A Look at the Game Theory of Online Auctions: The Choice Between End-Time Formats on Yahoo! Auctions

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I. Introduction

Over the past decade, online auctions have grown tremendously in popularity. EBay, the largest provider of such services, sees $24 Billion worth of transactions annually after less than ten years in existence. Such auction sites provide a way for millions of potential sellers and countless potential buyers to interact in an online marketplace. This allows for transactions to take place which may never have been possible before. How, though, do individual decision makers act in this online marketplace? How do bidders respond to the rules set by the auction sites and by the sellers? Finally, how do these actions and reactions affect the final prices of the auctioned items?

To answer these questions, we must look at the academic field called Game Theory. Game Theory is the study and analysis of strategic behavior in social interactions among decision makers. Some of the many social interactions analyzed using game theory include, but are not limited to, strategic voting, research and development decisions, pricing strategies, and, of course, auctions.

In an Auction "Game," there are two groups of "players-" the bidders and the sellers. There may be one or more of each. These groups compete against each other as well as among themselves. That is to say, bidders compete not only with sellers (over the

price), but also with other bidders (to win the auction). Similarly, sellers compete with each other for business and interest from potential bidders.

Both of these groups have different decisions to make and, therefore, different strategies are available to them. Sellers must decide the price at which to start the bidding, what time the auction will start, how long the auction will last, and certain other rules for bidding. Some of the strategic options available to them include setting a low starting price versus setting a high starting price or setting a high bid increment versus setting a low bid increment.

Some of the decisions bidders must make include when to bid on an item, and how much to bid for it. The strategic options available to bidders include, but are not limited to, submitting a first bid early versus submitting a first bid late and submitting a low first bid versus submitting a high first bid. Different combinations of seller and bidder strategies may result in different payoffs for each individual involved. In the case of an auction, the payoff can be measured using the price paid or received for an item.[1]

The three major online auction sites are run by eBay, Amazon, and Yahoo. These sites run auctions that can be best described as Second-Price Auctions. A Second Price Auction is one in which the bidder who submits the highest bid wins the auction, but pays a price equal to the second highest bid rather than their own bid.

The online auctions from these sites are similar to Second Price Auctions because of a tool called **"**Proxy**"** or **"**Automatic**"** bidding. Under this system, a bidder tells the site the most they are willing to pay. The site then bids on their behalf up to this price. Thus, if you submit a maximum bid of $20, and the second highest bid is for $13, you

[1] For a seller, the actual payoff is the amount of the payment minus how much the seller values the item. For the winning bidder, the payoff is how much they value the item minus the amount of the payment.

will win the auction at a price of just over $13 (depending on the minimum increments allowed). If, however, somebody submits a higher bid, say $22, you will lose. In theory, a bidder in this situation should feel ambivalent about being outbid since they just were not willing to pay more than $20 for the item. [2]

According to this system, the outcome of every auction should be efficient. The bidder who has the highest willingness to pay (i.e., the bidder who values the item the most and submits the highest maximum bid) should win the auction.[3] Also, the seller will receive the best possible price for their listed item. However, knowing this, there is incentive for bidders to try to "cheat" the system.

One method by which bidders can, and quite often do, "cheat" is an action called "Sniping." This is possible due to the existence of a time-dimension in these online auctions. Sniping is the placing of a bid in the final moments of an auction in hopes of winning the item at a low price. Doing this gives other bidders little, if any, time to respond. Thus, if other bidders did not enter the true maximum price they are willing to pay, then they may lose the auction when they could have won it at a price at or even below where they value the item. It is important to mention that, although I refer to sniping as "cheating," it is not by any means against the rules. It simply is not a part of the way in which the auction site designers envisioned their systems reaching economic efficiency.

---

[2] The kind of auction I describe here is known as a private value auction. That is, every item has a unique value to each bidder. There is, however, another kind of auction known as a common value auction. This type of auction includes items that are considered to be more for investment than for personal utility. Thus, in a common value auction, as the name suggests, the item should have the same value to all bidders.

[3] Varian, Hal. "Economic Scene: Online Users as Laboratory Rats." New York Times, November 16, 2000.

Sniping has a different impact on each of the three major online auction sites because of differences in end-of-auction rules between the three. Auctions on eBay are characterized by what is called a "hard close." This means that before the auction even begins, the end time is set. When this time comes, the highest bidder wins and no more bids can be accepted.

Amazon, on the other hand, has an extended end time rule. This setting, sometimes referred to as the "Going, Going, Gone" Feature, automatically extends the end time for any given listing by ten minutes if anybody bids in the closing moments of the auction. Thus, all bidders will be given a fair chance to respond to any bid placed just before the scheduled close of an auction.

Auctions run by Yahoo, however, leave this choice up to the seller. Individuals listing auctions on Yahoo are given the choice between a hard close and an extended end time format. On any Yahoo auction page, there will be a note saying either "Auction does not get automatically extended" or "Auction may get automatically extended," and thus, informing the bidder of the seller's decision.

The end time rule of an auction clearly will have an impact on the strategy involved in bidding. In an auction with a hard close, the strategy of sniping is still effective because it sometimes avoids a bidding war with other potential buyers. Thus, the price should remain lower than if everyone simply submits the highest price they are willing to pay. If many bidders observe this and begin to bid in this way, the result can be compared to collusion among bidders. Essentially, this means individuals may be willing to lose auctions they might otherwise win, so long as the ones they still do win are at lower final prices.

In an extended end time auction, however, the story is different. If a last-minute bid is placed, other bidders will still get more time to respond, so there is less incentive to place a bid late as opposed to early. Thus, the effectiveness of sniping is significantly diminished.

In 2002, Al Roth, of Harvard University, and Axel Ockenfels, of the University of Magdeburg in Germany, published a paper related to the topic of last-minute bidding on eBay and Amazon (Roth and Ockenfels, 2002, American Economic Review). They aimed to test the theory that last-minute bidding would be much more common on eBay, where bidders encounter a hard close end time, than on Amazon, where auctions can be automatically extended. To do this, they compiled auction data from both sites. They looked at listings for antiques as well as computers and took note of the timing of the bids for each auction. Their findings confirmed that online auctions with a hard close seemed to encourage last-minute bidding.

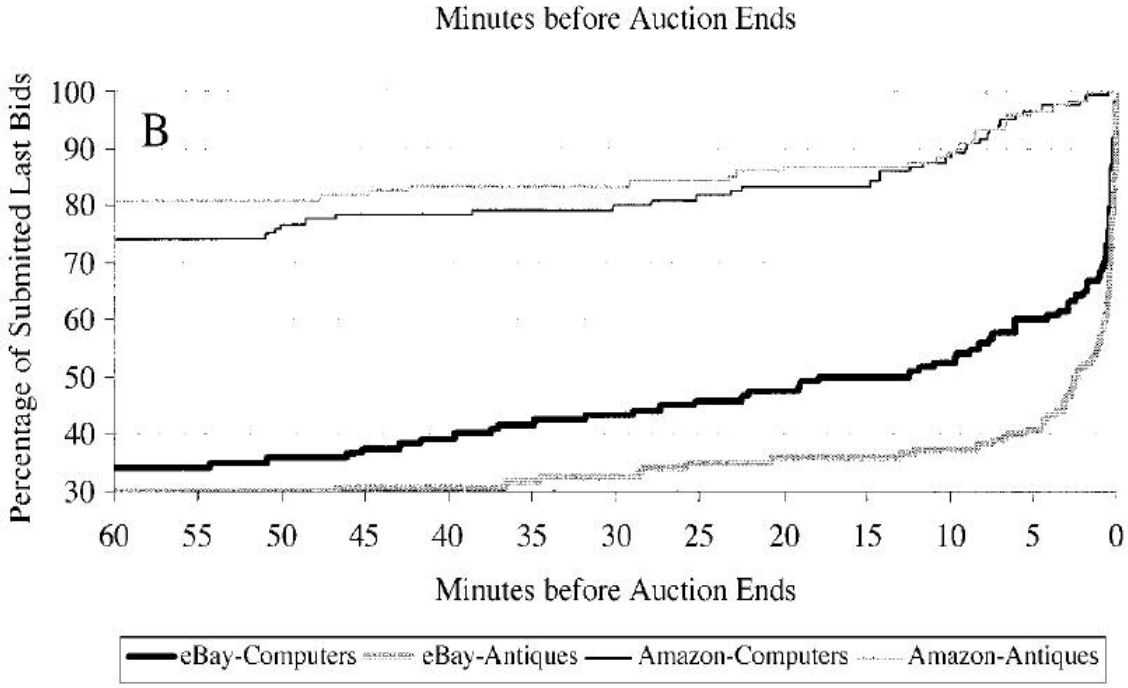


Figure 1 (Roth & Ockenfels, 2002, American Economic Review)

From the above graph, taken from the Roth & Ockenfels research, one can see the disparity between when final bids are placed on each site. The data for both sites progresses somewhat similarly, with final bids coming in steadily, until about ten minutes before the auction is scheduled to end. At this time, the pace picks up at both sites, but much more so for eBay- especially in the very last minute. It appears as though bidding is concentrated even closer to the end of the auction for eBay Antiques. This is explained by Roth & Ockenfels as a result of experts not wanting to reveal how much they truly value an object to those with less expertise in the field.

Although the paper does not directly address price, it seems to be implied that this last minute bidding often rewards the bidder. The following excerpt addresses this issue:

> "One Reason we might see snipers on eBay is that sniping can be a best response to a variety of strategies. For example, inexperienced bidders might make an analogy with first price "English" auctions, and be prepared to continually raise their bids to maintain their status as high bidder. In an eBay style auction with a hard close, bidding very late might be a best response to 'incremental bidding' of this sort. That is, bidding very near the end of the auction would not give the incremental bidder sufficient time to respond, and so a sniper competing with an incremental bidder might win the auction at the incremental bidder's initial, low bid."

That is, the tendency to bid at the last minute avoids the socially efficient outcome and replaces it with an allocation of goods based more upon random chance, with lower prices being charged to these lucky winning bidders. It seems obvious that bidding behavior in these auctions would be much different than behavior witnessed in auctions on Amazon, where strategic incentives for late bidding is substantially lower. As Roth says, "In such an auction, an attentive incremental bidder can be provoked to respond whenever a bid is placed. So there is no advantage in bidding late, and certainly no

advantage in delaying one's bid until so late that there is some probability that there will not be time to successfully submit it." It seems obvious, then, that prices for auctions on eBay should, in theory, be noticeably lower than their counterparts in auctions on Amazon.

The best way to test this theory would be to compare prices for similar objects on both eBay and Amazon. This method, however, has some considerable flaws. For one, eBay is the largest online auction auction marketplace by far. According to "The Business Guide to Selling Through Online Auctions,"[4] an introduction for new sellers available through the Independent Publishers Group, eBay has recently had more than twice the amount of registered and active users as Amazon Auctions. As of March of 2001, eBay had 22.5 million users, while Amazon had approximately 10 million. Even beyond sheer numbers, it may be expected that the actual users on competing sites may be different as well. For example, one site's patrons may consist mostly of veteran sellers and bidders who have much experience doing what they do. The other site, however, may count more novices and new-comers among their users. Also, auctions are just a small part of Amazon's business, whereas auctions are what eBay was built on. These factors combined make comparing eBay and Amazon auctions, and the associated buyer and seller behavior, flawed.

However, based on the ideas discussed in Roth's paper, it does seem as though a seller, if given the choice, would want to pick an extended end time format. It just so happens that, on Yahoo, the seller is given this choice. However, from my early research exploring the site, it appears as though a significant majority of sellers on Yahoo pick the

[4] Available at www.ipgbook.com.

hard close option. In fact, from the auctions I have been tracking, it seems that 75% or more of sellers decide on an auction that cannot be automatically extended.

Why is this the case? In Economics, most of our theories and generalizations are based on the assumption that people act reasonably when making decisions. However, the fact that Roth's theory and actual seller actions on Yahoo seem to be in conflict leads to a problem. Are the implications in Roth's paper wrong, or are sellers on Yahoo acting irrationally?

In an effort to come up with an answer to this question, I have collected information from listings on Yahoo's auction site. Between late November and mid-March, I periodically browsed the Yahoo Auctions page for particular items being sold. For each appropriate auction found, I would then choose the option entitled "Watch This Auction." Once these auctions closed, I would retrieve information from the auction page and enter it all into an Excel spreadsheet. From here, I use this information to run regressions in Stata. These regressions are used primarily to determine whether or not, in reality, prices for auctions with an extended end-time format are higher than those with a hard close.

II. The Data

As easy as it is to access listings on Yahoo Auctions, there are still some difficulties that come up in collecting data for this kind of study. My first concern was regarding the volume of the data I would be able to collect. I needed to ensure that I had a sufficiently large sample size for any item I decided to use. As such, I began by

collecting data on many different types of items. I chose items that I thought would be fairly uniform and new (or like new) for the large majority of listings I would collect. Some of these items are as follows:

- Apple iPods (varying models, the data for which were kept separate)
- Dell D600 laptops
- Dell Inspiron 9100 laptops
- Sony Vaio X505 laptops
- Compaq Presario laptops
- Motorola RAZR V3 camera phones
- Canon G5 digital cameras
- Halo 2 video game for Xbox

These were all items which appeared to be available on Yahoo Auctions quite frequently. I never intended to use all of these items for analysis. However, I knew that, eventually some of the items would be ruled out for various reasons. So, for the first month or two, I collected data for all of these items.

Before long, it became apparent that the Motorola RAZR, Canon G5, and Halo 2 items would not be available in the volume I needed to analyze their data for this study. There may have been plenty being auctioned one week, but very few available the following week. With such irregularity, I could not count on collecting an adequate amount of data for these items.

The various laptops, on the other hand, presented a different problem. Here, the issue was not volume, but uniformity. There were plenty of each of these 4 kinds of laptops being auctioned off at any time. The problem, though, was that, while most of

them were extremely similar, too many had minor differences. Slight disparities in amounts of memory space, processor speeds, and included accessories made data for these laptops virtually unusable in terms of analysis for this study.

That left iPods as the only remaining item on my list. Luckily, iPods seemed to be the perfect item to use for my purposes. Their recent popularity ensured that there would always be plenty of iPods available on Yahoo Auctions. Also, iPods of each size are almost perfectly uniform, provided they are of the same "generation." So, the two sets of data used for analysis in this study are 4th Generation iPod Minis and 4th Generation 20 GB iPods.

Once I had these items selected, there were still some problems in collecting the actual data. Just because I found and saved an appropriate auction did not necessarily mean it would provide valuable data. Occasionally, for example, a seller will set the starting price for an auction so high that it receives no bids at all. Thus, this auction would provide no useful information.

Another setting available to sellers that presented occasional problems was the "Buy Now" option. This feature allows sellers to set a "Buy Price" at or above the starting bid price of the auction. This gives bidders the option of bypassing the bidding process and simply purchasing the item at the stated price. While this may be convenient for both the seller and the bidder, it does not provide much in the way of useful information on bidding behavior.

There also seems to be an issue of fraud on Yahoo Auctions. Occasionally, I would come across a seller whose auctions seemed to draw suspiciously low amounts of bids. Upon further investigation it appeared as though this was sometimes a result of

bidders claiming they paid the seller for an item they won, but never received. Any auctions listed by such sellers had to be removed from the data set.[5]

Once these problems were taken into account, I was left with a set of auctions that seemed to accurately reflect bidding behavior on Yahoo. From here, I transferred the data manually to an Excel spreadsheet as to enable myself to work with this data with greater ease. An image of the first twelve iPod Mini auctions that were used appears below.

	A	B	C	D	E	F	G	H
1	price	bids	length	start	extend	end	day	xmas
2	165	15	48	1	0	20-Nov	1	35
3	197.5	28	50	0.99	1	24-Nov	2	31
4	180	31	50	0.99	1	24-Nov	2	31
5	187.65	18	100	9.99	1	26-Nov	1	29
6	128.5	27	72	25	0	1-Dec	8	24
7	145	16	72	25	0	1-Dec	8	24
8	130	19	72	25	0	1-Dec	8	24
9	120	17	72	25	0	1-Dec	8	24
10	119.5	8	72	25	0	1-Dec	8	24
11	135	21	72	25	0	1-Dec	8	24
12	125.75	23	72	25	0	1-Dec	8	24
13	122	17	72	25	0	1-Dec	8	24

The column labeled “price” contains the final price, or the amount of the winning bid, for each observation. “Bids” represents the number of bids received for each auction. The column headed “Length” indicates how long, in hours, each auction lasted. The “Start” column contains the price at which bidding was started. “Extend” is a dummy variable indicating what type of end-time format the seller chose. A “0” here indicates a hard close format, while a “1” indicates an automatically extended format. The column labeled “end” simply states on what day the auction closed. “Day” contains

[5] It should be noted that prices for iPods on Yahoo Auctions are very often lower than retail prices. The existence of such fraud may be one reason why. Not knowing who you are doing business with likely takes away some of the value from any auction item. Such uncertainty is certainly not something consumers desire.

the number of similar items that I have data for that closed on the same day. For example, above, the last eight entries have an "8" in this column because they were all posted by the same seller and set to end on the same day.

After a while of collecting data on just these seven variables, I sensed the need for another one. Prices seemed to get higher as Christmas approached, then slowly drifted back down after Christmas. The first half of this statement makes perfect sense. With the holiday approaching, one would expect that demand for potential gift items would increase. As a result, noticing an increase in final prices over this time period should come as no surprise.

It also seems logical to assume, however, to assume that demand for these potential gift items would drop back down immediately after Christmas rather than gradually. The demand for iPods was so high during the 2004 Christmas season, though, that many stores, even Apple's own retail locations, were sold out of many models and had waiting lists long after Christmas. To give an idea of how high demand for iPods was during that Christmas season, you need only look at Apple's financial results for its fiscal 2005 first quarter, which ended on December 25, 2004. Apple reports shipping more than 4.5 million iPods during this quarter, which represents a 525 percent increase over the same period the previous year.[6]

With such high demand, it is easy to see how stores would have a hard time keeping these items on the shelves, forcing consumers to explore other options- like buying the items through online auctions. Taking this information into account, it is not surprising that demand appeared to be just as high a couple of weeks after Christmas as a

[6] Information found in "Apple Reports First Quarter Results" press release, January 12, 2005. http://www.apple.com/pr/library/2005/jan/12results.html

couple of weeks before. Thus, I added a column labeled “xmas” to the data, noting how many days before or after Christmas of 2004 each auction ended. So, for example, auctions ending on December 5, 2004 and January 14, 2004 would both have an “xmas” value of 20.

Between November, 2004 and March, 2005, I ended up with 195 observations for iPod Minis and 166 observations for 20GB iPods. Transporting this data into Stata, I ran regressions with “price” as the dependent variable and the others as independent variables. Below are the results for the iPod Mini data:

Stata Results

```
. regress price bids length start extend day xmas

      Source |       SS       df       MS              Number of obs =     195
-------------+------------------------------           F(  6,   188) =   47.19
       Model |  73038.0955     6  12173.0159            Prob > F      =  0.0000
    Residual |  48499.2556   188  257.974764            R-squared     =  0.6010
-------------+------------------------------           Adj R-squared =  0.5882
       Total |  121537.351   194  626.481191            Root MSE      =  16.062

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bids |    .470219   .1863891     2.52   0.012      .1025363    .8379018
      length |   .0599199   .0402731     1.49   0.138     -.0195254    .1393652
       start |   .0439114   .0275604     1.59   0.113     -.0104559    .0982788
      extend |   23.52548   2.599533     9.05   0.000      18.39748    28.65349
         day |  -2.563039   .3386741    -7.57   0.000     -3.231128   -1.894949
        xmas |  -.6240025   .0645918    -9.66   0.000     -.7514203   -.4965847
       _cons |   167.0089   5.992256    27.87   0.000      155.1882    178.8296
------------------------------------------------------------------------------

. regress price extend day xmas

      Source |       SS       df       MS              Number of obs =     195
-------------+------------------------------           F(  3,   191) =   88.14
       Model |  70565.3668     3  23521.7889            Prob > F      =  0.0000
    Residual |  50971.9842   191  266.869027            R-squared     =  0.5806
-------------+------------------------------           Adj R-squared =  0.5740
       Total |  121537.351   194  626.481191            Root MSE      =  16.336

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      extend |    24.6067   2.488973     9.89   0.000      19.6973    29.51611
         day |  -2.852488   .3308824    -8.62   0.000     -3.505141   -2.199835
        xmas |  -.6605401   .0577553   -11.44   0.000     -.7744603    -.54662
       _cons |   183.0395   2.984151    61.34   0.000      177.1534    188.9257
------------------------------------------------------------------------------

.
```

Clearly, the variable I was looking at most closely was the "extend" variable. It was my hope that this variable would show a significant relationship between the type of end-time format chosen and the final price. The top set of data results from the regression run with all of the other variables included as independent variables, while the bottom set comes from a regression with just "extend," "day," and "xmas" as independent variables. These three variables all have a p-value of 0.000. This implies that, for any of these three variables, the hypothesis that the coefficient is equal to zero can be rejected at any level of significance.

Thus, it certainly seems to appear that these variables have a significant relationship with the price. Moving from the top set to this bottom set results in the Adjusted R-squared decreasing from .588 to .574. That means that these variables appear to explain approximately 59% and 57%, respectively, of the variance in the final price. Although the first model does appear to explain more, the much simpler second model is not far off. So, I will work with this model as a way to describe the expected final price of an auction:

$$\textbf{price} = 183.04 + 24.61(\textbf{extend}) - 2.85(\textbf{day}) - .66(\textbf{xmas})$$

To find the expected final price of an auctioned iPod Mini, start with $183.04. If this item is being auctioned with an extended end-time format, add $24.61, if it has a hard close, add nothing. Then, take the total number of iPod Minis which close on the same day, multiply this number by $2.85 and subtract this from the previous total. Finally, subtract 66 cents from the total for the number of days away from Christmas the auction closed.

As an example, imagine there were an iPod Mini auctioned off on Yahoo that closed with an extended end-time format on January 3, 2005, the same day as one other iPod Mini. We would expect the price of final price for this item to be:

$$price = 183.04 + 24.61(1) – 2.85(2) - .66(9) = \$196.01$$

$$since \quad extend = 1, \quad day = 2, \quad xmas = 9,$$

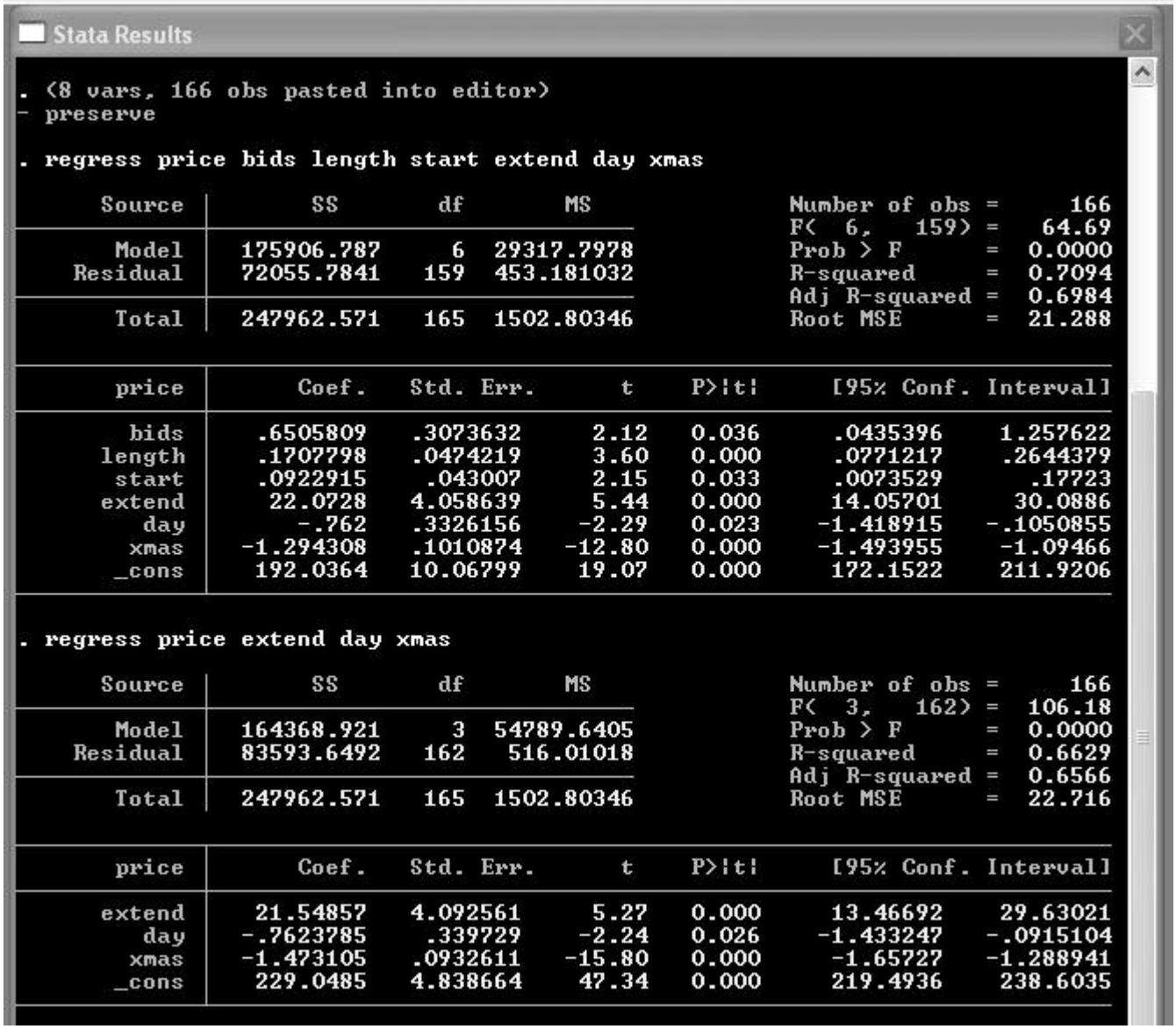
On the other hand, if the other iPod Mini that closed that day had a hard close format, we would expect the final price for this item to be:

$$price = 183.04 + 24.61(0) – 2.85(2) - .66(9) = \$171.40$$

$$since \quad extend = 0, \quad day = 2, \quad xmas = 9$$

That is to say, all things being held equal, we do, in fact, expect iPod Mini auctions with an extended end-time format to have a higher price than those with a hard close.

The results for the 20GB iPod data are similar in many ways. The following page contains the regression results obtained from Stata using the same process as with the iPod Mini data.



Stata Results

```
. (8 vars, 166 obs pasted into editor)
- preserve

. regress price bids length start extend day xmas

      Source |       SS       df       MS              Number of obs =     166
-------------+------------------------------           F(  6,   159) =   64.69
       Model |  175906.787     6  29317.7978            Prob > F      =  0.0000
    Residual |  72055.7841   159  453.181032            R-squared     =  0.7094
-------------+------------------------------           Adj R-squared =  0.6984
       Total |  247962.571   165  1502.80346            Root MSE      =  21.288

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bids |   .6505809   .3073632     2.12   0.036     .0435396    1.257622
      length |   .1707798   .0474219     3.60   0.000     .0771217    .2644379
       start |   .0922915    .043007     2.15   0.033     .0073529     .17723
      extend |    22.0728   4.058639     5.44   0.000     14.05701    30.0886
         day |     -.762   .3326156    -2.29   0.023    -1.418915   -.1050855
        xmas |  -1.294308   .1010874   -12.80   0.000    -1.493955   -1.09466
       _cons |   192.0364   10.06799    19.07   0.000     172.1522    211.9206
------------------------------------------------------------------------------

. regress price extend day xmas

      Source |       SS       df       MS              Number of obs =     166
-------------+------------------------------           F(  3,   162) =  106.18
       Model |  164368.921     3  54789.6405            Prob > F      =  0.0000
    Residual |  83593.6492   162   516.01018            R-squared     =  0.6629
-------------+------------------------------           Adj R-squared =  0.6566
       Total |  247962.571   165  1502.80346            Root MSE      =  22.716

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      extend |   21.54857   4.092561     5.27   0.000     13.46692    29.63021
         day |  -.7623785    .339729    -2.24   0.026    -1.433247   -.0915104
        xmas |  -1.473105   .0932611   -15.80   0.000     -1.65727   -1.288941
       _cons |   229.0485   4.838664    47.34   0.000     219.4936    238.6035
------------------------------------------------------------------------------
```

The "extend" dummy variable has a coefficient in the low-20s[7] range and a p-value of 0.000, just as in the Mini data. The "xmas" variable has a coefficient of greater magnitude in the 20GB set, but still has a 0.000 p-value. For some reason, however, the "length" variable appears to be much more significant than in the Mini data and "day"

[7] I was somewhat surprised to see that the coefficient for extend was so high. It is my belief that the extreme popularity of theses items may have made this coefficient larger than it would have been on a less popular item. However, since I was not able to collect enough data for other items, I have no way to prove this.

appears to be slightly less significant. This disparity is likely a result of 20 observations for 20GB iPods collected on January 5, 2005. This was by far the most collected for any one day. It is quite possible that these observations, all with auction lengths much longer that average, are imposing a bias on the results. Here is a look at the same regressions without these 20 observations included:

Stata Results

```
. regress price bids length start extend day xmas

      Source |       SS       df       MS              Number of obs =     146
-------------+------------------------------           F(  6,   139) =   61.96
       Model |  171078.121     6  28513.0201            Prob > F      =  0.0000
    Residual |  63969.0147   139  460.208739            R-squared     =  0.7278
-------------+------------------------------           Adj R-squared =  0.7161
       Total |  235047.136   145  1621.01473            Root MSE      =  21.452

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bids |   .5774127   .3255764     1.77   0.078    -.0663098    1.221135
      length |   .1475591   .0498228     2.96   0.004     .0490506    .2460676
       start |   .0991251   .0450972     2.20   0.030     .0099598    .1882903
      extend |   21.62047   4.125333     5.24   0.000     13.46396    29.77699
         day |  -1.996525   .6819777    -2.93   0.004    -3.344916   -.6481338
        xmas |  -1.280462   .1048167   -12.22   0.000    -1.487703   -1.073221
       _cons |     198.36   10.42238    19.03   0.000     177.7531    218.9669
------------------------------------------------------------------------------

. regress price extend day xmas

      Source |       SS       df       MS              Number of obs =     146
-------------+------------------------------           F(  3,   142) =  105.54
       Model |  162269.157     3  54089.7191            Prob > F      =  0.0000
    Residual |  72777.9783   142  512.520974            R-squared     =  0.6904
-------------+------------------------------           Adj R-squared =  0.6838
       Total |  235047.136   145  1621.01473            Root MSE      =  22.639

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      extend |   20.57653   4.097277     5.02   0.000     12.47699    28.67608
         day |  -2.311136   .7072528    -3.27   0.001    -3.709241   -.9130312
        xmas |  -1.430214   .0945227   -15.13   0.000    -1.617068   -1.243361
       _cons |   233.2297   5.105341    45.68   0.000     223.1374     243.322
------------------------------------------------------------------------------
```

This now appears much more similar to the iPod Mini data. This leaves us with:

$$\textbf{price} = 233.23 + 20.58(\textbf{extend}) - 2.3(\textbf{day}) - 1.43(\textbf{xmas})$$

The biggest variation between the two sets of data is the difference of approximately 50 between the two constant terms. This makes sense, though, as 20GB iPods typically retail for exactly $50 more than iPod Minis. Other than this, the most significant disparity is the Adjusted R-squared, which stands at approximately .68, about .10 more than the corresponding Mini result. If all of the many slight differences and similarities are trimmed away, though, leaving just one conclusive result from these regressions, it is that the "extend" variable is significant. That is, just as the data collected by Roth and Ockenfels implies, an extended end-time format does, in fact, result in a higher price than a hard close format.

III. Bidders' Strategies

Now we know that extended end-time auctions do appear to have higher prices than hard close auctions, but why? What are the relevant bidding strategies and what impact do they actually have on the final price? Clearly, when the factor being examined is the end time, the most relevant strategy is bidding late.

The bid history on auction listings can be used to determine when there is late bidding and when there is not. However, there is not necessarily any way to tell what motivation led to this behavior. Both Al Roth and Neeraj Gupta, in his 2001 thesis at Harvard University, offer some hypotheses, both strategic and non-strategic, for bidding late. Two strategic reasons seem to be very relevant with this Yahoo Auctions study. One of these reasons implies bidders are taking advantage of other bidders, while the other implies that bidders are colluding in order to gain an advantage over the seller.

This first hypothesis is that more experienced bidders bid late to take advantage of less experienced bidders. That is, it is presumed that there are many users of online auction sites who are not as well informed of the options available to them as others. For example, it is likely that many bidders are unaware of the proxy bidding system. Under this option, users only need to bid once, entering the maximum amount they are willing to pay. The proxy bidding system will then bid on their behalf up to this amount. Bidders that are unaware of how this works, though, are likely to place many bids for whatever the minimum amount is at any given time. These less knowledgeable bidders will then proceed simply by responding to other bids. Thus, by sniping, more experienced bidders submit a bid at the last minute, potentially leaving these uninformed bidders with too little time to respond.

The other relevant strategic hypothesis is one of collusion. That is to say that some bidders bid late to avoid bidding wars with like-minded bidders. This, clearly, is somewhat similar to the first hypothesis in that the goal is to leave one's bidding opponents with too short a period of time in which to respond. Here, though, there is also an element of expecting to occasionally be outbid at the last-minute. Bidders may accept this reality if they know they may occasionally be the ones "stealing" an item at a low price. Of course, with either strategy, if the other bidders are using the proxy bidding system, it may not be an effective strategy.

Of course, there are also many non-strategic hypotheses for late bidding as well. Among these are procrastination, the previously mentioned lack of proxy bidding knowledge, and the tendency of auctions sites to list auctions ending soonest first. When considered in the context of Yahoo Auctions, these hypotheses are relevant for both hard

close and extended end-time auctions. The previously mentioned strategic hypotheses, however, are most likely to be a factor solely on hard close auctions.

So, while we should expect to find late bids with both formats, they should be more common when looking at auctions with a hard close.[8] This does, in fact, appear to be the case. Approximately 15% of the auctions with an extended end-time format have bids in the last 15 minutes of the auction. Auctions with a hard close, however, appear to have a bid in the final 15 minutes more than 50% of the time. The fact that there are more late bids for an auction with a hard close implies that one or both of the previously stated strategic hypotheses is most likely at play.

While many auctions on Yahoo are for similar items, each listing is unique. In addition to end time differences, each auction has its own unique length, starting price, and competing bidders, among many other variables. As such, it is very difficult to compare bid histories between two different auctions. Here, however, are two representative bid histories for both end time formats. The following Advanced Bid History is for a 20GB iPod auctioned with an extended end time format. The auction was set to close on March 8 at 21:40 PST (9:40 PM Pacific Standard Time).

[Mar 08 16:09 PST] exoticpryncs77 places proxy bid at $149.50
[Mar 08 16:09 PST] blackrooster97 places proxy bid at $147.00
[Mar 08 16:09 PST] exoticpryncs77 places proxy bid at $147.00
[Mar 08 16:09 PST] blackrooster97 places bid for 1 at $144.50
[Mar 08 16:08 PST] exoticpryncs77 places proxy bid at $144.50
[Mar 08 16:08 PST] blackrooster97 places proxy bid at $142.00
[Mar 08 16:08 PST] exoticpryncs77 places proxy bid at $142.00
[Mar 08 16:08 PST] blackrooster97 places bid for 1 at $139.50
[Mar 08 16:08 PST] exoticpryncs77 places proxy bid at $139.50
[Mar 08 16:08 PST] blackrooster97 places proxy bid at $137.00

[8] Shah, Harshit; Joshi, Neeraj and Wurman, Peter. “Mining for Bidding Strategies on eBay.” North Carolina State University, May 2002.

[Mar 08 16:08 PST] exoticpryncs77 places proxy bid at $137.00
[Mar 08 16:08 PST] blackrooster97 places bid for 1 at $134.50
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $134.50
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places proxy bid at $132.00
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $132.00
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places bid for 1 at $129.50
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $129.50
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places proxy bid at $127.00
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $127.00
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places bid for 1 at $124.50
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $124.50
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places proxy bid at $122.00
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $122.00
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places bid for 1 at $119.50
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $119.50
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places proxy bid at $117.00
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $117.00
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places bid for 1 at $114.50
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $114.50
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places proxy bid at $112.00
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $112.00
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places bid for 1 at $109.50
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $109.50
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places proxy bid at $107.00
[Mar 08 05:49 PST] exoticpryncs77 places proxy bid at $107.00
[Mar 08 05:49 PST] dvanstraten@sbcglobal.net places bid for 1 at $104.49
[Mar 07 22:17 PST] exoticpryncs77 places proxy bid at $104.49
[Mar 07 22:17 PST] exoticpryncs77 places bid for 1 at $101.99
[Mar 07 22:15 PST] zamazingt places proxy bid at $101.99
[Mar 07 22:15 PST] exoticpryncs77 places proxy bid at $100.00
[Mar 07 22:15 PST] zamazingt places proxy bid at $100.00
[Mar 07 22:15 PST] exoticpryncs77 places bid for 1 at $72.00

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[Mar 03 00:32 PST] merl_long places proxy bid at $51.00
[Mar 03 00:32 PST] carrieaprater places proxy bid at $50.00
[Mar 03 00:32 PST] merl_long places proxy bid at $50.00
[Mar 03 00:32 PST] carrieaprater places bid for 1 at $1.04
[Mar 02 20:16 PST] ntdhillon places proxy bid at $1.00
[Mar 02 20:16 PST] merl_long places proxy bid at $1.04
[Mar 02 20:16 PST] merl_long places bid for 1 at $0.99
[Mar 02 16:55 PST] ntdhillon places bid for 1 at $0.99
[Mar 01 16:40 PST] Auction created with quantity 1 at $0.99

For simplicity's sake, some of the bidding between March 3 and March 7 is not shown. You can see quite easily, however, that there was no last minute bidding in this particular auction.[9] In fact, the highest bid was received five and a half hours before the closing time.

For the sake of comparison, here is the Advanced Bid History for a 20 GB iPod auctioned with a hard close. It was set to close on the same day, March 8, but at a different time, 16:45 PST (4:45 PM Pacific Standard Time). This, coincidentally, is quite close to the time of the final bid in the previously mentioned auction. However, since none of the involved bidders appear to have been active in both of the auctions, I believe these facts are unrelated.

[Mar 08 16:44 PST] idougert places proxy bid at $132.50
[Mar 08 16:44 PST] faltandgalt places proxy bid at $130.00
[Mar 08 16:44 PST] idougert places proxy bid at $130.00
[Mar 08 16:44 PST] faltandgalt places bid for 1 at $114.06
[Mar 08 16:20 PST] idougert places proxy bid at $114.06
[Mar 08 16:20 PST] idougert places bid for 1 at $111.56
[Mar 08 10:29 PST] jrpittman2000 places proxy bid at $111.56
[Mar 08 10:29 PST] earnestnam01 places proxy bid at $110.00
[Mar 08 10:29 PST] jrpittman2000 places proxy bid at $110.00
[Mar 08 10:29 PST] jrpittman2000 places bid for 1 at $102.50
[Mar 08 01:14 PST] earnestnam01 places proxy bid at $102.50
[Mar 08 01:14 PST] earnestnam01 places bid for 1 at $100.00
[Mar 08 01:14 PST] earnestnam01 places proxy bid at $100.00
[Mar 08 01:14 PST] pddouglas places proxy bid at $100.00
[Mar 08 01:14 PST] earnestnam01 places bid for 1 at $91.00
[Mar 07 18:48 PST] pddouglas places proxy bid at $91.00
[Mar 07 18:48 PST] jencremieux places proxy bid at $90.00
[Mar 07 18:48 PST] pddouglas places proxy bid at $90.00
[Mar 07 18:48 PST] jencremieux places bid for 1 at $61.00
[Mar 07 16:13 PST] pddouglas places proxy bid at $61.00

[9] This, in fact, is quite common for automatically extended auctions. As ironic as it may be, automatically extended auctions are rarely actually extended. This is discussed further in Section IV.

[Mar 07 16:13 PST] pddouglas places bid for 1 at $60.00
[Mar 07 14:52 PST] whiteboy90210sg places proxy bid at $60.00
[Mar 07 14:52 PST] neunic places proxy bid at $60.00
[Mar 07 14:52 PST] whiteboy90210sg places bid for 1 at $59.00
[Mar 07 14:52 PST] neunic places proxy bid at $59.00
[Mar 07 14:52 PST] whiteboy90210sg places proxy bid at $58.00
[Mar 07 14:52 PST] neunic places proxy bid at $58.00
[Mar 07 14:52 PST] whiteboy90210sg places bid for 1 at $57.00
[Mar 07 14:52 PST] neunic places proxy bid at $57.00
[Mar 07 14:52 PST] whiteboy90210sg places proxy bid at $56.00

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[Mar 03 15:41 PST] krossin_ova03 places proxy bid at $5.50
[Mar 03 15:41 PST] ykryukov places proxy bid at $5.00
[Mar 03 15:41 PST] krossin_ova03 places proxy bid at $5.00
[Mar 03 15:41 PST] krossin_ova03 places bid for 1 at $0.99
[Mar 03 15:30 PST] ykryukov places bid for 1 at $0.99
[Mar 03 13:33 PST] Auction created with quantity 1 at $0.99

Again, some of the bidding history has been omitted for simplicity. This information does, however, show how bidding can play out differently for an item with a hard close format. Here, we see that there was a flurry of bidding action in the final minute of the auction. This last minute surge increased the final price almost $20. This is in contrast to entire days earlier in the auction when there was not much movement in the price at all. This does suggest that, perhaps, there were bidders using the previously mentioned strategies to try to obtain this item at a price lower than what it may have been worth. This is in contrast with the extended end time format where bidders seem to understand that sniping would not be as efficient as a strategy and, thus, revealed their true willingness to pay well before the close of the auction.

There is no way to tell how much higher this price might have gone if other bidders were given the opportunity to respond to the bids in the final minute of the

auction. Perhaps it might have been as high as the above auction with an extended end time format. Then again, it is also entirely possible that there was not any strategic sniping going on here at all.

IV. Sellers' Strategies

It seems clear that bidders often use a strategy that is advantageous to them when bidding on an auction with a hard close. This strategy that is beneficial to them, though, is detrimental to the seller. Luckily, sellers have a way to prevent this strategy by choosing to list their auction with an extended end time format. This way, anyone who tries to snipe will cause time to be added to the auction, giving other bidders more opportunity to respond. This should, and very often does seem to, dissuade online auction users from even attempting to snipe.

Why is it, then, that sellers do not use this option more often? The majority of auctions listed on Yahoo are operated with a hard close. Of the observations in my data set, 63% of iPod Mini auctions had a hard close and 68% of 20GB iPods had such a setting.

One way to figure out sellers' rationale for choosing the option they did would be to ask them directly. In an effort to gain such information, I sent messages to sellers who had chosen a hard close for their iPod auctions. I asked if they knew about the extended end time option and, if so, why they chose the hard close instead. Unfortunately, it seems as though sellers did not wish to spend their time answering a question that was not

directly related to bidding on their item. I only got a couple of responses back and, thus, gave up such a quest for this information.

The few, and short, replies I did get, however, all left me with the same impression. That is that sellers, quite often, are not even aware of the option or, if they are, they never gave the differences much thought. If these sellers had been more knowledgeable and had experience with both of these end time formats, it is much more likely that they would have been aware of the potential differences in price that result.

I also checked how the option was presented to sellers when listing an item on Yahoo Auctions. By going through the procedure of listing an auction until I got the stage where the seller chooses the rules for their auctions, I realized that the end-time option is pre-set to be a hard close. If a seller wants an extended end time format, he must change the setting. If he does nothing at all, it is automatically a hard close. One reason for this may be that Yahoo is hoping to emulate eBay. Since eBay is by far the most popular online auction site, it might make sense for Yahoo to try to appeal to eBay users by making their auctions as comfortable and familiar to them as possible. This may also be why some sellers themselves prefer this option. They may be used to hard close auctions from their own experience or be trying to emulate an online environment that many of their bidders may be comfortable with.

Another hypothesis is that sellers are fearful of the auction being extended for too long of a time period. In theory, it is possible for an auction to be extended an infinite number of times. Of course, it is possible that even delaying an auction closing by a day could inconvenience a seller considerably. Still, this hypothesis assumes a lack of familiarity with the Yahoo site. Auctions with an extended end time format are rarely

actually extended. Even when they are, they are almost never extended for more than about 20 minutes. So this fear is an irrational one if the sellers are familiar with Yahoo Auctions.

So, for the most part, it seems as though sellers choose a hard close format over an extended end time format due to inexperience. Other than the possibility of wanting to conform to eBay, all of the other hypotheses seem to fall into this category of inexperience. It seems likely that many sellers do not know about the choice. Perhaps they know about the choice but just have not considered the potential effects of sniping. They may also be too inexperienced to know that fears of auctions being extended indefinitely are irrational. Again, there is no way to know all of the actual reasons behind seller decisions, but these are surely some of them.

V. Conclusion

Al Roth and Axel Ockenfels confirmed a very reasonable hypothesis that the type of end time format used in an online auction can affect bidding strategies. This implies, although they did not explicitly say, that these differences result in a difference in price. That is, one can expect an auction with a hard close to have a lower final price than an auction with an extended end time format.

Is this implication correct? If this is true, it seems irrational for a majority of sellers on Yahoo Auctions to choose a hard close over an extended end time format. So, does the data collected by Roth and Ockenfels lead us to make an incorrect assumption or

are these sellers irrational? According to my results, it may be that neither of these options is actually the case.

The data I collected from iPod Mini and 20GB iPods presents some convincing evidence. My regressions show that the end time format choice does have a significant effect on the final price. The results show that, for iPods auctioned on Yahoo between November 2004 and March 2005, one can expect the final price for an auction with a hard close to be about $20 lower than an auction with an extended end time format, all else being held equal.

Clearly, this price difference has something to do with the timing of bids. There are several hypotheses to potentially explain the existence of late bids. Some of these are strategic. For example, a person might bid late to avoid a bidding war with novice users who are unaware of the proxy bidding system. Experienced bidders may also be acting in collusion, essentially agreeing to bid late to keep prices lower. There are also a few non-strategic hypotheses. For example, users may bid late due to procrastination or simply because auctions that are ending soon are typically listed first.

All of these reasons could potentially lead to the existence of late bids. The difference, however, is that the strategic hypotheses are much more applicable to auctions with a hard close rather than auctions with an extended end time format. With this in mind, we would expect there to be late bids much more often in auctions with a hard close. This is, in fact, the case. Approximately 15% of auctions with an extended end time format have bids in the last 15 minutes, as opposed to more than 50% of auctions with a hard close that receive such bids. This implies that these strategic forces are likely at work in Yahoo Auctions.

Taking all this information, combined with the information that most auctions listed on Yahoo have a hard close, one might assume that sellers are exhibiting irrational behavior. It seems more likely, though, that these are the effects of inexperience and conformity. Inexperienced sellers may not know about the option or, if they do, might not have considered the implications of the option. It is also very possible that sellers are just trying to conform to formats used on eBay, the most popular of the online auction sites.

Auctions with an extended end time format generally end up with a higher price than their counterparts with a hard close. Yet, sellers continue to list auctions with a hard close format. While game theory and economic analysis can go a long way in interpreting certain social scenarios, irrationality and inexperience sometimes detract from the validity of such methods.

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