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Discussion Paper No. 15-4, April 2015

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Auctions with a buyout price: A survey

Toshihiro Tsuchihashi*

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Abstract

A seller can put a buyout price on online auctions. In an auction with buyout price, a bidder can purchase an item at a fixed price before the auction closes. Recently, the buyout price is increasingly capturing the attention of economists; numerous studies have theoretically and empirically examined the impact of a buyout price on seller revenue and the optimal decision of a bidder to exercise a buyout option. This paper reviews existing studies and their findings and concludes by exploring the direction for future research.

1 Introduction

Online auctions have become popular since Onsale and eBay emerged in the market in 1995. Today, multitudes of people use the Internet to sell products. According to an eBay report, over 128 million users listed over 550 million items on auction in 2013 (eBay Inc., 2014).

Unlike many traditional auction houses such as Sotheby's and Christie's, online auctions allow sellers to customize their auctions. With the setup of an auction period, an auction opens and the seller posts a starting price. She may also set a secret reserve price and a buyout price.

A buyout price is increasingly capturing the attention of economists these days. In this model, a bidder can purchase an item at a fixed price before the auction closes. This was first introduced by Yahoo in 1999 under the name *Buy Now.* Soon thereafter, eBay announced its *Buy It Now* model in 2000. These two services provide different timings for bidders to exercise a buyout price. On the one hand, *Buy Now* remains throughout the auction period and allows bidders to exercise the buyout option any time before the going price reaches the buyout price. On the other hand, *Buy It Now* does not continue for the whole period if the competitors offer a regular bid. The literature refers to the former as *permanent* and to the latter as *temporary.*

The buyout option appears to have been received warmly by eBay users. For the PlayStation Portable (PSP) video games category on eBay, Mathews (2004) reports that the buyout price was used in 124 out of 210 cases (59%). Hof (2001) demonstrates that 40% of all sellers had put a buyout option by the end of 2001.

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Why do sellers tend to set a buyout price in auctions? Naively speaking, a buyout price prevents the sellers' revenue from maximizing. First, a buyout price has the feature to fix a selling price on merchandise. However, when the demand for merchandise is uncertain, sellers are known to prefer auctions to a fixed pricing system (Wang, 1993; Kultti, 1999). In an auction, the seller sets a price and the item is sold at the hammer price. In this process, a buyout option seems to have no role. Second, a buyout price functions as an upper bound to a selling price. A seller would rather earn more without a buyout price than by adopting it (Budish and Takeyama, 2001). In this case, there seems to be no rationale for a seller to put a limit on the selling price. Lucking-Reiley (2000, p. 245) briefly demonstrates the benefits of a buyout price for both the seller and buyers. A buyout price not only helps the seller and buyers save time, but also ensures that a buyer wins the auction. Lucking-Reiley further notes that considerably high buyout prices are frequently used in auctions and asks as to what could be the optimal buyout price in an ascending auction. The literature, expanding in volume, explains who can benefit from a buyout price and how.

Theoretical studies from the perspective of seller revenue suggest that a risk-neutral seller profits by posting an appropriate buyout price when bidders are risk averse (Budish and Takeyama, 2001; Mathews, 2003; Hidvegi et al., 2006; Mathews and Katzman, 2006; Reynolds and Wooders, 2009) and impatient (Mathews, 2004; Gallien and Gupta, 2008), cover the entry cost (Che, 2011), have competitors who cannot use the buyout option (Kirkegaard and Overgaard, 2008), and use a buyout price as reference point (Shunda, 2009). Moreover, bidder utility is better off with a buyout price when the seller is risk averse (Mathews, 2003; Hidvegi et al., 2006; Mathews and Katzman, 2006; Reynolds and Wooders, 2009) and impatient (Mathews, 2004; Gallien and Gupta, 2008). Some of these studies examine a temporary buyout price, and others examine a permanent one (Table 1). Using eBay data (Durham et al., 2004; Anderson et al., Durham et al., 2008) and laboratory experiments (Grebe et al., 2006; Ivanova-Stenzel and Kroger, 2013), empirical studies reveal that a buyout price can raise seller revenue and facilitate early bidding (Durham et al., 2013). Additionally, some studies clearly show that experienced sellers are more likely to put a buyout price (Durham et al., 2004), although experience itself does not impact their price decision (Grebe et al., 2004).

A buyout price has mainly been analyzed in the context of auctions with private value. A few notable exceptions are Shahriar (2008) and Shahriar and Wooders (2011). Shahriar theoretically shows that a buyout price in auctions with common value yields an opposite effect compared to that with private value. Meanwhile, Shahriar and Wooders report on their experimental paper that a buyout price raises seller revenue in both contexts (auctions with private value and common value).

This paper reviews some existing studies and their findings. Section 2 mainly focuses on Reynolds and Wooders' (2009) theoretical model and discusses risk aversion. Section 3 views the impact of

Table 1: Theoretical studies of buyout price

	Temporary (eBay)	Permanent (Yahoo)
Risk aversion	Budish and Takeyama (2001), Mathews (2003), Mathews and Katzman (2006), Reynolds and Wooders (2009)	Hidvegi, Wang, and Winston (2006), Reynolds and Wooders (2009)
Time sensitivity	Mathews (2004), Gallien and Gupta (2008)	Gallien and Gupta (2008)
Other topics	Kirkegaard and Overgaard (2008), Shahriar (2008), Shunda (2008), Che (2011)	

time sensitivity following Mathews (2004) and Gallien and Gupta (2008). Section 4 discusses other factors relating to buyout price, including entry cost, seller competition, and reference-dependent utility. Section 5 reviews empirical studies, and Section 6 concludes the paper.

2 Risk aversion

Budish and Takeyama (2001) is the first study to formalize an auction with (temporary) buyout price. They construct a simple model with two bidders and two values, either of high or low. They focus on an equilibrium in which only a high-value bidder exercises the buyout option. Their major finding is that a risk-neutral seller benefits from posting an appropriate buyout price if the bidders are risk averse. Risk-averse bidders are willing to pay a risk premium to avoid variance in selling prices. Thus, seller revenue increases from a high buyout price that a risk-neutral bidder would never accept but a risk-averse bidder would.

Mathews (2003), Hidvegi et al. (2006), Mathews and Katzman (2006), and Reynolds and Wooders (2009) extend Budish and Takeyama (2001) to a general case (i.e., $n \geq 2$ bidders and continuous values) with either a temporary or permanent buyout price, and show that this important result is valid for the general environment. Moreover, bidders are indifferent between auctions with and without a buyout price. Related studies following Budish and Takeyama clarify a bidders optimal decision on when to exercise a buyout option instead of bidding in an auction. The common result is that bidders employ a threshold strategy for an optimal decision.

Mathews and Katzman (2006) introduce risk aversion into seller attitude and analyze an auction with a temporary buyout price in which a risk-averse seller faces risk-neutral bidders. A seller improves her expected utility by optimally choosing a low buyout price with positive probability, whereas risk-neutral bidders are indifferent between auctions with and without such a buyout price. Therefore, a buyout option may result in Pareto improvement compared to an auction without buyout price.

In the rest of this section, we introduce a theoretical model based on Reynolds and Wooders (2009) and discuss risk aversion. A seller intends to sell her item to $n \geq 2$ potential bidders. A bidder's value is independently and identically drawn from $[\underline{v}, \bar{v}]$ with a cumulative distribution function F. The corresponding density function is given by $f = F' > 0$, and $F_k(v)$ denotes the cumulative distribution function of the highest value among k bidders; that is, $F_k(v) = F(v)^k$. All participants are involved in an ascending auction with buyout price B, either temporary (the eBay format) or permanent (the Yahoo format). We assume that no reserve price is available and that the starting price is zero. Given the buyout price, a bidder decides whether to exercise a buyout option and what bids to submit. If some bidders exercise the buyout option, the auction closes immediately and the item is sold at the buyout price. In case two or more bidders try to exercise the buyout option simultaneously, the winner is randomly chosen.

We assume a risk-neutral seller and risk-averse bidders. Specifically, bidders have a constant absolute risk aversion (CARA) utility in the form of $u(x) = (1 - e^{-\alpha x})/\alpha$ for $\alpha \geq 0$. The degree of risk aversion increases as α increases, and $\alpha = 0$ corresponds to risk neutrality because $\lim_{\alpha \to 0} u(x) = x$.

In an ascending auction, a bidder has the weakly dominant strategy of submitting his value regardless of risk aversion whenever he does not exercise the buyout option. Therefore, a buyout price has no impact on the bidding behavior of a bidder with value below the buyout price ($v < B$). Following the literature, we restrict our attention to a symmetric Bayesian Nash equilibrium.

2.1 Temporary buyout price (the eBay format)

When bidders face a temporary buyout price, they have to first decide on whether to exercise the buyout option or submit a bid. Since the latter option leads to an ascending auction, this situation can be modeled as a two-stage game. Bidders decide whether to accept or reject a buyout price in the first stage and submit a bid in the second stage. Note that the second stage arises when all bidders reject the buyout price. We assume that an active bidder observes the current price but does not observe the number of active bidders.

We first consider a bidder's optimal decision in the first stage. A bidder will never accept a buyout price if his value is below it ($v < B$). Alternatively, assume that a bidder has a value at or above the buyout price ($v \geq B$). Conditional on winning, the higher his value, the higher is the final price he faces on average. Therefore, given the buyout price, a bidder with higher value finds it more beneficial to exercise the buyout option because it saves him money. In other words, a bidder optimally follows a threshold strategy where he accepts the buyout price if and only if his value is at or above a certain threshold. Clearly, the threshold depends on the buyout price.

Next, we investigate this threshold. We denote the threshold by c. Assume that all other bidders follow the threshold strategy. If a bidder with value v accepts the buyout price, his expected utility is

$$\begin{aligned}U^B(v,c) &= u(v-B)\sum_{k=0}^{n-1}\binom{n-1}{k}\frac{1}{k+1}(1-F(c))^k F(c)^{n-1-k} \\ &= \frac{u(v-B)}{n}\sum_{k=0}^{n-1}F(c)^k \\ &= \frac{u(v-B)}{n}\frac{1-F(c)^n}{1-F(c)},\end{aligned}$$

where k is the number of other bidders who also choose to exercise the buyout option. On the other hand, if the bidder rejects the buyout price and submits his actual value in the subsequent auction, his expected utility is

$$\begin{aligned}U^A(v,c) &= E[u(v-y)|y<\min\{v,c\}] \\ &= \frac{1}{F(\min\{v,c\})^{n-1}}\int_0^{\min\{v,c\}} u(v-y)dF(y)^{n-1} \\ &= u(v-\rho_\alpha(\min\{v,c\})).\end{aligned}$$

Note that a bidder wins the auction only if his value is the highest among n bidders and no other bidder accepts the buyout price in the first stage. In the above equation, $\rho_\alpha(z)$ represents the risk premium associated with the variance in selling prices, that is, certainty equivalence.[1] Certainty equivalence depends on the degree of risk aversion (α):

$$u(v-\rho_\alpha(z)) = E[u(v-y)|y<z].$$

If the threshold strategy constructs a symmetric equilibrium, a bidder with value equal to the threshold ($v=c$) should be indifferent between exercising the buyout option and bidding; that is, $U^B(c,c) = F(c)^{n-1}U^A(c,c)$. Reynolds and Wooders (2009, Proposition 1) show that the threshold strategy indeed constructs a symmetric equilibrium.

Proposition 1 (Reynolds and Wooders (2009)) Suppose that bidders have a CARA utility function. In a symmetric equilibrium of auction with temporary buyout price B, bidders employ the following threshold strategy. A bidder with value $v \geq c^*$ accepts the buyout price B, whereas one with value $v < c^*$ rejects the buyout price and submits value v in the subsequent auction. The threshold satisfies

$$\frac{u(c^*-B)}{n}\frac{1-F(c^*)^n}{1-F(c^*)} = u(c^*-\rho_\alpha(c^*))F(c^*)^{n-1}.$$

Threshold c^* is increasing in buyout price B and decreasing in degree of risk aversion $\alpha \geq 0$.[2]

[1] For a more detailed discussion, see, for example, Section 4.1 in Krishna (2010).

[2] If the reserve price is $r < B$, the threshold decreases in the reserve price. If bidders consider the subsequent auction less attractive for higher reserve prices, the buyout option is more exercised.

From Proposition 1, first, a higher buyout price induces a higher threshold and is less exercised. This result is intuitive because a high buyout price is less attractive and consequently bidders are more likely to reject it and bid in the subsequent auction. Second, a risk-averse bidder is more likely to accept the buyout price. Intuitively, a risk-averse bidder is willing to pay more for "insurance."

Reynolds and Wooders (2009) do not consider an optimal buyout price for a seller, but provide a range of buyout prices that could increase seller revenue. A buyout price can be classified under three levels.

By the definition of certainty equivalence, a bidder with value v should be indifferent between paying the second-highest value conditional on winning and paying the certainty equivalence $\rho_\alpha(v)$ to win with certainty. Proposition 1 implies that certainty equivalence is larger for a bidder with higher value; that is, $\partial\rho_\alpha(v)/\partial v > 0$ for any $\alpha \geq 0$. Therefore, no bidder accepts a sufficiently high buyout price such that $B > \rho_\alpha(\bar{v})$, implying no impact on seller revenue.

Next, we confirm that a seller cannot benefit from a buyout price if the bidders are risk neutral ($\alpha = 0$). Moreover, any buyout price ($B \leq \rho_0(\bar{v})$) accepted with a positive probability strictly lowers seller revenue. This is because an ascending auction (with an appropriate reserve price) is an optimal auction (Myerson, 1981). Such a buyout price is accepted with a positive probability by risk-averse bidders ($\alpha > 0$) as well. Therefore, a sufficiently low buyout price reduces seller revenue such that $B \leq \rho_0(\bar{v})$.

Finally, Reynolds and Wooders (2009, Corollary 1) show that an intermediate buyout price increases seller revenue such that $\rho_0(\bar{v}) < B < \rho_\alpha(\bar{v})$, given $\alpha > 0$. This intermediate buyout price is also accepted with a positive probability, resulting in ex post inefficient outcomes, because if two or more bidders simultaneously try to exercise a buyout option, the bidder with highest value may fail to obtain an item.

2.2 Permanent buyout price (the Yahoo format)

When facing a permanent buyout price, bidders can exercise the buyout option any time during an auction, even after they submit a bid. Therefore, a bidder has to decide when to exercise a buyout option. A bidder remains active until the price is within his threshold and then exercises the buyout option. As shown in the previous subsection, a buyout option is more advantageous to a bidder with high value. Therefore, the threshold is a decreasing function $t(v)$ in bidder value. In other words, a bidder with a relatively lower bid value exercises the buyout option more quickly. A bidder with value v exercises the buyout price B if the current price reaches the threshold $t(v)$.

If all bidders follow the threshold strategy $t(v)$, the following two cases arise. First, as the auction starts and the price goes up, some bidder exercises the buyout option. Note that this bidder should have the highest value because the threshold is decreasing in bidder value. This case is possible whenever $\underline{v} < t(\bar{v}) \leq t(v)$ holds for all v.

Second, the buyout price is accepted as soon as the auction opens. This case is possible whenever the threshold satisfies $t(v) = \underline{v}$ for some bidder. Note that two or more bidders may intend to exercise the buyout option at the same time.

Next, we investigate the characteristics of this threshold. Suppose that all bidders follow the threshold strategy and $t(v) > \underline{v}$ holds for all v. A bidder with value v pays the second-highest value (y) if it is below her threshold ($y < t(v)$). Alternatively, she pays the buyout price (B) if the second-highest value is above her threshold ($t(v) < y < v$). Therefore, a bidder with value v obtains the expected utility

$$U(v,t) = \int_0^{t(v)} u(v-y)dF(y)^{n-1} + [F(v)^{n-1} - F(t(v))^{n-1}]u(v-B).$$

The threshold strategy constructs a symmetric equilibrium if no bidder can profitably choose the threshold $t(z) \neq t(v)$. Hidvegi et al. (2006, Proposition 1) and Reynolds and Wooders (2009, Proposition 3) independently show that the threshold strategy described above indeed constructs a symmetric equilibrium.

Proposition 2 (Hidvegi et al. (2006), Reynolds and Wooders (2009)) Suppose that bidders have a CARA utility function. In a symmetric equilibrium of an auction with permanent buyout price B, bidders employ the following threshold strategy. A bidder with value v exercises the buyout option if the current price reaches his threshold $t(v) \geq \underline{v}$. If $t(v) = \underline{v}$ holds, the bidder immediately accepts the buyout price right after the auction opens. For a buyout price such that $B \geq \rho_\alpha(\bar{v})$, the threshold satisfies

$$E[u(v-y)|t(v) \leq y \leq v] = u(v-B).$$

For a buyout price such that $B < \rho_\alpha(\bar{v})$, the threshold satisfies

$$E[u(v-y)|t(v) \leq y \leq v] = u(v-B)$$

for $v \in [B, c^*]$, and $t(v) = \underline{v}$ for $v \geq c^*$. The threshold function $t(v)$ is continuous and decreasing in v for $v > B$.

As discussed previously, any permanent buyout price satisfying $B < \rho_0(\bar{v})$ lowers seller revenue. Reynolds and Wooders (2009) show that an intermediate buyout price ($\rho_0(\bar{v}) < B < \rho_\alpha(\bar{v})$) can be accepted when the auction opens as well ($t(v) = \underline{v}$ for some v). Furthermore, even if such a permanent buyout price is not accepted initially, it can be accepted later. This is the bid difference between temporary and permanent buyout prices. Finally, a high buyout price ($B > \rho_\alpha(\bar{v})$) also can be accepted with a positive probability even if it is not accepted when the auction opens. Such a buyout price leads to *ex post* efficient outcomes because a bidder exercising the buyout option actually has a higher value.

2.3 Temporary versus permanent buyout prices

Following Reynolds and Wooders (2009), in this subsection we compare the two formats for a fixed common buyout price.[3] First, we confirm the important finding of Reynold and Wooders. If bidders have a CARA utility, the set of bidders exercising the buyout option when the auction opens will be the same in the two formats. The set of bidders is characterized by the threshold c^* described above in Proposition 1. That is, a bidder accepts the buyout price in the two formats if and only if his value is above the threshold ($v > c^*$).

Second, the *ex post* outcomes in the two formats may differ. If the buyout price is rejected in the temporary format, the auction ends with the second-highest value. On the other hand, a temporary buyout price initially rejected can be accepted later. Note that if the buyout price is initially rejected, the item is allocated to the bidder with highest value in the two formats.

Third, bidders are indifferent between the two formats, given a buyout price. If the buyout price is rejected in the temporary format, the bidder with highest value wins the auction and pays the second-highest value. On the other hand, a buyout price initially not accepted in the permanent format may be later accepted by the bidder with the highest value. In fact, this occurs when the second-highest value (y) is above the threshold of the bidder with highest value (x); that is, $x > y > t(x)$ holds. This case is further classified into two. First, the buyout price lies between x and y (i.e., $y < B < x$). In this case, the bidder with highest value pays more in the permanent format because he pays a buyout price above the second-highest value. Second, the buyout price is below y (i.e., $B < y$). In this case, the bidder with highest value pays less in the permanent format because he pays a buyout price below the second-highest value. Reynolds and Wooders (2009, Proposition 2) show that this trade-off is actually canceled out and leads to *ex ante* utility equivalence for bidders.

Finally, given the buyout price, the permanent format (weakly) generates higher seller revenue than the temporary one. A high buyout price $B > \rho_\alpha(\bar{v})$ is rejected with probability 1 in the temporary format, leading to *ex ante* revenue equivalence for a seller in an ascending auction. However, such a high buyout price can be accepted later in the permanent format if it is below the highest bid value

[3]Reynolds and Wooders (2009) introduce a reserve price (r) into the model as well. Therefore, an auction is given a point $(r, B) \in \mathcal{R}^+ \times \mathcal{R}^+$. We will discuss the reserve price in the concluding section.

(i.e., $B < \bar{v}$). The benefit from posting a buyout price satisfying $\rho_\alpha(\bar{v}) < B < \bar{v}$ increases as bidders become more risk averse (i.e., larger α). Therefore, such a buyout price generates higher seller revenue in the permanent format if the bidders are risk averse.

Moreover, Reynolds and Wooders (2009) analyze the case where bidders have decreasing absolute risk aversion (DARA) and increasing absolute risk aversion (IARA). Reynolds and Wooders show that for a common buyout price in the two formats, (1) a temporary buyout price is more exercised than a permanent one if the bidders have DARA utility, whereas a temporary buyout price is less exercised than a permanent one if the bidders have IARA utility; and (2) a bidder with DARA utility prefers an auction with permanent buyout price to that with temporary one, whereas a bidder with IARA utility prefers an auction with temporary buyout price to that with permanent one.

3 Time sensitivity

With regard to online auctions, a seller may intend to sell her item as soon as possible because she needs money, or a bidder may intend to obtain an item as soon as possible because, for example, he wants to prepare a birthday present for his friend. Such a seller and bidder know the value of time and are sensitive to the passage of time. Mathews (2004), Mathews and Katzman (2006), and Gallien and Gupta (2007) introduce a time-sensitive seller and bidder into the model.

Mathews and Katzman (2006) study a temporary buyout price and investigate the impact of patience on seller revenue. They mainly analyze two cases: the seller is impatient, and both the seller and bidders are impatient. Following Mathews and Katzman (2006), Gallien and Gupta (2007) study the permanent buyout price and compare the two formats. In Gallien and Gupta's model, the number of bidders is not fixed and bidders arrive at an auction following a Poisson process.

Mathews (2004) and Gallien and Gupta (2007) in common show that a buyout price provides the advantage of early closing to impatient sellers and bidders. This result may be consistent with the following view presented in eBay help that prompts early bidding:[4]

> Why did the Buy It Now option disappear after the first bid? For auction-style listings with Buy It Now option, you have the chance to purchase an item immediately, before bidding starts. But, you have to act fast. After someone bids, the Buy It Now option disappears and bidding continues until the listing ends, with the item going to the highest bidder. Learn more about buying with the Buy It Now option.

In what follows, we discuss time patience in line with Mathews (2004) and Gallien and Gupta (2007). We introduce a model based on Mathews' (2004) model. This model has a seller and $n \geq 2$

[4]URL: http://pages.ebay.com/help/buy/questions/buy-it-now.html

bidders, all of whom are risk neutral. The seller posts the temporary buyout price B, and an ascending auction starts at time $t = 0$. The auction ends at $t = T$ unless the buyout price is exercised. Bidders appear randomly in the auction according to a cumulative distribution function J on arrival time interval $[0, T]$ with corresponding density function j. A newly arrived bidder at time t observes the current price p_t and can exercise the buyout option any time the option is available. We assume that bidders are time sensitive in the sense that they discount their payoffs with a common discounting factor $\delta \in (0, 1]$. That is, the utility function is given by $u(x) = \delta^t x$ for $\delta \in (0, 1]$. The degree of time sensitivity increases as δ approaches zero, $\delta = 1$ corresponds to the case of no discounting, and the buyout option is never exercised in equilibrium, consistent with the literature.

First, a newly arrived bidder at time t observes the current price p_t. A positive current price $p_t > 0$ implies that a bidder has already submitted a bid and that the buyout price has disappeared. Thus, the newly arrived bidder should submit his value as a proxy bid. We assume that a bidder submits a bid immediately on arrival if he decides to submit, because bidding at any time before the auction closes ($t \leq T$) induces the same outcome.

In contrast, a newly arrived bidder at time t observes a zero price ($p_t = 0$) if a buyout price is available. If he is willing to exercise the buyout option, he should exercise it immediately upon arrival. It is never optimal for him to wait for a while and then exercise the buyout option. This is because the current price remains only until someone appears and places a bid; moreover, the payoff becomes discounted as time passes. Therefore, to find a symmetric equilibrium, we focus on the trade-off between a bidder exercising the buyout option immediately and submitting his valuation as a proxy bid on arrival.

As usual, we find the symmetric equilibrium in which bidders follow the threshold strategy. The threshold $c(B, t)$ is a function of buyout price (B) and arrival time (t). On arriving at time t, a bidder with value v immediately exercises the buyout option if it is available and his value is at or above the threshold (i.e., $v \geq c(B, t)$); on the other hand, he submits his value as a proxy bid at time t if the buyout price is not available or his value satisfies $v < c(B, t)$.

Now, assume that all other bidders follow the above threshold strategy and that a bidder with value v arrives at the auction at time t. If the buyout price has already disappeared, he would simply submit his bid. Thus, we assume that the buyout price is still available. Clearly, he is the first bidder to arrive in this case. If he immediately exercises the buyout option at time t, he obtains $\delta^t(v - B)$. Otherwise, a proxy bid equal to his actual value leads to

$$\delta^T[F(v)^{n-1}v - \int_{\underline{v}}^{v} y dF(v)^{n-1}].$$

Mathews (2004, Proposition 1) and Gallien and Gupta (2007, Theorem 1) show that this threshold strategy indeed constructs a symmetric equilibrium.

Proposition 3 (Mathews (2004), Gallien and Gupta (2007) Suppose that bidders discount the future utility using discounting factor $\delta \in (0, 1]$. In a symmetric equilibrium of an auction with temporary buyout price B, bidders employ the following threshold strategy. A bidder with value v on arrival at time t immediately exercises the buyout price if his value is at or above the threshold ($v \geq c(B,t)$); alternatively, he submits his value v as a proxy bid if his value is below the threshold ($v < c(B,t)$). The threshold $c(B,t)$ satisfies

$$\delta^t(c(B,t) - B) = \delta^T[F(c(B,t))^{n-1}c(B,t) - \int_{\underline{v}}^{c(B,t)} ydF(y)^{n-1}].$$

The threshold is increasing in arrival time t and decreasing in buyout price B.

First, given the arrival time t, a higher buyout price is less accepted. This is quite intuitive because a higher buyout price is less attractive to a bidder. Second, given the bidder value v, a bidder arriving later is less likely to accept the buyout price. The advantage of saving time by accepting the buyout price is lower for a bidder arriving late at an auction. Third, given the arrival time t, a bidder with higher value has a stronger incentive to exercise the buyout price.

Since the threshold $c(B,t)$ is increasing in arrival time t, a buyout price $\bar{B}$ satisfying $c(\bar{B}, 0) = \bar{v}$ is never accepted. The critical buyout price is

$$\begin{aligned}\bar{B} &= \bar{v} - \delta^T[F(\bar{v})^{n-1}\bar{v} - \int_{\underline{v}}^{\bar{v}} ydF(y)^{n-1}] \\ &= \bar{v} - \delta^T[\bar{v} - \int_{\underline{v}}^{\bar{v}} ydF(y)^{n-1}].\end{aligned}$$

On the other hand, any buyout price $B < \bar{B}$ is accepted with a positive probability.

Given this threshold strategy, assume that a seller chooses buyout price B. If the bidder arriving first has a value at or above the threshold ($v \geq c(B,t)$), which occurs with probability $1 - F(c(B,t))$, the item is sold at the buyout price B at time t. Otherwise, the item is sold at the second-highest value at time $t = T$. Therefore, by choosing B, the seller obtains the expected revenue

$$\Pi^S(B) = n\Big[B\int_0^T [1 - F(c(B,t))]dJ(t) + \int_{\underline{v}}^{\bar{v}}\int_{\underline{v}}^{v} ydF(y)^{n-1}dF(x)\Big].$$

A seller optimally chooses B^* to maximize her expected revenue shown above.

Mathews (2004, Theorem 1) shows that if the seller as well as bidders are patient (i.e., they do not discount the future expected payoffs), the seller should set the buyout price high enough so that bidders do not exercise their buyout option. This result is consistent with the existing studies on risk aversion. On the other hand, if the seller is impatient, she optimally chooses a low buyout price that is exercised with a positive probability, regardless of whether bidders are patient or impatient

(Mathews, 2004, Theorem 1, Theorem 2). Note that the optimal buyout price depends on the degree of time sensitivity. In addition, Mathews numerically shows that a time-sensitive seller chooses a lower buyout price that may be exercised quickly as she becomes more impatient (i.e., she discounts her payoff more), and that given the time sensitivity, an optimal buyout price is increasing in number of bidders.

If a buyout price is the permanent one, it may be optimal for the bidder to wait for a while and then exercise the buyout option. In other words, he remains active until the current price goes up to his threshold, and then exercises the buyout option. Therefore, the threshold function depends on buyout price as well as arrival time and current price; that is, $c(B, t, p_t)$.

Since a permanent buyout price does not disappear even if some bidders submit bids, the current price may depart from zero. In equilibrium, however, all bidders submit their bid at the end of the auction and hence the price remains unchanged until time T (Gallien and Gupta, 2007).

Clearly, there are other equilibria in this auction. For example, a newly arrived bidder may optimally wait for a while and then exercise the buyout price. In fact, the following threshold strategy also constitutes a symmetric equilibrium: for a certain threshold $c(B, t, p_t)$, a bidder with value v on arrival at time t exercises the buyout option at $\tau \geq t$ if his value is at or above the threshold ($v \geq c(B, t, p_t)$); alternatively, he submits his value v as a proxy bid at T if his value is below the threshold ($v < c(B, t, p_t)$). Gallien and Gupta (2007) explain that this equilibrium is not robust in a certain sense.

Gallien and Gupta (2007) analyze the difference in optimal buyout prices and seller utility between the two formats when both the seller and bidders are time sensitive and the number of bidders is uncertain. They numerically show the following results. First, they show that for a common buyout price, the threshold is lower and a bidder exercises the buyout option more often in the permanent format. This finding is counterintuitive at first glance, because a bidder appears to be under strong pressure when facing a temporary buyout price: a temporary buyout price disappears immediately if someone bids. Gallien and Gupta (2007) explain that there are more potential bidders in the permanent format, intensifying competition in bidding, because some competitors may have already arrived by the time a new bidder arrives at the auction. Thus, for a bidder, exercising the buyout option is more attractive in the permanent format. The uncertain number of bidders plays an important role in Gallien and Gupta's (2007) model.

Second, in case the bidders are extremely impatient ($\delta \to 0$), the seller optimally sets a permanent buyout price higher than the temporary one. The second result is intuitive. From the first result, a temporary buyout price is less exercised than a permanent one. Thus, the seller should optimally choose a temporary buyout price lower than the permanent one to prevent her from discounting the expected utility.

Third, an optimal buyout price is increasing in expected number of bidders in both formats.

Fourth, as compared with an auction without buyout price, a permanent buyout price increases seller revenue more than a temporary one.

4 Other explanations

Economists have proposed other theoretical models to explain the rational usage of buyout price. This section considers three frameworks: seller competition and multi-unit demand, participation cost, and reference point. All the studies below assume that the seller as well as bidders are risk neutral and patient.

4.1 Seller competition and multi-unit demand

The works mentioned above consider a monopolistic seller, but we often observe that similar (or identical) items are sold on online auctions. Kirkegaard and Overgaard (2008) extend Black and de Meza's (1992) model to formalize this situation and study a temporary buyout price.

We first examine Black and de Meza's (1992) finding regarding sequential second-price auctions. In their model, two sellers sequentially intend to sell identical items to $n \geq 2$ bidders demanding two units of the item with diminishing utility. A bidder with value v obtains utility v from the first unit and kv $(< v)$ from the second unit with $k \in (0, 1)$. Clearly, in the second auction, bidders have a weakly dominant strategy to submit the marginal value, that is, v for the first unit and kv for the second unit. Black and de Meza show that in the first auction, bidders optimally submit a bid below their values ($b(v) < v$) in a symmetric equilibrium. Specifically, in the first auction, a bidder with value v submits

$$\begin{aligned} b(v) &= E(\max\{ky_1, y_2\}|y_1 = v) \\ &= \frac{1}{F(v)^{n-2}}\Big(kv(F(kv))^{n-2} + \int_{kv}^{v} x dF(x)^{n-2}\Big), \end{aligned}$$

where y_1 and y_2 represent the highest and second-highest values among $n - 1$ bidders, respectively.

Intuitively, competition in bidding is not severe in the first auction because every bidder can get a chance to obtain the first unit later even if he loses the first auction. Moreover, he may win the bid in the second auction even if his value is only the second highest among all bidders. Because of bid shading (i.e., placing a bid below the actual value), the first seller gains less than the second seller.

In an equilibrium, there are only two outcomes. The bidder with highest value wins two units ($v_1 > kv_1 > v_2$), and the bidder with highest value and the one with second-highest value obtain one unit each ($v_1 > v_2 > kv_1$). The intuition behind this equilibrium is as follows. Suppose that there are three bidders, X, Y, and Z with values x, y, and z, respectively. Without loss of generality, we assume that $x > y > z$ holds (Figure 1). Now, let us denote bidder X's bid in the i'th auction by x_i, $i = 1, 2$, and so on. According to the equilibrium bidding strategy, bidder X submits $x_1 = \max\{y, kx\}$ in the first auction.[5] In cases 1, 2, and 3, bidders X and Y obtain one unit each. Clearly, bidder X makes no profitable deviation because he cannot affect the winning price in the nature of the second-price auction. Bidder Y can gain one unit by a more intensive bid in the first auction, but gains nothing in the second auction. Therefore, such a bid merely increases his payment. Alternatively, in cases 4 and 5, bidder X obtains two units. Bidder Y can obtain one unit by raising his bid but wins in the first auction only if the payment exceeds his value. Figure 1 shows the highest and second-highest bids in the first and second auctions.

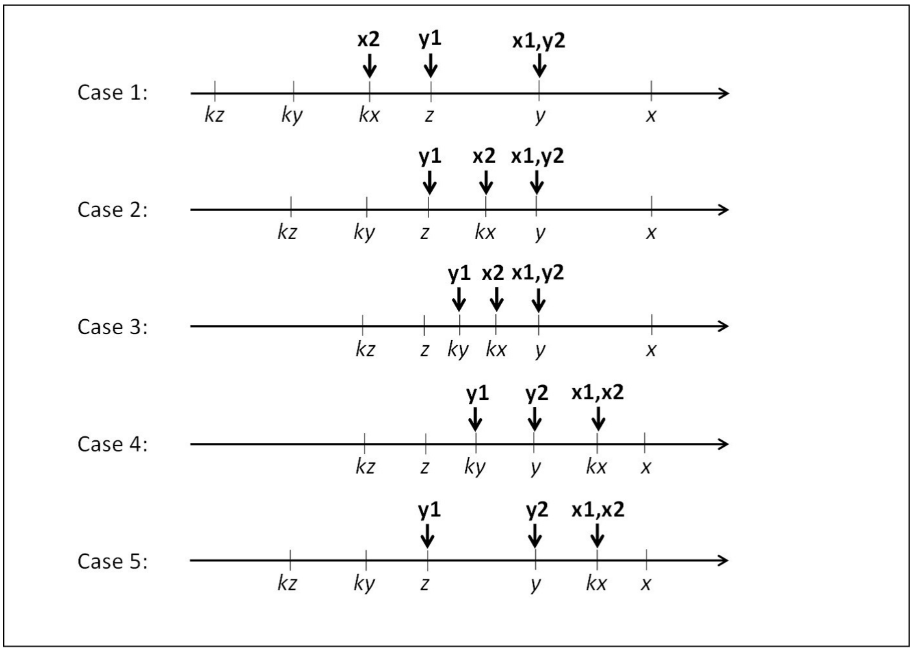

Figure 1: Bidder values and bids

Kirkegaard and Overgaard (2008) allow only the first seller to post a temporary buyout price in their model. As usual, bidders employ the threshold strategy to decide whether to accept or reject a buyout price. Kirkegaard and Overgaard (2008, Proposition 2) show that the threshold is non-monotonic in a buyout price. This result implies that multiple equilibria may arise, given the buyout price.

[5]To simplify this discussion, we describe equilibrium bids as if every bidder completely knows the other bidders' values.

A seller can increase revenue by choosing an appropriate buyout price in cases 4 and 5, but the bidder with second-highest value would obtain nothing without a buyout price. Suppose the buyout price is between the second-highest value and the second-highest bidder's bid (i.e., $y_1 < B < y$). By exercising the buyout option, the second-highest bidder can obtain one unit and gain a positive payoff (i.e., $y - B > 0$). On the other hand, the first seller can sell her item at a higher price (i.e., $B > y_1$). In other words, the additional revenue by posting a buyout price stems from changing the winner in the first auction. However, a seller may fail to post a buyout price within the appropriate range stated above because of uncertainty about bidder values. A buyout price set below y_1 reduces seller revenue. Kirkegaard and Overgaard (2008, Proposition 3) show that the advantage dominates the disadvantage when a buyout price is appropriately chosen and the first seller's expected revenue increases with a buyout price. The optimal buyout price is accepted with a positive probability (Kirkegaard and Overgaard, 2009, Theorem 1), and thus a buyout price results in inefficiency.

Moreover, Kirkegaard and Overgaard show that a buyout price reduces the second seller's revenue as well as the sum of revenue of the first and second sellers.

4.2 Participation cost

Empirical evidence shows that bidders incur positive costs for participating in auctions and bidding. A participation cost is often discussed in the context of choosing selling formats, that is, pure auctions, auctions with buyout price, and a posted price. The literature interprets a participation cost in (at least) two ways. A participation cost emerges from bidding behavior (Wang et al., 2008; Sun et al., 2010). Usually, it is difficult for bidders to determine a bid price from information such as the potential number of competitors and the current price. This type of costs, a cognitive cost, might discourage bidders from placing a bid and encourage them to exercise a buyout option. Alternatively, bidders may find it disgusting to search for particular objects from excessive items on online auctions and hence hesitate to participate in auctions (Che, 2011). This type of costs reduces the chance of a buyout price being accepted as well as a bid being placed because bidders may leave auctions owing to the cost.

Wang et al. (2008) and Sun et al. (2010) consider the impact of the former type of costs on the optimal choice of selling formats.

Wang, Montgomery, and Srinivasan introduce separately the costs bidders incur to submit a bid (participation cost) and to exercise a buyout option (completion cost). In their model, emulating eBay auctions, the seller first sets a temporary buyout price, and then the bidders decide whether to exercise the buyout option and what bid price to place on arrival. The number of bidders $n \geq 2$ is exogenous. Given the buyout price, while a bidder with a sufficiently low value (i.e., below the participation threshold) leaves the auction, a bidder with a sufficiently high value (i.e., above the buy threshold) immediately buys the item at the buyout price. A bidder with intermediate value incurs a participation cost and takes part in the bidding process. Both participation and completion costs affect the thresholds.

By using the above model with a uniform distribution of bidder value, Wang, Montgomery, and Srinivasan derive a symmetric equilibrium and obtain the following results. First, the participation threshold is increasing in participation cost and number of bidders. In other words, bidders are more likely to participate in an auction and submit a bid as the participation cost gets lower and number of bidders fewer. The impact of participation cost is clear. The latter is also intuitive. A bidder with fewer competitors has a larger chance of winning and a stronger incentive to enter an auction.

Second, the buy threshold is increasing in buyout price and decreasing in participation cost and number of bidders. In other words, bidders are more likely to exercise a buyout option if the buyout price is set lower, the participation cost gets higher, and there are more bidders. A relatively high participation cost increases the advantage of a buyout price for bidders because bidders can save on the participation cost by exercising the buyout option. Similarly, bidders find it more beneficial to exercise the buyout option if they face more competitors, because an increase in the number of bidders intensifies bidding competition and reduces the chance of winning the auction.

Third, an optimal buyout price is unique, increasing in number of bidders but indeterministic in participation cost. A positive correlation between the optimal buyout price and number of bidders is consistent with Gallien and Gupta's (2007) finding.

Finally, a numerical analysis shows that a buyout price generates an increase in seller revenue with a wide range of parameters of number of bidders and participation cost.

Following the empirical studies of online auctions, Sun, Li, and Hayya (2010) introduce *entry* and *operation* costs and compare the three formats: posted price, pure auction, and auction with a buyout price. Bidders incur an entry cost for participating in auctions, but do not have to pay extra for buying an item at the posted price. On the other hand, a seller incurs an operation cost when the item remains unsold, regardless of whether selling through a posted price or auction with/without a buyout price. They numerically show that under a broader range of parameters (number of bidders and participation and operational costs), a seller prefers an auction with buyout price to a pure auction (i.e., an auction without buyout price).[6]

[6] Sun, Li, and Hayya report that a posted price can outperform an auction with buyout price when the number of bidders is large and participation cost high (Sun et al., 2010, Observation 3). In other words, a seller's optimal choice of format depends on these parameters (i.e., number of bidders and participation and operational costs). They state that this observation can explain why these formats co-exist on online auctions.

Che (2011) uses a two-bidder two-type model, similar to Budish and Takeyama's (2001) model, and studies a temporary buyout price. The differences are in entry cost and sequential arrival of bidders. A seller initially chooses a buyout price and a reserve price. A second-price auction consists of two periods. In period 1, on observing the buyout and reserve prices, a bidder (early-arrived bidder) arrives and decides whether or not to enter the auction by incurring the entry cost. In period 2, another bidder (arriving later) arrives and decides whether or not to enter the auction by incurring the entry cost after observing the early-arrived bidder's entry decision as well as the buyout and reserve prices.

In a benchmark where the seller sets only the reserve price, she optimally chooses a reserve price that is either high or low. A high reserve price prevents a low-value bidder from entering in both periods; thus, the seller can sell the item for a high price if at least one bidder has a high value. Alternatively, a low reserve price encourages both types of bidders to enter in period 1, inducing two outcomes. A high-value bidder enters an auction in period 2 if the early-arrived bidder is less likely to have a high value, and does not otherwise.

A low-value bidder never enters an auction in period 2 if the early-arrived bidder entered in period 1, because a later-arrived bidder with low value cannot gain a positive payoff. The entry of a high-value bidder in period 2, on the other hand, depends on the probability of the early-arrived bidder having a low value. Note that a later-arrived bidder with high value can gain a positive payoff if and only if the early-arrived bidder has a low value. Therefore, if a bidder has a high value with a sufficiently high probability, there would be no entry in period 2. In other words, a low reserve price discourages the later-arrived bidder from entering in some cases.

A buyout price can improve this situation for a seller. Che (2011) derives two equilibria where solely a high-value bidder can exercise a buyout option, similar to the equilibria in Budish and Takeyama (2001). In the first equilibrium, a seller posts a low reserve price with an appropriate buyout price. A high-value bidder enters an auction in period 1 and immediately accepts the buyout price, but a low-value bidder does not enter the auction. However, both types of bidders enter the auction in period 2 and submit a bid.

In the second equilibrium, a seller posts a low reserve price with an appropriate buyout price. A high-value bidder enters an auction in period 1 and immediately accepts the buyout price; a low-value bidder also enters the auction. However, in period 2, the high-value bidder enters the auction and submits a bid, but the low-value bidder does not enter.

A buyout price, accompanied by a low reserve price, encourages a later-arrived bidder to enter the auction. Consequently, a seller obtains higher revenue in both the equilibria than in the benchmark case. The two equilibria lead to efficient outcomes.

4.3 Buyout price as a reference point

Shunda (2009) adopts a behavioral economics framework to examine the rationality of using a buyout price and constructs a model similar to Rosenkrantz and Schmit's (2007) model, where bidders have reference-dependent utility. Bidders can incur disutility if the winning price is far from a certain reference price. The only difference between the models is that in Rosenkrantz and Schmit (2007), bidders use a reserve price to form the reference price, but in Shunda (2009), the reference price (ρ) is given as a convex combination of the buyout and reserve prices; that is, $\rho = \lambda r + (1-\lambda)B$ with $\lambda \in (0,1)$. Conditional on winning with payment x, a bidder with value v and reference price ρ obtains

$$v - x - \varepsilon(x - \rho).$$

The positive impact of a reference price is featured by ε increases, where $\varepsilon = 0$ corresponds to a standard reference-free preference.

An auction consists of two stages. In the first stage, the seller chooses temporary buyout and reserve prices and bidders simultaneously decide whether to accept or reject the buyout price. If all bidders reject the buyout price, the second stage, that is, a sealed-bid second-price auction, emerges.

Shunda (2009, Proposition 1, Proposition 2) shows that the two thresholds characterize a unique symmetric equilibrium. A bidder accepts a buyout price if his value exceeds the *buyout threshold*. A reference-dependent utility does not change this feature. As usual, the buyout threshold is determined as the value of the bidder who is indifferent between accepting and rejecting the buyout price, given that all other bidders follow the equilibrium strategy. In the second stage, a bidder participates in an auction and places a bid if his value exceeds the *participation threshold*. The following proposition specifies these two thresholds.

Proposition 4 (Shunda (2009)) Suppose that bidders have a reference-dependent utility. Then, there exists a unique symmetric equilibrium. In the first stage, bidders employ the following threshold strategy. A bidder with value v accepts the buyout price B if it is at or below a certain buyout threshold $B(v,r)$. The buyout threshold satisfies

$$B(v,r) = \frac{v + \varepsilon\lambda r}{1+\varepsilon\lambda} - \left(\frac{n(1-F(v))}{(1-F(v)^n)(1+\varepsilon\lambda)}\right)\int_{V(B(v,r),r)}^{v} F(x)^{n-1}dx.$$

The buyout threshold $B(v,r)$ is increasing in bidder value (v) and reserve price (r).

In the second stage, the bidder has a weakly dominant strategy in which if he has a value at or above a certain participation threshold $V(B,r)$, he participates in the auction and submits a bid of

$$\beta(v) = \frac{v+\varepsilon\rho}{1+\varepsilon},$$

and does not participate in the auction otherwise. The participation threshold satisfies

$$V(B, r) = (1 + \varepsilon)r - \varepsilon\rho = (1 + \varepsilon - \varepsilon\lambda)r - \varepsilon(1 - \lambda)B.$$

The participation threshold $V(B, r)$ is increasing in buyout price (B) and decreasing in reserve price (r).

This proposition indicates a positive impact of buyout price on bidding behavior. In a dominant strategy, a bidder raises the bid with buyout pricein the subsequent auction after rejecting the buyout price. Shunda emphasizes the importance of this result. Other theoretical works assuming a reference-free utility cannot explain the effect of a buyout price on bidding behavior, although empirical evidence indicates that a buyout price itself raises the winning bid.

A buyout price affects the decision on entry in an auction as well. A high buyout price encourages bidders to participate in an auction ($\partial V(B, r)/\partial B < 0$), whereas a high reserve price discourages participation ($\partial V(B, r)/\partial r > 0$). On the other hand, the buyout price as well as reserve price intensifies bidding competition ($\partial\beta(v)/\partial B > 0$ and $\partial\beta(v)/\partial r > 0$).

Finally, we discuss the optimal choice of a buyout price and the efficiency of an auction with buyout price. Given the reserve price r, let v^* and V^* be the buyout and participation thresholds, respectively, associated with the buyout price B^*; that is, $B^* = B(v^*, r)$ and $V^* = V(B^*, r)$. Suppose that bidders follow the threshold strategy. By choosing B^*, a seller obtains the expected payoff

$$R(v^*, r) = \int_{V^*}^{v^*} \Big(\frac{1}{F(x)^{n-1}} \int_{\underline{v}}^{V^*} r dF(y)^{n-1} + \int_{V^*}^{x} \Big(\frac{y + \varepsilon\rho}{1 + \varepsilon}\Big) dF(y)^{n-1} + \int_{v^*}^{\bar{v}} B(v^*, r) dF(x)^{n-1}\Big).$$

Shunda (2009, Theorem 1) shows that a seller optimally chooses the cutoff $v^* < \bar{v}$, implying that the buyout price is accepted with a positive probability. Further, in this model, an appropriate buyout price leads to inefficiency.

5 Empirical studies

As shown above, a number of studies theoretically explain that for a seller, posting a buyout price is rational behavior, and suggest that a buyout price raises seller revenue. Theory might not provide testable predictions because key factors such as risk attitude and patience are not usually available in field data. Field studies are usually motivated with questions such as who uses a buyout option and when, and focus on the relation between observable seller characteristics and buyout price. On the other hand, experimental studies can control for the environment and examine bidder behavior. In this section, we examine some empirical studies.

5.1 Field study

This subsection introduces three field studies. Anderson et al. (2008) investigated the relation between seller and product characteristics and Buy-it-now price. What auctions do sellers tend to post a buyout price and who posts a Buy-it-now price? Anderson et al. (2008) used the original dataset collected from eBay to answer these questions. Chen et al. (2013) studied the buyout price with similar motivations as Anderson et al. (2008). Chen et al. (2013) first constructed a theoretical model relating to risk aversion and then empirically tested their predictions. They chose Taiwan Yahoo Auction for building the dataset. Both studies in common consider the impact of Buy-it-now price on seller revenue. Wang et al. (2008) were motivated with the issue of optimal choice of selling formats. They first constructed a theoretical model relating to participation cost and then empirically tested their predictions using data from eBay. Wang et al. (2008) focused on how a Buy-it-now price is influenced by auction environments such as participation cost, reserve price, and number of potential bidders. In what follows, we examine these studies in detail.

Anderson et al. (2008) collected data from the Palm Vx PDA (a personal digital assistant) auctions on eBay from August 6 to September 11, 2001. They focus on 722 samples from a successful sale: 212 auctions with Buy-it-now price and 510 auctions without one. The average transaction price is \$201.5 in the former and \$198.0 in the latter.

They investigated the effects of product and seller characteristics on seller choices. The empirical analysis was carried out as follows. First, they estimated the effects of product and seller characteristics on seller choices. Product characteristics include the condition of items (new or damaged), and seller characteristics include the number of listings by the seller and the seller's ratio of negative feedback score. They use Ordinary Least Squares (OLS) estimation for continuous choices such as starting and Buy-it-now prices and logit estimation for binary choices such as sellers' decision on whether to offer a Buy-it-now option.

Second, they estimated the contribution to the transaction price using 2-stage Least Squares (2SLS) estimation. To control for potential endogeneity, they employed four instrumental variables: the duration, number of bids, number of unique bidders, and whether the Buy-it-now price is accepted. As noted above, the dataset is restricted to auctions resulting in a successful sale; thus, the result is conditional on successful sale.

Each sample includes product characteristics such as quality and condition (e.g., new or damaged product) and seller characteristics such as frequency of listing items (e.g., once or multiple times) and reputation (e.g., ratings or comments on transactions). Anderson et al. (2008) clarified the relation between product and seller characteristics and seller choice on starting and Buy-it-now prices, and predicted auction outcomes by using regression analysis.

Their findings are as follows. First, with regard to product characteristics, sellers on eBay appear to put a Buy-it-now price more on new items and damaged ones. The share of Buy-it-now auctions of new items (31.8%) and items mentioning significant damages (33.3%) exceeded the average share (29.4%). However, the Buy-it-now prices of new and damaged items are totally different. As a matter of fact, OLS regressions suggest that sellers increase the Buy-it-now price by $20.0 for a new item but reduce it by $32.2 for a damaged one.

Second, the frequencies of listing items and posting a Buy-it-now price are positively correlated. Statistics indicate that 34.7% of frequent sellers posted a Buy-it-now price, whereas the ratio of infrequent sellers using a Buy-it-now price was 25.2%. This result, suggesting a positive relation between experience in trading on eBay and usage of Buy-it-now price, has been confirmed by other empirical studies (Durham et al., 2004).[7]

Third, providing a Buy-it-now price raises the selling price. A regression analysis using 2SLS estimation found that a $1 increase in Buy-it-now price raises the selling price by $0.29. Note that the selling price in a Buy-it-now auction increases even when the Buy-it-now price is rejected. In fact, the average selling price of cases of the Buy-it-now price being accepted is $201.8 and of cases of the Buy-it-now price being rejected is $201.4.

Chen et al. (2013) empirically investigated the impact of a buyout price on seller revenue. There are two important differences between Chen et al. (2013) and other empirical studies. First, Chen et al. (2013) chose (Taiwan) Yahoo Auction, which provides a buyout price in the permanent format, rather than eBay. They point out the advantage of empirically studying a permanent buyout price in that the record of a buyout price remains until the auction closes.

Second, they exclude auctions with a Buy-it-now price equal to the starting price from their main analysis. Such a usage of buyout price features fixed price selling. This is an important point because posting a buyout price and fixed price selling are completely different strategies to a seller.

Chen et al. (2013) collected data from digital camera auctions (several types of Nikon Coolpix digital compact cameras) on Taiwan Yahoo Auction from April 3 to August 2, 2008. The empirical analysis mainly focused on 785 samples—131 auctions with Buy-it-now price and 654 auctions without one. The average transaction price is NT$6,977 in the former and NT$3,758 in the latter.

[7]Durham et al. (2004) collected 138 samples of US Silver Dollar (American Eagle coins) auctions from eBay and study the functions of a temporary buyout price. In their experimental field study, all auctions have the same starting price of $1.00, but the Buy-it-now prices were diverse. Durham et al. (2004) found a positive correlation between feedback number and frequency of posting a Buy-it-now price. Moreover, they found that Buy-it-now prices are accepted more often in auctions listed by a seller with better reputation and less accepted in auctions listed by new sellers (i.e., sellers with limited feedback). A buyout price statistically and significantly raises the selling price. The average price for 41 auctions with buyout price was $10.27 and the remaining auctions had an average selling price of $9.56.

The analysis is twofold. First, they considered the selection problem, observing the transaction price only in auctions resulting in a successful sale. For the selection problem, they adopted a probit selection model. The variables explain a successful sale and include the seller's feedback rating score, the number of bidders, and the starting price.

Second, they estimate the contribution to the transaction price using the 2SLS method. For the estimation, they employed two instrumental variables (number of days since the seller joined Yahoo Auction as a member, and number of listings by the seller) to consider the potential endogeneity on posting a Buy-It-Now price.

They made the following findings. First, probit regression showed the negative effect of a starting price on successful sale. On the other hand, the seller's feedback rating and number of bidders positively contributed to a successful sale.

Second, 2SLS analysis results with the instruments suggest that a Buy-it-now price significantly increases the transaction price. The seller's feedback rating and number of bidders have positive impacts on the transaction price as well. The auction of new items tends to end with higher transaction prices, but this is not statistically significant.

Wang et al. (2008) predicted the positive correlation between optimal buyout price and number of potential bidders and the negative impacts of the participation cost of bidders and reserve price on the optimal buyout price in their theoretical model. They attempted to test these predictions using the data of four categories of electrical product auctions on eBay.[8] They collected the data from April 1 to May 20, 2003. They employed the original auction duration and feedback rating score as proxy variables for the number of potential bidders and participation cost of bidders, respectively. The dataset consists of a total 1418 samples, where approximately 30% of auctions indicate a Buy-it-now price, the share of Buy-it-now auctions being diverse among the four categories.

They first test their prediction using the log-normal regression model. For the analysis, they restrict their attention to Buy-it-now auction data. Second, using the multinominal logit model, they estimate the effects of the variables on endogenous entry in an auction.

Wang et al. (2008) empirically make the following findings. First, regression analysis shows the positive correlation between duration and Buy-it-now prices. Since an auction with longer duration tends to attract more bidders, duration can work as a proxy variable for number of potential bidders. Thus, this evidence supports the prediction of positive relation between the optimal buyout price and number of potential bidders.

Second, a Buy-it-now price is positively correlated with bidder experience measured by feedback

[8] The categories are Apple iPod MP3 player 10 GB, Lexar memory stick 128 MB, KitchenAid 525 W mixer, and KitchenAid KSM103 professional mixers.

rating. Wang et al. (2008) state that a bidder with higher feedback rating incurs a smaller participation cost because more experienced bidders are more familiar with the auction rules and transactions. Thus, this evidence supports the prediction of positive relation between optimal buyout price and participation cost.

Third, they estimate the impacts of variables on the choice of selling formats. Theory predicts that a seller is likely to choose a pure auction when the participation cost, reserve price, and number of bidders are high. A logit analysis supports this prediction in all the four categories.

5.2 Field experiment

Standifird et al. (2005) conducted a field experiment using the eBay platform and considered the impacts of a buyout price on bidding behavior. They prepared new eBay accounts for the auction of 84 US Silver Dollar (American Eagle coins) on eBay between October and December 2001. They explain that it is easy to obtain and evaluate the coins and that the auction participants do not buy the coins for resale. The auctions were controlled for in that they have identical starting prices ($1.00), shipping costs ($2.00), and descriptions, although the Buy-it-now prices were diverse. The auctions were classified into four groups, each consisting of 21 auctions. The silver coins in the first group were sold in auctions without a Buy-it-now price to obtain the market price of the coin. From the market price ($6.82), the rest of the auctions offered different Buy-it-now prices; that is, a high price ($8.05) for 21 coins in the second group, an average price ($6.80) for the third group, and a low price ($5.60) for the last group.

All the coins were successfully sold out. The high Buy-it-now price was never accepted, but out of 21 auctions, 2 and 5 auctions (9.5% and 23.8%, respectively) in the third and fourth groups respectively end with Buy-it-now price.

Standifird et al. (2005) discovered the following findings. First, a Buy-it-now price did not affect the selling price. Since all the 21 coins were sold out through auction in the first group with a high Buy-it-now price, it may seem natural that the average final bid price ($6.72) is almost the same. A chi-square test confirms no statistically significant difference between the final bid prices in all the four treatments. The finding suggests that a Buy-it-now price does not increase seller revenue.

Second, experienced bidders are more likely to accept a Buy-it-now price. The average rate of bidders accepting a Buy-it-now price was 179.3, whereas that of bidders not exercising a Buy-it-now price was 79.2. As Standifird et al. (2005) noted, the small sample of bidders exercising the Buy-it-now price (7 out of 62 or 11.1%) limits the scope of the analysis.

Finally, few bidders accepted a Buy-it-now price set below the market price. In fact, only 23.8% of the Buy-it-now prices were accepted. Moreover, the average final bid price exceeded the Buy-it-now price. This finding contradicts the theory suggesting risk aversion or impatience of bidders. Alternatively, Standifird et al. (2005) explain this phenomenon by hedonic benefits; that is, bidders enjoy participating in auctions and beating competitors.[9]

Grebe et al. (2006) conducted a framed field experiment and analyzed the impact of a Buy-it-now price on seller revenue and auction efficiency. They performed seven experimental sessions, each session consisting of six eBay auctions. In total, 84 subjects were assigned to a group consisting of a seller and two bidders, following Ivanova-Stenzel and Kroger's (2008) lab experiment. The experimenters prepared valid eBay accounts with similar transaction history and rating to control for the effect of reputation. A seller uses the prepared account to log into eBay. On the other hand, bidders use their existing accounts. In the experiment, a seller first accesses eBay and lists on a used book, and then she posts a Buy-it-now price. The starting price was set as the minimum price. Second, two bidders are separately informed their "values" of the auctioned item, which were independently drawn from $V = \{1, 1.5, 2, \cdots, 49.5, 50\}$ with equal probability, while a seller evaluates an item at zero. In the following discussion, we normalized V to $[0, 1]$ with uniform distribution. Bidders have asymmetric roles. Bidder 1 has to decide whether to exercise the Buy-it-now option within two minutes. If Bidder 1 rejects the offered price, both Bidder 1 and Bidder 2 compete in bids. Since the bidders were given five minutes for bidding, they could make multiple bids. In addition, they conducted a follow-up experiment where the experiments offer ten pairs of lotteries to the subjects. A series of lotteries provides the risk attitude of subjects.

With the normalization of V to $[0, 1]$ and a uniform distribution, theory predicts as follows. If both the seller and the bidders are risk neutral, the seller optimally sets the Buy-it-now price high enough ($B > 0.50$) for the bidders not to accept in equilibrium. According to the equilibrium threshold strategy, bidders accept $B < 0.50$ but reject $B > 0.50$.

The following results are obtained. First, as theory predicts, the average Buy-it-now price ($B = 0.50$) falls within the range of optimal prices ($B \geq 0.50$). In fact, the price of $B = 0.50$ is the one most frequently observed (13.3%). However, 47% of buyout prices were chosen below the optimal level. This observation implies that half of the sellers are risk averse.

Second, 36% of buyout prices were accepted. High buyout prices ($B > 0.50$) were often accepted whereas low buyout prices ($B < 0.50$) were sometimes rejected. In fact, 31% of bidders accepted high buyout prices ($B > 0.50$) and 14% rejected low prices ($B < 0.50$). This result indicated diverse risk attitudes among bidders.

[9]The concept is commonly used in the marketing and psychology literature. Hedonic benefits emerge as a significant factor, where the transaction itself provides value to the individual consumer independent of actual procurement of a particular item (Standifird et al., 2005).

Third, a buyout price did not significantly impact seller revenue and bidder payoff, although a buyout price yielded a small reduction (6%) in bidder payoff. In addition, higher Buy-it-now prices significantly lead to higher seller revenue.

Fourth, after the Buy-it-now prices were rejected, 65% of bids were set below the bidder's value. In fact, bidders reduced their bids by 13.5%. That is, they did not follow a weakly dominant strategy.

Fifth, the ratio of efficient outcomes was 87%.

Finally, experience in trading on eBay has no significant impact on the decision on Buy-it-now prices, but has a weak positive impact on bidding behavior; that is, experience reduces the degree of underbidding.

Ivanova-Stenzel and Kroger's (2008) lab experiment and Grebe et al.'s (2006) framed field experiment give entirely consistent results, except on one factor. Underbidding is observed in the latter but not in the former study.

In addition, Grebe et al. (2006) collected 668 auction samples in arts, antiques, and collectibles on eBay in March and April 2002. They observe that selling prices did not reach the Buy-it-now prices in 92% of auctions when the Buy-it-now prices were rejected, implying that bidders could make a "correct" decision. This observation contradicts Anderson et al.'s (2008) result. Furthermore, they note that time preferences might not explain the benefits of a buyout price, because a Buy-it-now price can save only 2.9 days while the duration is, on average, 7 days.

5.3 Laboratory experiment

Ivanova-Stenzel and Kroger (2008) conducted a laboratory experiment to consider the impacts of a buyout price on seller revenue, bidder payoff, and auction efficiency. The experiment was conducted at Humboldt University on a total of 90 subjects recruited from students of various departments at the university. They performed four experimental sessions, each session comprising eight auctions. The subjects were randomly assigned to a group consisting of a seller and two bidders. The bidder value was independently drawn from $V = \{0, 1, 2, \cdots, 99, 100\}$ with equal probability, while a seller evaluates an item at zero. The auction consists of two stages. In the first stage, one bidder is randomly selected from two bidders. A seller chooses an integer between 0 and 100 as buyout price. The selected bidder then decides whether to accept or reject the buyout price. If he rejects it, the second stage emerges. In the second stage, both the bidders enter an ascending auction. Note that the second bidder is not informed of what the rejected buyout price was. This random selection of a bidder features online auctions in which bidders randomly arrive at an auction and in many cases early-arrived bidders can solely exercise the buyout option.

We normalize V to $[0, 1]$ with a uniform distribution. In equilibrium, theory suggests that if both the seller and the bidders are risk neutral, the seller should optimally choose a high price ($B > 0.50$), which is never accepted by the selected bidder. A bidder follows the threshold strategy in which he accepts $B < 0.50$ but rejects $B \geq 0.50$.

Ivanova-Stenzel and Kroger (2008) made the following findings. First, sellers on average set the optimal buyout price as $B = 0.51 > 0.50$, but more than half of the buyout prices (51.6%) were chosen below the optimal level. This result may indicate the risk aversion of sellers.

Second, 33% of buyout prices were accepted. High buyout prices ($B > 0.50$) were frequently accepted (57%), whereas low ones ($B < 0.50$) were sometimes rejected (18%). This result implies diverse risk attitudes among bidders. Moreover, the excessive acceptance by over half of the bidders may imply that the majority of bidders are risk averse. In fact, they note that the assumption of risk-averse bidders with CRRA ($u(x) = x^{1-\alpha}/(1-\alpha)$) fits the data. Empirical evidence confirms that a threshold strategy is prevalent. Only 10% of bidders did not employ the threshold strategy.

Third, a buyout price did not significantly impact seller revenue and bidder payoff, although bidders slightly reduced the payoffs with a buyout price (11% reduction in bidder payoff). A buyout option gives the advantage to neither seller nor bidder. As Ivanova-Stenzel and Kroger (2008) discussed, the overall results coincide with theoretical predictions assuming that both the seller and bidders are risk neutral.

Fourth, the introduction of a buyout price did not change bidding behavior. In fact, they statistically show that bidders submitted bids according to a dominant strategy, regardless of whether they faced a buyout price or not.

Finally, 85% of outcomes were *ex post* efficient. As Ivanova-Stenzel and Kroger (2008) point out, it is not clear whether the introduction of a buyout price exactly induced *ex post* inefficient outcomes in the experiment, because other experimental studies of a sealed-bid second-price auction without a buyout price report that the ratio of efficient outcomes is approximately 90% (Guth et al., 2005; Pezanis-Christou, 2002).

Shahriar and Wooders (2011) conducted a laboratory experiment at the University of Arizona and explored the impact of a temporary buyout price on seller revenue and auction efficiency under both private and common values. They performed six experimental sessions, each session comprising 30 auctions. All subjects (totally 96) were randomly assigned to a group consisting of four bidders. The subjects in each group participated in either of four auctions: private value auctions with and without a buyout price, and common value auctions with and without a buyout price. In this section, we focus on private values. A bidder was given a private value independently and uniformly drawn from $[0, 10]$ in dollars, and the buyout price was set at \$8.10 by the experimenters. From the answers to the questionnaire aimed to measure the risk attitude of subjects, any buyout price above $7.50 theoretically raises seller revenue. Following the theoretical frames (Mathews and Katzman, 2006; Reynolds and Wooders, 2003, 2009; Shahriar, 2008), a two-stage game features an auction with temporary buyout price. In the first stage, bidders simultaneously decide whether to accept or reject the buyout price. If all bidders reject the buyout price, bidders enter the second stage, which is an ascending auction.

Shahriar and Wooders (2011) made the following findings. First, a buyout price was accepted in 45% of auctions, implying that bidders are risk averse. They estimated a degree of risk aversion, assuming that bidders have CARA utility, and obtained evidence that bidders are significantly risk averse ($\alpha = 1.092$). Probit regressions show that among bidders with value above the buyout price, a $1 increase in bidder value significantly increases the probability of acceptance by 26.6%.

Second, the introduction of a buyout price entirely yields a 6.8% increase in seller revenue from $6.06 to $6.47. This increase is statistically significant. A pairwise comparison also shows that bidders exercising a buyout option would submit a bid below the buyout price if they participated in auctions without a buyout price. Moreover, the data show that a buyout price reduces the variance in seller revenue, suggesting that a risk-averse seller will also prefer a buyout option.

Third, the introduction of buyout price did not impact bidding behavior. After rejecting a buyout price, bidders submitted a bid in the subsequent auction as if they participated in an auction without a buyout price. However, note that bidders did not follow a dominant strategy but lowered the bid in auctions with/without a buyout price. Regressions show that the bids were approximately 95% of bidders' values.

Finally, as theory predicts, auction efficiency reduces with buyout price. The bidder with highest value obtained an item in 93.3% of auctions without a buyout price, whereas the ratio was only 89.4% in auctions with a buyout price. That is, introducing a buyout price reduced *ex post* efficiency by 3.8%. However, the difference is not statistically significant.

The overall results appear to be consistent with the theoretical predictions assuming risk-averse bidders.

Durham et al. (2013) conducted a laboratory experiment and considered the impacts of buyout price on seller revenue, the frequency of exercising a buyout price, bid timing, and auction efficiency. Their study was especially motivated by the question of why eBay and Yahoo adopt different buyout systems. Durham et al. (2013) recruited 48 subjects from students of economic courses at Western Washington University and performed eight experimental sessions between May 2005 and October 2009. Each session consisted of four blocks of 10 auctions; thus, each subject engaged in totally 40 auctions. The subjects were randomly assigned to a group consisting of two bidders. Two bidders first entered into a series of ascending auctions without a buyout price in the first block, and then a series of ascending auctions with temporary/permanent buyout prices in the subsequent blocks.[10] A bidder value is a uniform draw from $[1, 100]$, and the buyout prices are either high (75), middle (50), or low (25), as chosen by the experimenters. Bidders are given 60 seconds for each auction. After the experiments, the subjects answered a risk questionnaire aimed at measuring their risk attitude.

Since a low buyout price ($B = 25$) is suboptimal, in the sense of lowering seller revenue, we focus on the results relating to the middle and high buyout prices ($B = 50, 75$). First, the acceptance rates of permanent and temporary buyout prices are almost the same (55.8% vs. 52.6%). In fact, probit regressions show that the difference is not statistically significant. Naturally, in both formats, the probabilities were greater when the values of both bidders exceed the buyout price than when a single bidder has a value above it. Moreover, low buyout prices were more accepted than high ones.

Second, both temporary and permanent buyout prices improve seller revenue in common. Statistics show that permanent buyout prices yield a 12.8% higher revenue than temporary ones, but the difference is not statistically significant.

Third, both temporary and permanent buyout prices facilitate early bidding, defined as bids occurring in the first four seconds in their study. The data show that bids concentrate on the ending time in auctions without a buyout price; the timing is separated into early and late in auctions with a buyout price. Especially, in restriction to the proxy bidding case, 44% of bids were early bids when bidders faced a temporary buyout price, whereas only 18% were early bids in auctions with permanent buyout price. The difference is statistically significant. The result seems consistent with Gallien and Gupta's (2007) findings, indicating that a bidder submits a bid at the closing when facing a permanent buyout price.

Finally, buyout prices, regardless of whether they are temporary or permanent, improved auction efficiency. An item was allocated to a bidder with higher value in 69.6% of auctions without a buyout price. On the other hand, the shares were 77.4% in the temporary format and 73.3% in the permanent one. The final finding completely contradicts theoretical prediction and hence is interesting. All the theoretical works state that the introduction of a buyout price reduces auction efficiency; that is, the bidder with highest value does not always obtain an item. As stated above, late bidding was observed in all auctions, regardless of whether a buyout price existed or not. Durham et al. (2013) argue that late bidding (known as sniping) basically reduces auction efficiency, and that early bidding induced by a buyout price improves efficiency. This point can be empirically tested by conducting an experiment which employs a soft-close rule as ending auction, because late bidding occurs less in soft-close auctions (Roth and Ockenfels, 2002; Ariely, Ockenfels, and Roth, 2005; Ockenfels and Roth, 2006).

[10] Durham et al. (2013) distinguish two bidding systems. Bidders are allowed to submit a proxy bid, and not allowed.

In summary, the two formats impact seller and bidder behaviors in similar ways, except with regard to timing of bids.

Overall, the results obtained in empirical studies seem incoherent. We discuss the empirical findings below.

First, sellers on eBay tend to post relatively high Buy-it-now prices, although half of the subjects choose low buyout prices in laboratory experiments. Anderson et al. (2008) suggest signaling and bounded rationality to explain high Buy-it-now prices. Regarding Grebe et al. (2006) reporting no significant impact of experience of trading in eBay on Buy-it-now prices, high Buy-it-now prices may signal product characteristics. In laboratory experiments, sellers have no private information and thus prefer low buyout prices. In another line of explanation, the number of potential bidders may impact the choice of buyout prices. In online auctions, sellers can often infer the approximate number of bidders in their auction pace (e.g., *My eBay* in eBay and *My Auction* in Yahoo), especially after the item remains unsold. Therefore, it may be valuable to analyze the relation between number of bidders and buyout prices, both theoretically and experimentally.

Second, the acceptance rate of buyout prices is diverse in experiments. Clearly, the difference between buyout prices results in diverseness. In addition, experimental designs may directly lead to diverseness. The data in Shahriar and Wooders (2011) and Durham et al. (2013) report that a buyout price is exercised with a probability of approximately 50–60%. On the other hand, the probability in Ivanova-Stenzel and Kroger (2008) and Grebe et al. (2006) is about 33%. In fact, the environment of Shahriar and Wooders (2011) and Durham et al. (2013) may apply pressure on bidders to accept a buyout price, because bidders face direct competition. On the other hand, in Ivanova-Stenzel and Kroger (2008) and Grebe et al. (2006), a bidder is solely selected out and he alone can decide whether to accept or reject it. Thus, a bidder may be free from such a competition. This difference of pressure can perhaps explain the difference of probabilities of acceptance.

Third, it is not clear whether a buyout price raises seller revenue. Data from eBay show a significantly positive impact on seller revenue. Some experimental studies also obtain positive results, but others do not. Theory implies that the difference stems from the diverseness of risk attitudes between bidders.

Fourth, data from eBay imply that bidders raise bids if they observe a Buy-it-now price. On the other hand, experimental studies conclude that a buyout price does not have a significant impact on bidding behavior. Moreover, one experiment observes a dominant strategy (Ivanova-Stenzel and Kroger, 2008) whereas others report underbids (Durham et al., 20113 Grebe et al., 2006; Shahriar and Wooders, 2011).

6 Concluding remarks

Yahoo made its first move to introduce a buyout price in online auctions, and its model was followed by eBay shortly thereafter. Although a buyout option is preferred by many sellers and bidders, at first glance it seems irrational to use this technique. In fact, an auction is superior to a posted price under a variety of conditions, and the upper bound of a selling price can depress seller revenue. In such situations, economists have attempted to rationally explain what leads users to employ the buyout price. This paper marshals some of the existing studies on applying a buyout price, a frequently used method in online auctions.

The literature suggests some theoretical explanations. The first is risk aversion. If a seller and the bidders are risk averse in the sense that they avoid variance in selling price, they would benefit by applying a buyout price. A buyout price functions as insurance; the advantage of a buyout price lies in the risk premium that risk-averse users are willing to pay. Time sensitivity is another explanation. A seller saves her time by offering items with a lower buyout price, whereas bidders willingly pay a premium to quickly obtain the things they want. Behavioral economics presents another aspect of a buyout price. Along with a reserve price, a buyout price forms a reference price for bidders. Some other theoretical works suggest that a buyout price contributes to an increase in seller revenue in cases where bidders incur an entry cost and only one seller uses a buyout option among multiple competitors.

Field studies focus on the relation between a seller and product characteristics and a buyout price, and investigate a seller's decision on the use of a buyout price. The findings are that a buyout price is more likely to be employed by experienced sellers or those listing new or damaged items. Field and laboratory experiments analyze bidder behavior. These studies find that the threshold strategy is prevalent, as predicted in existing theory. However, studies show inconsistent results on whether a buyout price raises seller revenue and affects bidding behavior.

We saw a variety of theoretically and empirically considered cases where a buyout price raises seller revenue, but there are a few important exceptions. The first one is the effect of common value. Shahriar (2008) constructs a model of a common-value auction with temporary buyout price. Consisting of two stages, first the bidders receive a payoff-relevant signal individually, and then a common value is given from an average of all bidders' signals. Bidders are risk averse and have a CRRA utility. Similar to the results obtained in private-value auction, in a symmetric equilibrium, bidders follow a threshold strategy where they promptly exercise a buyout option if the buyout price is at or below the threshold.

In a specific case with two bidders, however, Shahriar (2008, Proposition 3) shows that any buyout price reduces seller revenue when exercised with a positive probability. The outcome implies that a common value possibly changes the impact of a buyout price dramatically. In the meantime, experimental observation does not support this result. Following Shahriar's (2008) model, Shahriar and Wooders (2011) conducted a common-value auction experiment with a temporary buyout price. From the report, a buyout price contributes to an increase in seller revenue, but the increase is not statistically significant. Besides, after turning down a buyout price, bidders submit a relatively lower bid than they do in an auction with no buyout price. This finding implies that a buyout price has a negative impact on bidding behavior when a buyout price is rejected; we see an opposite result in private-value auction.

The second one is discrete types. Inami (2011) extends Budish and Takeyama's (2001) model to $n \geq 2$ bidders with $m \geq 2$ types. Inami (2011) focuses on the equilibria where a bidder exercises a buyout price if his value is at or above a certain threshold and otherwise submits his value truthfully. Inami (2011) shows that a buyout price has an effect to increase seller revenue in two-type cases, but not necessarily in three-or-more-type cases. Discrete types may cause an optimal choice of buyout price to be more complicated.

On the other hand, an increase in seller revenue with a buyout price may not be important. As Bulow and Klemperer (1996) show, a seller should devote every effort to attract one additional bidder instead of bothering about reserve and buyout prices. Figure 2 illustrates the seller revenue in various cases where the bidder value is uniformly distributed in $[0, 1]$ interval. The vertical axis shows the seller revenue and horizontal axis the reserve and buyout prices. Without reserve and buyout prices, an additional third bidder induces a 50% raise in seller revenue (from 1/3 to 1/2). In a case where two bidders compete, a reserve price can deliver a 25% increase in seller revenue (from 4/12 to 5/12) if the seller can choose an appropriate reserve price. Similarly, an appropriate buyout price generates approximately a 10–30% increase in seller revenue, depending on the degree of risk attitude of bidders. In the cases shown in Figure 2, bidders have a CRRA utility in forms of $u(x) = x^\alpha/\alpha$, where $\alpha \in (0, 1]$ represents the degree of risk aversion and $\alpha = 1$ corresponds to risk neutrality. If a seller employs either the reserve or buyout price, an appropriate buyout price is more effective than a reserve price when bidders are sufficiently risk averse ($\alpha = 0.10$).

An optimal reserve price is theoretically clear, but a seller could fail to post an appropriate reserve price on online auctions. A downward failure is harmless to a seller, whereas a sufficiently high reserve price is harmful. Such mispricing has a severe effect for a seller when she posts a buyout price. Low as well as high buyout prices can lead to a reduction in seller revenue. As a matter of fact, a seller in online auctions faces uncertainty about the bidders' risk attitude and the interval of bidder value. Thus, the benefit of a buyout price may be overestimated.[11]

[11] Empirical evidence suggests that a buyout price is posted by sellers with a lot of experience in trading on online auctions (Wang et al., 2008; Chen et al., 2013). Chen et al. (2013) explain that sellers with more experience are more familiar with information such as risk attitude and the interval of bidder value and are willing to offer a buyout option.

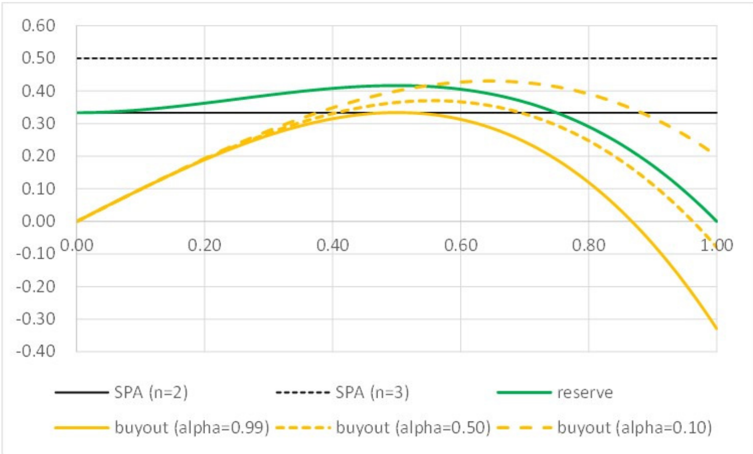

Figure 2: Comparison of Seller Revenue

We close this section by indicating directions for future study on this topic. First, we observe a number of second-hand items being listed on online auctions. Bidders are naturally interested in the quality or condition of used goods but are usually uninformed of such details. From a seller's perspective, she wishes to reveal more information if her item is of high quality or is in a good condition. A reserve price may contribute to satisfy the situation. Cai, Riley, and Ye (2007) characterize a symmetric equilibrium where a seller reveals her private information with a sense of security by using a reserve price. Empirical evidence shows that a starting price (i.e., public reserve price) has a slightly positive impact on selling price (Anderson et al., 2008). A buyout price can become another candidate for a credible signal. In fact, Anderson et al. (2008) note that the signaling function of a buyout price may explain the phenomenon of a selling price ending extremely high with a large buyout price. To the best of my knowledge, no theoretical paper so far has considered a buyout price as signal.

Second, sellers on online auctions post reserve and buyout prices in varied combinations. A natural question that arises is, What is the optimal combination of reserve and buyout prices? Since the pair jointly provides the lower and upper bounds of a bid price, deciding their optimal combination is equivalent to determining the optimal interval of a bid price.[12] Despite the introduction of both reserve and buyout prices in the model, a reserve price is exogenous in most of the studies.[13] The important exceptions are Shunda (2009) and Che (2011). Shunda (2009) introduces a reference price formed jointly by the reserve and buyout prices. The optimal buyout price exceeds the optimal reserve price, and Shunda's model delivers a higher optimal reserve price relative to the one where a reference price is solely formed by a reserve price. In the model where bidders incur participation cost,

[12] Chen et al. (2013) report the positive relation between the starting and Buy-it-now prices in Taiwan Yahoo Auction. The average of minimum bids is NT$5,978 in Buy-it-now auctions whereas it is only NT$4,991 in auctions without Buy-it-now price.

[13] For example, a reserve price is not a strategic variable in Gallien and Gupta (2007) and Reynolds and Wooders (2009).

Che (2011) characterizes an optimal combination of the reserve and buyout prices. However, only two values appear in Che's model and the relation between the reserve and buyout prices (i.e., complement or substitute) is generally ambiguous. With regard to the two major theoretical explanations in the literature on buyout price, risk aversion, and the impatience of participants, we await the complete answer to come from future research.

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