Analysis of an Internet Auction Market where Ascending Auction and Fixed-Price Selling Simultaneously Exist

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ABSTRACT
The auctions are nothing like what they once were. Some consumers prefer to buy stuff quickly at a fixed price. To meet such a need Internet auction sites offer a buyout option. Yahoo! JAPAN and uBid provide a permanent buyout option that a fixed-price sale is allowed within an auction, while eBay provides a temporary buyout option called “buy-it-now.” If a seller chooses to use a buyout option, shoppers can purchase items at a set price even when the merchandise is also listed in an auction. It has been reported that the buyout-option trades are increasing. Understanding how a buyout option affects the market is significant to design the future auction markets. For sellers there has been a keen interest in the choice between auctions and fixed-price (posted-price) selling. Previous studies have mainly focused on clarifying the conditions which selling format outperforms. However, researchers have paid little attention to the interaction between two selling formats. In auction sites, identical goods are sold in an auction and at a fixed-price simultaneously. To investigate the interaction between the two selling formats, we have analyzed the real auction data obtained from Yahoo! JAPAN auction, characterized the typical strategies of the seller, built a model, and carried out a simulation on it. Thus, we can successfully provide a model able to explain the situation that the two strategies of using ascending auction and fixed-price selling simultaneously exist.

Keywords
Auction, Internet Auction, Buyout Option

1. INTRODUCTION
The auctions are nothing like what they once were. Some consumers prefer to buy stuff quickly at a fixed price. To meet such a need Internet auction sites offer a buyout option. Yahoo! JAPAN¹ and uBid² provide a permanent buyout option that a fixed-price sale is allowed within an auction, while eBay³ provides a temporary buyout option called “buy-it-now.” If a seller chooses to use a buyout option, shoppers can purchase items at a set price even when the merchandise is also listed in an auction. It has been reported that the buyout-option trades are increasing [3]. Understanding how a buyout option affects the market is significant to design the future auction markets.

For sellers there has been a keen interest in the choice between auctions and fixed-price (posted-price) selling. Previous studies have mainly focused on clarifying the conditions which selling format outperforms. However, researchers have paid little attention to the interaction between two selling formats. In auction sites, identical goods are sold in an auction and at a fixed-price simultaneously.

To investigate the interaction between the two selling formats, we have analyzed the real auction data obtained from Yahoo! JAPAN auction, characterized the typical strategies of the seller, built a model, and carried out a simulation on it.

The rest of this paper is organized as follows. Section 2 describes the buyout option and the related researches about it. In section 3, the actual auction data is analyzed. Section 4 proposes the model considering the major strategies obtained from the actual data. In section 5, the experiments using the proposed model are conducted. Finally section 6 concludes this paper.

2. BUYOUT PRICE
A buyout option is one of the options used in Internet auction sites. When a seller uses the option, the seller sets a buyout price of his good in addition to a start price. When a buyer bids at the buyout price, the auction quickly ends and the buyer can purchase the good by using a buyout option and selling another good by using an ascending auction. Thus, we can successfully provide a model able to explain the situation that the two strategies of using ascending auction and fixed-price selling simultaneously exist.

¹http://auctions.yahoo.co.jp/
²http://www.ubid.com/
³http://www.ebay.com/
tion is available for the entire duration of the action, whereas a temporary buyout option may cease to be available before the conclusion of the auction [5]. For example, “Buy Price (Sokketsu Kakaku in Japanese)” in Yahoo! JAPAN auction corresponds to a permanent buyout option. On the other hand, “Buy It Now” option in eBay corresponds to a temporary buyout option. This paper considers the auctions with a permanent buyout option.

2.1 Fixed-Price Selling at a Buyout Price

Setting a buyout price equal to the start price corresponds to selling at a fixed-price in auctions. Therefore, in the recent Internet auctions, there are two selling types: (1) auction without a buyout price, (2) auction with a buyout price. (2) can be further divided into the following two types: (2-a) auction with a buyout price higher than the start price and (2-b) auction with a buyout price equal to the start price (fixed-price selling).

It has been reported that the buyout-option trades are increasing [3]. Understanding how a buyout option affects the market is significant to design the future auction markets.

2.2 Related Researches

Buyout options are noted firstly by Lucking-Reiley [4]. He notes that buyout options allow the bidder to buy an early end to the auction by submitting a sufficiently high bid. Budish et al. show that a seller’s revenue is improved by setting buyout price when a risk-averse buyer exists [1]. The research of Hidvegi et al. show that social utility is improved by setting the appropriate buyout price in English auctions with permanent buyout price [2]. They have analyzed the case where a seller is risk-averse or buyers are risk-averse. On the other hand, Mathews et al. have discussed “Buy-It-Now” option in eBay [5]. They have analyzed the case where a seller is risk-averse and buyers are risk-neutral. Reynolds et al. have discussed the two major buyout options: “Buy-It-Now” in eBay and “Buy Price” in Yahoo! JAPAN auction [6]. They have analyzed the case where a seller and two risk-averse buyers exist.

Previous studies have mainly focused on clarifying the conditions which selling format outperforms. For example, the model of Hidvegi et al. elucidates the conditions when the seller should use a buyout option and how to calculate the optimal buyout price [2]. However, researchers have paid little attention to the interaction between two selling formats. In auction sites, identical goods are sold in an auction and at a fixed-price simultaneously. The previous studies cannot explain this situation. Therefore, we develop a model to explain this situation.

3. ANALYSIS OF THE AUCTION DATA

As a first step to understand the effect of a buyout option, we must know the real situation in an Internet auction market. In particular, understanding sellers’ behaviors in an actual market with a buyout option is required. In this section, sellers’ behaviors are analyzed by using the actual auction data in an Internet auction market with a buyout option. We particularly focus on the setting of buyout prices.

3.1 Definition of Indexes

In an actual Internet auction market, the final prices of the auctions widely differ from the types of items. Therefore, we introduce the indexes to treat many data of multiple items. At first, define $\mu_{ij}$ as the average of the final prices in the auctions about item i in term j. The indexes of start price, buyout price and final price are defined as follows: $P_{\text{start}} = (x - \mu_{ij})/\mu_{ij}$, $P_{\text{buyout}} = (y - \mu_{ij})/\mu_{ij}$, $P_{\text{final}} = (z - \mu_{ij})/\mu_{ij}$ where $x$ is the amount of the start price, $y$ is the amount of the buyout price and $z$ is the amount of the final price in the one of the auctions about the item i in the term j. In this case, the bound $-1 < P_{\text{start}} \leq P_{\text{final}} \leq P_{\text{buyout}}$ is satisfied.

For example, $P_{\text{final}} = 0.1$ indicates that the auction was bought at the price 10% higher than $\mu_{ij}$. $P_{\text{buyout}} = -0.1$ indicates that the buyout price was set to the price 10% lower than $\mu_{ij}$. When $P_{\text{start}} = P_{\text{buyout}}$, the auction is sold at the fixed-price. When an auction with a buyout price was purchased at the buyout price, the equation $P_{\text{final}} = P_{\text{buyout}}$ is satisfied. The lower the price is, the value of the index is closer to $-1$. When $\mu_{ij} = 5000$ and $x = 1$, $P_{\text{start}} = -0.999$.

3.2 Data

The auction data in Yahoo! JAPAN auction was used. Yahoo! JAPAN auction provides a permanent buyout option that a fixed-price sale is allowed within an auction, while eBay provides a temporary buyout option. A seller can set a buyout price in addition to a start price. Setting a buyout price at the price equal to the start price corresponds to fixed-price selling. Once a buyout price is set, it cannot be changed until the end of the auction. While an auction is held, the start price and buyout price are disclosed. Even buyers bid at the price less than a buyout price in the auction, the buyout price is valid. In other words, if an auction with a buyout price is held, a buyer can quickly purchase the good by bidding at the buyout price.

The auction data of 50 items for 12 weeks was analyzed. 11,921 auction data were examined. These data do not include auctions having no bid. The term in the defined indexes was set to two weeks and the data were divided into six terms.

The auction data was extracted as follows. First, the auctions in the particular category whose titles match with the keyword were extracted. For example, if the intended item has its name “ABC123”, the keyword is set to the name. Auctions whose titles include the keyword “ABC123” were extracted. Next, the unwanted data were removed by doing visual inspections. For example, the following auctions were removed: (1) auctions selling only the other items, (2) auctions selling the other items in addition to the intended item.

3.3 Result of Data Analysis

The results of data analysis is showed. Table 1 shows the result of classifying the data into three classes according to the setting of a buyout price. The classes in this table correspond to the following auctions. The class No Buyout Price includes the auctions where buyout prices were not set. The class $P_{\text{start}} < P_{\text{buyout}}$ includes the auctions where buyout prices set at the price higher than the start prices. The class $P_{\text{start}} = P_{\text{buyout}}$ includes the auctions where buyout prices set at the price equal to the start prices. About 55% of the data corresponds to auctions with buyout prices and about 45% of the data corresponds auctions purchased at buyout prices. In the auctions satisfying $P_{\text{start}} < P_{\text{buyout}}$, the number of the auctions purchased at buyout prices is

March 9th 2009 – May 31st 2009

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Table 1: Classification of the data

<table>
<thead>
<tr>
<th>Class</th>
<th>Frequency</th>
<th>Relative Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Buyout Price</td>
<td>5,348</td>
<td>0.449</td>
</tr>
<tr>
<td>$P_{start} &lt; P_{buyout}$</td>
<td>4,895</td>
<td>0.411</td>
</tr>
<tr>
<td>$P_{start} = P_{buyout}$</td>
<td>1,678</td>
<td>0.141</td>
</tr>
</tbody>
</table>

Figure 1: Distribution of the index of start price $P_{start}$ (auctions without buyout prices)

Figure 2: Distribution of the index of start price $P_{start}$ (auctions with buyout prices)

Figure 3: Distribution of the index of buyout price $P_{buyout}$ (auctions with buyout prices)

3.3.1 Auctions without Buyout Prices

The auctions without buyout prices in the data were analyzed. In the auctions, the sellers set only start prices. Figure 1 shows the distribution of the index of start price $P_{start}$. The highest relative frequency is 0.39 in the lowest class $-1 < P_{start} \leq -0.9$. In the other classes, the relative frequency in each class satisfying $P_{start} \leq 0$ is within the values within 5 to 7%. On the other hand, the relative frequency of auctions satisfying $P_{start} > 0$ is only 6.3% in auctions without buyout prices.

Therefore, it is indicated that the start prices are set to the quite low price in many of the auctions without buyout prices.

3.3.2 Auctions with Buyout Prices

The auctions with buyout prices in the data were analyzed. When a seller uses a buyout option, he must set both start price and buyout price. Therefore, we investigated the setting of the combination of start price and buyout price in the auctions.

Figure 2 shows the distribution of the index of start price $P_{start}$ in auctions with buyout prices. In the figure, many of the auctions with buyout prices are included in the class $-0.1 < P_{start} \leq 0$ and the class $0 < P_{start} \leq 0.1$. The class $-0.1 < P_{start} \leq 0$ has the highest relative frequency 0.27, and the second highest relative frequency is 0.24 in the class $0 < P_{start} \leq 0.1$. Therefore, on the interval $-0.1 < P_{start} \leq 0.1$, the majority (51%) of auctions with buyout price are included. This result indicates that start prices are set to the prices near to the averages of final prices in many of auctions with buyout prices.

Therefore, such auctions are regarded as fixed-price selling. This result indicates the majority of auctions with buyout prices are regarded as fixed-price selling at buyout prices.

3.4 Typical Strategies of Sellers

The result of the data analysis indicates that the auctions corresponding to the following two types account for about half of the all data. The two strategies are regarded as the major strategies of sellers in Internet auctions.

**TYPE 1: Auctions where buyout prices are not set and quite low start prices are set**

TYPE 1 corresponds to auctions where buyout prices are not set and quite low start prices are set, i.e., $-1 < P_{start} \leq -0.9$. Since the start price is quite low, buyers easily bid the auction. However, the final price involves uncertainty.
Auctions corresponding to Type 2 are 60% in auctions with price $P$ responding to Type 1 are 62% in auctions without buyout.

Table 2: Comparison of the index of final price $P_{final}$ between typical sellers: TYPE 1 and TYPE 2

<table>
<thead>
<tr>
<th></th>
<th>TYPE 1</th>
<th>TYPE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of $P_{final}$</td>
<td>-0.008</td>
<td>-0.012</td>
</tr>
<tr>
<td>Standard deviation of $P_{final}$</td>
<td>0.171</td>
<td>0.141</td>
</tr>
</tbody>
</table>

40% of auctions without buyout prices can be classified into TYPE 1. They account for about 17% of all data.

**TYPE 2:** Auctions where buyout prices are set at a price almost equal to the start price

The buyout option is used in 55% of auctions, while the buyout option is not used in 45% of auctions. The model of Hidvegi et al. elucidates the conditions when the seller should use a buyout option and how to calculate the optimal buyout price [2]. However, the actual data shows that the buyout option is used in 55% of auctions, while the buyout option is not used in 45% of auctions. The previous studies are difficult to explain this coexistence of TYPE 1 sellers and TYPE 2 sellers. To explain this situation, we have developed a model including two sellers and three buyers as follows.

Based on the analysis in section 3, we further investigate sellers’ behaviors by building a model. The previous studies about buyout-price ascending auctions have discussed the seller’s strategy whether using the buyout option or not. The model of Hidvegi et al. elucidates the conditions when the seller should use a buyout option and how to calculate the optimal buyout price [2]. However, the actual data shows that the buyout option is used in 55% of auctions, while the buyout option is not used in 45% of auctions. The previous studies are difficult to explain this coexistence of TYPE 1 sellers and TYPE 2 sellers. To explain this situation, we have developed a model including two sellers and three buyers as follows.

In this model, the seller’s strategy is restricted to the two strategies TYPE 1 and TYPE 2 defined earlier. Therefore, the strategy of a seller is selected from the following two strategies.

### 3.5 Analysis of the Item Group

We analyzed some item groups in the data to examine the typical two types in subclasses of the data.

First, we analyzed the items of Group A (digital camera) which includes two items. In Group A, the number of auctions without buyout prices is 239 (42%) and the number of auctions without buyout prices is 325 (58%). Figure 4 shows distribution of the index of start price $P_{start}$ as the auctions without buyout price in Group A. Auctions corresponding to Type 1 are 62% in auctions without buyout prices.

Secondly, we analyzed the items of Group B (comic book) which includes three items. In Group B, the number of auctions without buyout prices is 595 (68%) and the number of auctions without buyout prices is 276 (62%). Figure 6 shows distribution of the index of start price $P_{start}$ as the auctions without buyout price in Group B.

#### 4. MODEL

Based on the analysis in section 3, we further investigate sellers’ behaviors by building a model. The previous studies about buyout-price ascending auctions have discussed the seller’s strategy whether using the buyout option or not. The model of Hidvegi et al. elucidates the conditions when the seller should use a buyout option and how to calculate the optimal buyout price [2]. However, the actual data shows that the buyout option is used in 55% of auctions, while the buyout option is not used in 45% of auctions. The previous studies are difficult to explain this coexistence of TYPE 1 sellers and TYPE 2 sellers. To explain this situation, we have developed a model including two sellers and three buyers as follows.

In this model, the seller’s strategy is restricted to the two strategies TYPE 1 and TYPE 2 defined earlier. Therefore, the strategy of a seller is selected from the following two strategies.
Figure 7: Distribution of the index of start price $P_{\text{start}}$ (auctions without buyout prices in Group B)

- Ascending auction by setting the lowest start price without a buyout price
- Fixed-price selling by setting a buyout price equal to the start price

4.1 Assumptions
The model dealing two-stage game where two sellers and three buyers exist is build. Assumptions in the model are defined as follows.

In the model, two sellers and three buyers exist. Three buyers arrives before sellers start to sell goods. Two sellers $S_1$ and $S_2$ arrive sequentially.

All buyers are classified into risk-neutral or risk-averse. A risk-neutral buyer has a quasilinear utility function. A risk-averse buyer has a convex and continuous utility function. A constant probability $q$ that a buyer is risk-averse is given. The valuations of the buyers are drawn from the distribution function of $F$ (the probability density function of $f$) on the interval $[0, \pi]$. A seller has a quasilinear utility function and the valuation of the seller to its good is 0. The sellers can obtain the positive benefit and utility by selling their goods at any prices.

In Stage 1, seller $S_1$ starts to sell his good. If $S_1$ provides a buyout price of $B$ and there is at least one risk-averse buyer whose valuation is larger than or equal to $B$, the buyer purchases the good at the buyout price in Stage 1. Since auctions do not continue after Stage 2, it is sufficient to consider seller $S_1$ as a seller setting a buyout price.

In Stage 2, seller $S_2$ starts to sell his good. $S_2$ prefers to sell his good in an ascending auction and sets the lowest start price in the prices sellers can set. In this model, $S_2$ sets 1 as a start price. If seller $S_1$ cannot sell his good at the buyout price in Stage 1, $S_1$ sells it at the same price setting in the Stage 2. A buyer bids the auction whose current price is the lowest. If the lowest current price is higher than the buyer’s valuation or he has purchased the good at the buyout price, he stops bidding.

As examples of the model, figures 8 and 8 are showed. In figure 8, seller $S_1$ submits $B = 170$ as a buyout price. Since Buyer 1 is risk-averse and his valuation (180) is larger than $B$, he purchases the good of $S_1$ at the buyout price in Stage 1. In Stage 2, only the auction of $S_2$ are held. The rest buyers bid up the auction of $S_2$. As a result, the auction ends when the current price is 151 which is higher than the valuation of Buyer 3. Thus, Buyer 2 becomes the winner.

In figure 9, seller $S_1$ submits $B = 190$ as a buyout price. Since no risk-averse buyer has his valuation larger than or equal to $B$, there is no bid at the buyout price in Stage 1. In Stage 2, the two auctions of $S_1$ and $S_2$ are held. All buyers bid up the auction of $S_2$ whose current price is the lowest. As a result, the auction ends when the current price is 181 which is higher than the valuation of Buyer 1. Thus, Buyer 2 becomes the winner. Since the valuations of the rest buyers are lower than $B$, there is also no bid to the auction of $S_1$ in Stage 2.

4.2 Optimum Buyout Price
Consider the following four cases where how many buyers have their valuations larger than $B$.

(i) All three buyers have their valuations less than $B$

The probability of this case is $F(B)^3$. Since no buyer has his valuation larger than or equal to $B$, seller $S_1$ cannot sell the good at buyout price $B$. Therefore, the revenue of $S_1$ by selling at a buyout price in this case is 0.

(ii) A buyer has his valuation larger than or equal to $B$
The probability of this case is $3F(B)^2 (1 - F(B))$. Even if a buyer has his valuation larger than or equal to $B$, seller $S_1$ cannot sell the good when the buyer is not risk-averse. Here, the probability that a buyer is risk-averse is given as $q$. Therefore, the revenue of $S_1$ by selling at a buyout price in this case is $qB$.

(iii) Two buyers have their valuations larger than or equal to $B$

The probability of this case is $3F(B) (1 - F(B))^2$. If at least one of the two buyers is risk-averse, the auction of seller $S_1$ is purchased at a buyout price in Stage 1. Even if the two buyers is risk-neutral, the auction of seller $S_1$ is bid at buyout price $B$ after the auction of seller $S_2$ ascended to the price $B$ in Stage 2. Therefore, the revenue of $S_1$ by selling at a buyout price in this case is $B$.

(iv) All three buyers have their valuations larger than or equal to $B$

The probability of this case is $(1 - F(B))^3$. If at least one of the three buyers is risk-averse, the auction of seller $S_1$ is purchased at a buyout price in Stage 1. Even if the three buyers are risk neutral, the auction of seller $S_1$ is bid at a buyout price $B$ after the auction of seller $S_2$ ascended to the price $B$ in Stage 2. Therefore, the revenue of $S_1$ by selling at a buyout price in this case is $B$.

The expected revenue $r_B$ can be obtained by summing up the expected revenue of each case from (i) to (iv). $r_B$ is shown as

$$r_B = 3F(B)^2 (1 - F(B))qB + 3F(B) (1 - F(B))^2 B + (1 - F(B))^3 B.$$  \hspace{1cm} (1)

An optimal $B$ of $B^*$ can be obtained by solving the first-order condition of Eq.(1).

On the other hand, consider the expected revenues in the case where seller $S_1$ does not set a buyout price. The expected revenue $r$ of the seller is shown as

$$r = \int qf(z) (1 - F(z))^2 dz.$$  \hspace{1cm} (2)

When seller $S_1$ does not set a buyout price, the two ascending auctions are held in Stage 2. As a result, the final prices of the auctions are equal to the lowest valuation of all three buyers.

If buyout price $B$ satisfies $r_B \geq r$, seller $S_1$ can improve his revenue by selling at a buyout price.

5. EVALUATION OF MODEL

This section shows the result of experiments using the proposal model.

5.1 Optimum Buyout Price and Revenue of Seller Setting It

The optimum buyout price and the revenue of the seller setting it are calculated.

5.1.1 Buyers’ valuations depend on uniform distribution

First, consider the case where buyers’ valuations depend on the uniform distribution. The uniform distribution function of $F$ on $[\underline{v}, \overline{v}]$ is shown as $F(v) = (v - \underline{v})/(\overline{v} - \underline{v})$.

The expected revenue of seller $S_1$ in the case where he sets buyout price $B$ ($F$: uniform distribution on $[100, 200]$)

The probability density function of $f$ is shown as $f(v) = 1/(\overline{v} - \underline{v})$. The interval of $F$ was set to $[100, 200]$ in the experiments. The expected revenue of seller $S_1$ setting buyout price $B$ at the price on $[100, 200]$ was calculated by using Eq.(1) under the constant probability $q$. Additionally, the expected revenue in the case where seller $S_1$ does not set a buyout price was calculated by using Eq.(2).

Figure 10 shows the result of the experiment about the expected revenue in the case where seller $S_1$ sets buyout price $B$. This figure indicates the following things. First, the expected revenue is 100 when the buyout price is set to 100 the least valuation of buyers. Since all buyers have their valuations larger than or equal to 100, the auction with the buyout price equal to 100 must be bought by a buyer. The larger the buyout price is, the expected revenue increases in $B \leq B^*$. On the other hand, the larger the buyout price is, the expected revenue decreases in $B > B^*$. Buyout price $B^*$ to maximize the expected revenue differs from the value of $q$. The value of $B^*$ and $r_B$: the revenue in the case where the buyout price is set as is follows. When $q = 0.1$, $B^* = 117$ and $r_B = 108.8$. When $q = 0.5$, $B^* = 127$ and $r_B = 114.4$. When $q = 0.9$, $B^* = 142$ and $r_B = 127.1$.

Figure 11 shows the comparison of the expected revenue between the case where seller $S_1$ sets a buyout price and the case where he does not set it. The expected revenue of seller $S_1$ in the case where he does not set a buyout price does not be effected by the value of $q$. It is calculated as $r = 125.0$ by using Eq.(2). On the other hand, the larger the value of $q$ is, the expected revenue $r_B^*$: the in case where seller $S_1$ sets $B^*$ increases. In the figure, when $q \geq 0.86$, the condition $r_B^* \geq r$ is satisfied and the expected revenue is improved by setting the buyout prices.

5.1.2 Buyers’ valuations depend on the exponential distribution

In the experiments of 5.1.1, the case where the valuations of the buyers depend on the uniform distribution was considered. In the real auctions, however, if the price of the good is lower, the more buyers who desire to purchase it at the price may exist. In order to discuss the situation, consider the case where the valuations of the buyers depends on the exponential distribution $F$ on the interval $[\underline{v}, \overline{v}]$. $F$ is written as $F(v) = k_1 - k_2 \cdot \exp (- (v - \underline{v})/(\overline{v} - \underline{v}))$ where $k_1$
and $k_2$ satisfy $F'(y) = 0$ and $F'(\tau) = 1$. They are calculated as $k_1 = k_2 = e/(e-1)$. The probability density function of $f$ is expressed as $f(v) = (k_2/(\tau - y)) \cdot \exp(-(v - y)/(\tau - y))$. In this experiments, the interval of $F$ was set to $[100, 200]$.

Figure 12 shows the result of the experiment about the expected revenue in the case where seller $S_1$ sets buyout price $B$. This figure indicates the following things. First, as well as the case of the uniform distribution, the expected revenue is 100 in the case where the buyout price is set at 100 equal to minimum valuation of buyers. The larger the buyout price is, the more expected revenue is obtained in $B \leq B^*$. On the other hand, the larger the buyout price is, the less expected revenue is obtained in $B > B^*$. Buyout price $B^*$ to maximize the expected revenue differs from the value of $q$. These results are same as the case of the uniform distribution. The values of $B^*$ and $r_{B^*}$ are calculated as follows. In the case $q = 0.1$, $B^* = 108$ and $r_{B^*} = 104.0$. In the case $q = 0.5$, $B^* = 115$ and $r_{B^*} = 107.2$. In the case $q = 0.9$, $B^* = 130$ and $r_{B^*} = 117.2$. In all the value of $q$, buyout price $B^*$ and expected revenue $r_{B^*}$ in the case of exponential distribution are less than the case of uniform distribution.

Figure 13 shows the comparison of the expected revenue between the case where seller $S_1$ sets a buyout price and the case where he does not set it. The expected revenue of seller $S_1$ in the case he does not set a buyout price does not be effected by the value of $q$. It is calculated as $r = 118.4$ by using Eq.(2). On the other hand, the higher the value of $q$ is, the more expected revenue $r_{B^*}$ is obtained in each the value of $q$. In the figure, when $q \geq 0.94$, the condition $r_{B^*} \geq r$ is satisfied and the expected revenue is improved by setting the buyout price. Compared to the case of the uniform distribution, the larger value of $q$ is required to obtain the more revenue than the revenue without a buyout price.

These results indicate the following things. Under the same interval of $F$, compared to the case of the uniform distribution, the larger value of $q$ is required to improve the revenue and the increase of the revenue is less in the case of the exponential distribution.

### 5.2 Comparison of Sellers’ Revenue

We have carried out simulation to examine the sellers’ revenues. $F$ was set to the uniform distribution on $[100, 200]$. By increasing $q$ from 0 to 1 by 0.01, $B^*$ in each value of $q$ was obtained. For each $q$, 100000 examples were created. The averages of the revenues in the case where seller $S_1$ sets $B^*$ and the case where seller $S_1$ does not set a buyout price were calculated.

Figure 14 shows the comparison of each seller’s revenue. When no seller sets a buyout price (“No Buyout Price” in the figure), the revenue of seller $S_1$ is equal to the revenue of seller $S_2$. The revenue of seller $S_1$ who sets buyout price $B^*$ increases as $q$ increases. In the experiment, when $q \geq 0.85$, the revenue of seller $S_1$ with buyout price $B^*$ is higher than one without buyout price. On the other hand, the revenue of seller $S_2$ in the case where seller $S_1$ sets the buyout price is always larger than the case without buyout price $S_1$. In addition, as the value of $q$ increases, the revenue of seller $S_2$ decreases monotonically. In this experiment, when $q \geq 0.91$, the revenue of seller $S_1$ who set $B^*$ is larger than the revenue of seller $S_2$.

Figure 15 shows the comparison of total revenue of two sellers. In the figure, when $q \geq 0.78$, the total revenue of two sellers with buyout price $B^*$ is larger than the total revenue without buyout price. An interesting result from the experiment is that, when seller $S_1$ sells at a buyout price, seller $S_2$ can obtain the larger revenue than the revenue in the case where seller $S_1$ does not set it. The higher the value of $q$ is, the higher the revenue of seller $S_2$ is and the lower the revenue of seller $S_2$ is. However, the revenue of $S_2$ is always improved by $S_1$’s fixed-price selling at a buyout price. This result shows...
that if the probability that a buyer is risk-averse is quite high, both two sellers can benefit by selling a good by using a buyout option and selling another good by using an ascending auction. Thus, we can successfully provide a model able to explain the situation where the both types of sellers using the buyout option and not using the buyout option simultaneously exist. The model supposes a two-stage game where two sellers arrive sequentially. The seller’s strategy is restricted to the two strategies obtained from the actual data. The result of simulation on the model shows that if the probability that a buyer is risk-averse is quite high, both two sellers can benefit by selling a good by using a buyout option and selling another good by using an ascending auction.

6. CONCLUSION

It has been reported that the trades having buyout options are increasing in Internet auctions. Understanding the interaction between the two selling formats (auctions and fixed-price sellingis) is a keen interest for sellers. We have analyzed the actual auction data, characterized the typical strategies of the seller, built models, and carried out experiments on them, which leads to deeper understanding of the market where ascending auction and fixed-price selling simultaneously exist.

The contributions of this research are summarized as follows.

(1) Presenting major strategies of sellers in an Internet auction market 11,921 auction data obtained from an actual Internet auction site were examined by focusing on the setting of start price and buyout price. The results of data analysis show the two major strategies of the sellers in the market.

(2) Proposing the model to explain the coexistence of two type sellers We can successfully provide a model able to explain the situation where the both types of sellers using the buyout option and not using the buyout option simultaneously exist. The model supposes a two-stage game where two sellers arrive sequentially. The seller’s strategy is restricted to the two strategies obtained from the actual data. The result of simulation on the model shows that if the probability that a buyer is risk-averse is quite high, both two sellers can benefit by selling a good by using a buyout option and selling another good by using an ascending auction.

7. REFERENCES


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