\partial \tilde{x}_2^n}{\partial p_2} \end{aligned}$$

where the second equality is due to that $\tilde{p}_2(p_1, p_2)$ solves $\max_{\tilde{p}_2} \tilde{p}_2 \tilde{x}_2^n(p_1, p_2, \tilde{p}_2)$ in the neighborhood of $(p_1, p_2) = (p_E, \underline{p}_2)$, required by the sequential rationality of sequential equilibrium. If in the full-commitment case, \underline{p}_2 is not optimal given $p_1 = p_E$, then it is obvious that $d\pi_B^n(p_1, p_2, \tilde{p}_2(p_1, p_2))/dp_2 < 0$. Consider that $(p_1, p_2) = (p_E, \underline{p}_2)$ is optimal in the full-commitment case. Using arguments similar to (9) and (10) in the proof of Proposition 1, we can show that the first three terms in the RHS of the third equality converge to 0. Therefore, when $\tilde{p}_2 - p_2 \geq (1 - \delta)v$ is sufficiently large, we have $d\pi_B^n(p_1, p_2, \tilde{p}_2(p_1, p_2))/dp_2 < 0$. That is, decreasing p_2 from \underline{p}_2 so as to induce some buyers to return can improve the payoff of the seller. \square

In the game of exploding offer with no commitment, Proposition 4 shows that the equilibrium outcome is the same as using the optimal open offer under the full-commitment condition. In the cheap-talk game with naive buyers, the seller can possibly improve her expected payoff by announcing an exploding offer to deter some naive buyers from search, following the intuition provided by Proposition 7. We omit the proof of the following proposition given that it directly follows Propositions 2 and 7.

Proposition 9. *In the game of exploding offer with cheap talk,*

1. *if $x_1 > 0$ under the optimal open offer with price p_O , then making an exploding offer is more profitable than sending the optimal open offer if $1 - F(u)$ is concave for $u < \bar{u}$;*
2. *if $x_1 = 0$ under the optimal open offer with price p_O , then under Assumption 2, making the optimal exploding offer is more profitable than sending the optimal open offer if β is*

sufficiently large.

5 Conclusion

This paper theoretically and experimentally investigates two prevailing search deterrence strategies, exploding offer and buy-now discount, under different commitment conditions. Though these two tactics are similar in spirit, i.e., deterring search by endogenously increasing the cost of search, they are different in nature. An exploding offer deters a buyer from seeking alternative options by manipulating the availability of the seller's item in the future. A buy-now discount deters search by manipulating the future price of the item. In this paper, we first use a standard model to solve the equilibria of the exploding offer game and buy-now discount game and predict the consequences of removing the commitment power under these two tactics. Next, a lab experiment is conducted to (1) compare the performance of the two tactics under full commitment; (2) test the theoretical predictions on the effect of removing commitment power; and (3) examine the role of cheap talk on seller and buyer behaviors. Lastly, we construct a behavioral model that includes naive buyers to theoretically analyze the seller's cheap talk strategy. To our knowledge, this is the first theory-based experimental study that focuses on the differences between the tactics of exploding offer and buy-now discount in various commitment settings.

The theoretical results show that the role of commitment depends on which tactic is used in the market. In the game of buy-now discount, removing the seller's power to commit does not lead to less aggressive search deterrence pricing schemes, while in the exploding offer game, the lack of commitment power completely eliminates the seller's ability to deter search since every offer is essentially an open offer. Cheap-talk communication exerts no impact on the equilibrium outcomes of the two tactics if the buyer is full rational. The presence of a naive buyer type has different effects on seller strategies under the two search deterrence tactics. In the exploding offer game, the seller uses a claimed exploding offer to deter search. In the buy-now discount game, the seller claims a less aggressive pricing scheme due to the added incentive to encourage return and then opportunistically increase the buy-later price.

Our experimental results show that under full commitment, exploding offers are implemented more optimally and are more effective in search deterrence compared to buy-now discounts. Although removing a seller's power of committing to an exploding offer effectively removes her ability to deter search, we observe no effect on the payoffs of sellers or buyers due to a sudden increase in cooperation. We also find strong evidence that cheap talk affects buyers' search and return decisions but is not as effective as credible claims under full commitment. A majority of sellers use cheap talk to deter search in the exploding offer game but to induce return in the buy-now discount game; such findings are largely in line with the predictions of our behavioral model.

Supplementary Material

Appendix A: Proofs

Appendix B: Supplementary Tables and Figures

Table 8: Logit Marginal Effects for Optimal Strategy of Search Deterrence under Full Commitment

Marginal Effects for	<i>OptimalSD</i>		
	(1) All Rounds	(2) Rounds 1-11	(3) Rounds 12-22
<i>BND-FC</i>	-0.127	-0.020	-0.226**
<i>Round</i>	0.013***	0.025***	0.006
<i>RiskAverse</i>	-0.017	-0.020	-0.014

Table 9: Search by High-Value Buyers in BND-NC and BND-FC

Dep. Var.	<i>Search</i>			
	$p_1 = 20$ and (20, 30)		$p_1 = 10$ and (10, 20/30)	
<i>BND-NC</i>	0.297	(0.431)	1.423**	(0.724)
<i>Round</i>	0.025	(0.015)	-0.069**	(0.034)
<i>RiskAverse</i>	-0.135**	(0.069)	-0.110	(0.085)
Constant	0.595	(0.959)	-2.031	(1.258)
Observations	869		869	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Search by High-Value Buyers in EO-NC and EO-FC

Dep. Var.	<i>Search</i>			
	$p = 30$ and $(30, OP)$		$p = 20$ and $(20, OP)$	
<i>EO-NC</i>	-2.469***	(0.962)	-1.729***	(0.541)
<i>Round</i>	0.039	(0.047)	0.050***	(0.018)
<i>RiskAverse</i>	-0.144	(0.091)	0.144**	(0.062)
Constant	6.541***	(1.539)	-0.912	(0.850)
Observations	810		810	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 11: Effects of Claimed Search Deterrence in EO-CT

Dep. Var.	<i>Search</i>			
	(1) Claimed EO vs Claimed OP		(2) Claimed $(20, EO)$ vs Claimed $(30, OP)$	
<i>ClaimedSD</i>	-2.325***	(0.236)	-2.826***	(0.638)
<i>Round</i>	0.030**	(0.015)	0.037*	(0.019)
<i>RiskAverse</i>	-0.057	(0.053)	-0.058	(0.080)
Constant	1.574**	(0.721)	2.958***	(1.092)
Observations	1,840		1,728	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. In the regression, *ClaimedUP* is a dummy variable that equals 1 for a claimed uniform price offer in EO-CT and 0 for a claimed search-detering offer in EO-CT.

Table 12: Search in EO-FC and EO-CT

Dep. Var.	<i>Search</i>			
	(1)		(2)	
	EO vs Claimed EO		OP vs Claimed OP	
<i>EO-CT</i>	1.428***	(0.364)	-1.232***	(0.477)
<i>BuyNowPrice</i>	0.324**	(0.068)	0.245***	(0.055)
<i>Round</i>	0.029*	(0.016)	0.043**	(0.018)
<i>RiskAverse</i>	-0.012	(0.051)	-0.038	(0.066)
Constant	-8.254***	(1.529)	-4.315**	(1.853)
Observations	1,732		1,732	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 13: Effects of Claimed Buy-Later Discounts on Search in BND-CT

Dep. Var.	<i>Search</i>			
	(1)		(2)	
	Claimed BLD vs Claimed BND		Claimed BLD vs Claimed UP	
<i>ClaimedBLD</i>	2.589***	(0.372)	0.849***	(0.173)
<i>Round</i>	0.021*	(0.012)	0.012	(0.009)
<i>RiskAverse</i>	-0.036	(0.029)	-0.039	(0.043)
Constant	-1.045**	(0.451)	0.839	(0.585)
Observations	2,706		2,255	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. In the regression, *ClaimedBLD* is a dummy variable that equals 1 for a claimed buy-later discount and 0 for a claimed search-detering offer (regression (1)) or uniform-price offer (regression (2)) in EO-CT.

Table 14: Effects of Claimed Buy-Later Discounts on Return in BND-CT

Dep. Var.	<i>Return</i>			
	(1)		(2)	
	Claimed BLD vs Claimed BND		Claimed BLD vs Claimed UP	
<i>ClaimedBLD</i>	0.817**	(0.361)	0.641***	(0.240)
<i>Value</i>	0.112***	(0.023)	0.114***	(0.024)
<i>OutsideOption</i>	-0.129***	(0.028)	-0.137***	(0.028)
<i>Round</i>	-0.031**	(0.013)	-0.036**	(0.015)
<i>RiskAverse</i>	0.021	(0.031)	0.009	(0.027)
Constant	-2.757***	(0.713)	-2.283***	(0.797)
Observations	2,118		2,378	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. In the regression, *ClaimedBLD* is a dummy variable that equals 1 for a claimed buy-later discount and 0 for a claimed search-detering offer (regression (1)) or uniform-price offer (regression (2)) in EO-CT.

Table 15: Buy-Later Discounts in BND-FC and Claimed Buy-Later Discounts in BND-CT

Dep. Var.	(1)		(2)	
	<i>Search (High-Value Buyers)</i>		<i>Return (All Buyers)</i>	
<i>BND-CT</i>	-2.008***	(0.404)	-1.405***	(0.322)
<i>p</i> ₁	0.254***	(0.048)	-0.024**	(0.010)
<i>p</i> ₂	0.008	(0.013)	-0.147***	(0.028)
<i>Value</i>			0.119***	(0.020)
<i>OutsideOption</i>			-0.130***	(0.023)
<i>Round</i>	0.045**	(0.018)	-0.014	(0.013)
<i>RiskAverse</i>	-0.076	(0.064)	-0.006	(0.024)
Constant	-2.615*	(1.536)	2.089***	(0.567)
Observations	2,745		3,318	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 16: Search in BND-FC and BND-CT

Dep. Var.	<i>Search</i>			
	(1)		(2)	
	BND vs Claimed BND		UP vs Claimed UP	
<i>BND-CT</i>	0.996**	(0.402)	-1.167***	(0.419)
<i>p</i> ₁	0.229***	(0.043)	0.203***	(0.036)
<i>p</i> ₂	0.004	(0.013)		
<i>Round</i>	0.017	(0.015)	0.054***	(0.015)
<i>RiskAverse</i>	-0.057	(0.061)	-0.003	(0.045)
Constant	-5.192***	(0.841)	-3.929***	(0.911)
Observations	2,745		1,830	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 17: Seller and Buyer Payoffs in BND-FC and BND-CT

Dep. Var.	(1)		(2)	
	<i>SellerPayoff</i>		<i>BuyerPayoff</i>	
<i>BND-CT</i>	1.096	(0.830)	-1.368**	(0.544)
<i>Value</i>			0.285***	(0.042)
<i>Round</i>	-0.038	(0.039)	0.002	(0.038)
<i>RiskAverse</i>	-0.023	(0.101)	0.038	(0.072)
Constant	11.461***	(1.565)	10.688***	(2.164)
Observations	1,230		1,230	

Notes: Robust standard errors are shown in parentheses, allowing for clustering by subject. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

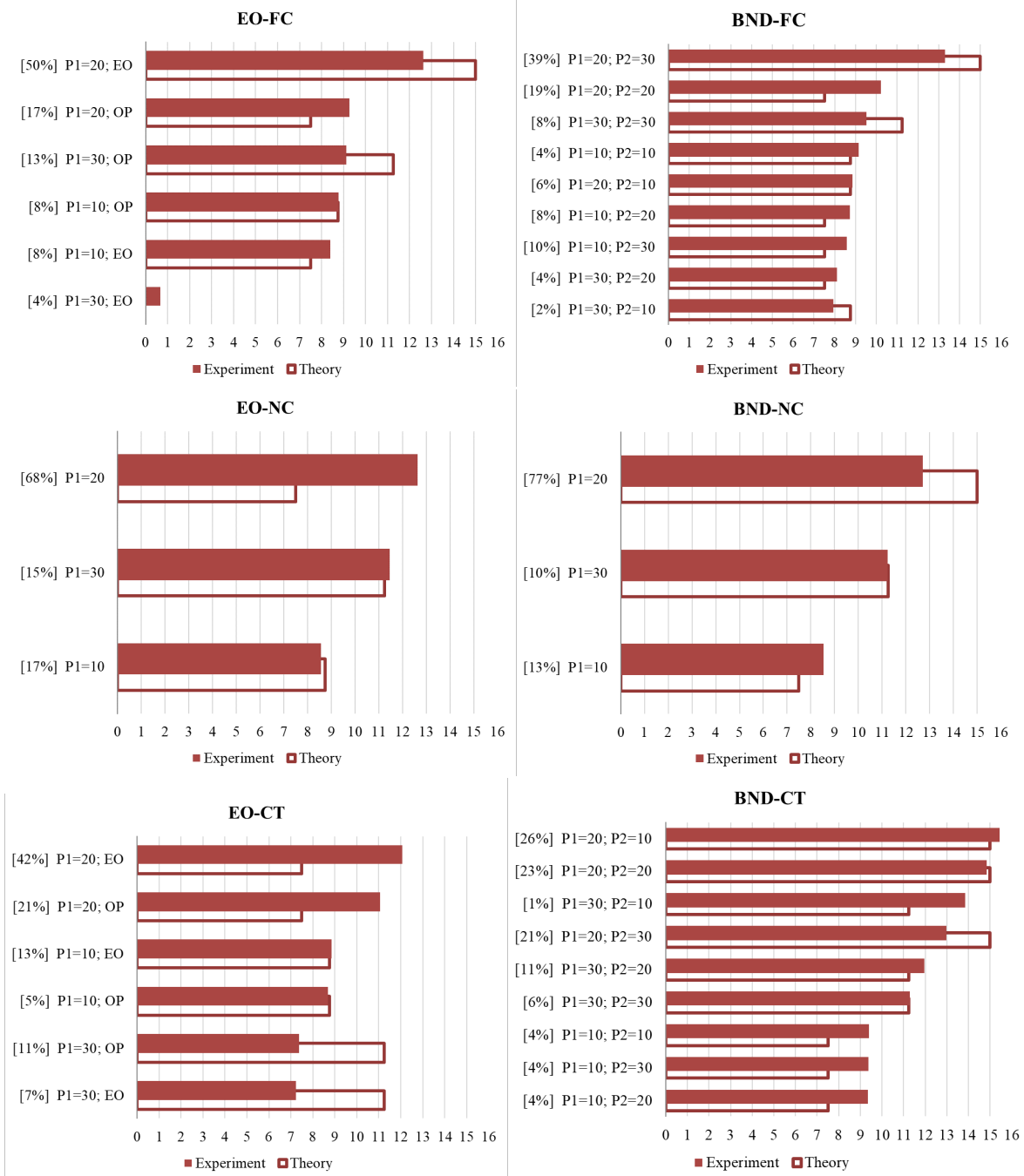


Figure 8: Marketing Tactics and Expected Profits Based on Experiments and Theory

Notes: Each percentage in brackets indicates the fraction of sellers who choose the corresponding strategy in the experiments. The experimental expected profits are calculated based on buyers' actual decisions in the experiments. The theoretically predicted expected profits are calculated based on the actions of rational buyers.

