ENDOGENOUS ENTRY OF LANDOWNERS INTO CONSERVATION MARKETS OVER TIME

by

Jacob R. Fooks

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Approved: _____
Kent D. Messer, Ph.D.
Professor in charge of thesis on behalf of the Advisory Committee

Approved: _____
Thomas W. Ilvento, Ph.D.
Chair of the Department of Applied Economics and Statistics

Approved: _____
Mark Rieger, Ph.D.
Dean of the College of Agriculture and Natural Resources

Approved: _____
Ann L. Ardis, Ph.D.
Interim Vice Provost for Graduate and Professional Education

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ABSTRACT

This research examines the effectiveness of different conservation auction formats in an endogenous entry setting. Induced value auction lab experiments are used to test behavior in both dynamic and static auction structures. The results support prior results on the importance of cost effectiveness in purchasing decisions, and further show that past results may have been understated by ignoring dynamic elements like strategic entry and underbidding that arise in a dynamic endogenous entry environment.

Chapter 1

INTRODUCTION

Public programs have a long history contracting with landowners to procure environmental benefits that would otherwise be under-provisioned by a competitive market. Recent implementations of these programs have focused on auction based provisioning formats which are believed to decrease the ability of landowners to extract surplus rent from information asymmetries. Research on these auctions have typically considered them as single round, first price, discriminative Independent Private Value (IPV) auctions with fixed subject pools. This approach has some notable limitations. In actual markets, landowners typically do not find themselves locked into a single shot bidding scenario, but instead have the option to choose whether or not to participate in an auction over a series of years until they are either successful or abandon their efforts. This research uses laboratory experiments to study the behavior of landowners in repeated auctions with endogenous entry. The endogenous entry environment offers a richer strategy space which can lead to very different behavior than the single independent rounds case.

By considering the landowner decision process as a dynamic entry decision, landowners are allowed to time their decisions to enter into the market or convert their land into an alternative use. This has real policy implications. An understanding of the effectiveness of auction structures in securing environmental benefits under budgetary constraints, the causes of these difference in formats,

differences in bidding and entry behavior, and differences between the single round and multiple round structures could be useful in crafting institutions which are more effective at optimally provisioning public goods. Our results support prior results of the importance of cost effectiveness in targeting conservation policies. They also demonstrates that the composition of the bidder pool has large implications for the effectiveness of conservation auctions and that one way to increase participation of high environmental value land is to explicitly account for environmental benefits in the decision criteria. There results also contribute to the literature by explicitly testing for differences in behavior and outcomes between static and dynamically framed conservation auction. We find several interesting behaviors that are displayed only in the dynamic, endogenous entry auction structure that can lead to higher levels of benefit accruement, as well as lower offer levels from prospective program participants.

The following section presents some background on conservation auctions and motivates the consideration of them in a dynamic, endogenous entry format. We examine these using an induced value auction experiment in which subjects take the role of landowners with endowments of several parcels. Subjects choose between competing uses for each of their parcels over sequences of several rounds. Treatments vary temporal and institutional structures. This provides a rich dataset which is analyzed in terms of overall performance, subject entry behavior, and subject bidding strategies. These results offer several interesting implications, as well as potential for future research.

Chapter 2

BACKGROUND AND MOTIVATION

Conservation Auctions

There is a positive externality to undeveloped land. Such land can provide environmental and ecological services including soil and water conservation, plant and animal habitat, scenic views and open space, recreation, food and fiber security, efficient and orderly urban development, and a continued viability of the rural agricultural lifestyle (Gardner, 1997; Merenlender et al. 2004). These services have substantial social value, but landowners receive no compensated for their use. As such, owners will tend to convert more land into developed uses than is socially efficient and these services will be under provisioned by a competitive market. There is a wide variety of institutions that a social planner could adopt to correct for this (Duke and Lynch, 2006). A common approach is to purchase or offer payments to ensure the continuation of some portion of land in an undeveloped or environmentally valuable use. This includes "working" land like farms and managed forests that are economically productive but creates less income for the landowner than they could receive for developing the land or adopting less ecologically valuable management practices. The idea of these programs is to cover some portion of the cost (either real or opportunity) of maintaining the land in an ecologically productive management state. Early attempts in this direction used fixed payment programs which offered some amount per acre to adopt some best

management practices; however these tend to perform less efficiently then auctions. (Schilizzi and Latacz-Lohmann 2007).

The format for most conservation auctions is a multi-unit procurement (sometimes called reverse) auctions where sellers (landowners) compete to offer items to a single buyer (a conservation program) at the lowest price. The contracts are typically heterogeneous, having variation in both opportunity cost for sellers and the environmental quality of the parcels contracted. Landowners have private values which re generally unknown to both the program and other landowners. Contracts can vary from several years to permanent.

These auctions tend to be dynamic in that there are several repeating rounds. Landowners may choose to enter as many times as they like until they are successful. There are, however, submission costs for those choosing to make offers. These can come from time spent searching for programs, navigating regulations, mapping potential sites and investigating appropriate management technologies, and bid preparation. Groth (2008) suggests that these types of costs represent 1.7% to 9.1% of the amount of submitted bids for participants in a European Agricultural Fund for Rural Development biodiversity conservation program. This combination dynamic format and submission costs give bidders the opportunity to strategically choose their entry time so as to maximize their expected profit.

Endogenous Entry into Dynamic Auctions

This paper seeks to address an aspect conservation auctions that have been under-addressed in the literature. Conservation auctions tend to be inherently dynamic.

Landowners may choose to participate in a given year. If they are not selected, they may then decide to develop the land, reenter the auction the next year, or continue in its current use. This implies the second aspect; each landowner in the pool of potential auction entrants has the option to participate in a conservation auction at a given time. Some landowners may participate in strategic waiting, where they choose to delay their participation in the auction in the hopes that the market may be thinner in a future period, giving them the opportunity to extract a higher rent premium.

Most work that has looked at incorporating time elements into models of conservation auctions has avoided developing a theoretical model of bidder behavior. Hailu and Schilizzi (2006), Schilizzi and Latacz-Lohmann (2007), and Rolfe et al. (2009) all note the complexity of conservation auctions over multiple rounds as being an impediment in developing a realistic theoretical model of their dynamics, and instead offer computational or experimental approaches as an alternative. In order to get the most value out of these applied results, however, it would be useful to have a theoretical context in which to discuss them. To that end, several results that could be useful in thinking about how behavior in conservation auctions would be affected when considered over time are offered below.

Another characteristic of this auction structure is that they have endogenous entry. Most experiments done on conservation auctions have assumed a fixed number of captive participants. In reality there are a large number of landowners who are potential bidders who may choose whether to participate based on a variety of complex policy factors including developmental pressure, environmental quality,

and the presence of alternative programs (Duke, 2004). In order to capture realistic behavior, experiments need to consider bidder entry as it might be affected by the state of the auction. Levin and Smith (1994) and Menezes and Monteiro (1999) develop models for bidder behavior in static single round endogenous entry auctions with varying information structures and show that this relaxation of assumptions can decrease the efficiency of auctions in the static format. Jofre-Bonet and Pesendorfer (2000) consider a similar case of sequential highway contract procurement auctions with capacity constraints among the participants. They developed a model with only two participants and two periods, but showed that even within a simplified context in may be optimal for a participant to forgo bidding in an earlier round in order to maximize returns in a later round.

When there is a submission cost, a typical entry decision can be cast as an expected value problem. The landowner has some prior distribution of their probability of winning for a given bid level. For the single round case, if the expected return is positive, then the landowner will choose to enter.

For this experiment we will assume that future returns are known so there is no option value that can be derived from uncertainty in that regard. There could be additional option value based on the priors that the landowner has of probabilities of winning in current round verses future rounds. If the landowner believes in round t that there is a higher probability of winning at the same price or has the same probability of winning at a higher price, then there will be some additional value to keeping the land in an undeveloped state to be able to have enter into the auction in the future.

There are several questions that arise in this context. Most importantly, what auction format is most effective at securing environmental benefits under budgetary constraints? Assuming that there is a difference between these formats, what is the cause of these? Is it from the difference in bidding behavior of those preserved in the auction? Does the buyer face a different set of potential parcels entering based on auction structure? Finally, is there a difference in behavior between the single round and multiple round structures?

Chapter 3

EXPERIMENT DESIGN

The landowner entry process is examined in this research using a dynamic auction experiment in which subjects must choose between uses of several parcels of land. We used an induced value experiment with behavior under different time and auction formats compared within subjects. 144 University of Delaware undergraduate subjects participated in the experiment. Participants were recruited by email from first year economics classes and economics department student mailing lists. The study was advertised as an experiment in decision-making, with expected length of 1.5 hours and average earnings of $20. Sessions were held at the Experimental Economics Laboratory for Policy and Decision Research at the University of Delaware.

Each session involved 12 subjects who were organized into two groups of six. These groups were run simultaneously, but their execution was independent in that during auctions each group faced independent budgets and competed only with other subjects in that group. Groups of 6 have been shown to be sufficient to consistently achieve competitive behavior in past auction experiments (Bernard et al., 1998). Upon entering the lab subjects were randomly assigned to a computer and given written instructions (see Appendix). Computers were spaced at least five feet apart, and used privacy screens to ensure subject confidentiality in decision making. Subjects were given 10 minutes to read instructions followed by a PowerPoint and oral presentation explaining the experiment protocols. Subjects had

the opportunity to ask questions of administrators, but were instructed not to speak to other subjects at any point during the experiment. During the session participants received all information and submitted all decisions using a custom Microsoft Excel based interfaced programmed using Visual Basic for Applications.

To avoid expressing environmental values in their behavior, or trying to play a cooperative game[1], the experiment instructions were given a generic framing, with subjects being put in the position of the owners of unspecified "assets." Subjects made decisions on the employment or "use" of these assets over a series of "eras". Each era was comprised of multiple "rounds." In each round, subjects chose a use for each parcel, or could choose to participate in an auction with rules and budget dependent on treatment. This process is described in detail below. Procedural details are displayed in Tables 1 and 2.

Participants were endowed with three parcels of land for the length of an era. Eras are divided up into one, eight, or a random number of rounds. Each treatment had one of each era length. Participants made a use decision for every parcel in each round. Each parcel could be left in its current (agricultural) use (Use 1) and receive a fixed return, or converted to an alternative (development) use (Use 2) and receive a higher level of fixed payment. The conversion to Use 2 is irreversible; once Use

[1] Even with generic framing, in pilot sessions with undergraduate participants some participants where very hesitant to enroll in Use 2, even during the control treatments. Upon debriefing several noted that they had participated in public good and coordination experiments in the past as part of a class and were suspicious that there was a similar "trick" here. Extra care was taken to emphasize the independence of individual Use Returns from other participants in all following sessions, which seemed to largely eliminate this effect.

2 is chosen Use 1 can no longer be chosen for that parcel for the remainder of the enrollment period. Participants could also choose to enter into a discriminative, sealed-bid auction where they would make offers on contracts to permanently enroll their parcel in Use 1. A fixed payment of $20 was paid upon submitting an offer. This represents 10% of the average opportunity cost. Assuming that subjects bid at or somewhat above opportunity costs, this would be in line with Groth (2008). If a bid was selected the subject would receive a onetime payment in the amount of their offer. They would receive the Use 1 return for that round and all following rounds of the era. If they were not selected that would receive the Use 1 return for that round, and have the ability to reenter the auction or convert to Use 2 in future rounds. Offers were selected using an auction format constrained by the buyer's budget. The budget was $18,000 in the single round eras, or divided up into $2,250 per round in the multiple round eras, so as to be equal over the (expected) length of each era. If applicable, unspent budget was rolled over into the following round within an era. Subjects were told the amounts the buyers received in each round, but not the actual working budget including rollover.

The auction mechanism was varied in three treatments: Control in which there is no auction and subjects could only select Use 1 or Use; Reverse Auction in which subjects offers are ranked from lowest offer amount to highest, and purchased sequentially until the budget is exhausted and Cost/Benefit Auction in which a Cost Effectiveness Ratio is calculated by dividing offer amount by benefits for each

submitted parcel. These ratios are ranked from lowest to highest and purchased sequentially until the budget is exhausted[2].

Participants received their three parcels of land (assets) at the beginning of each era. Use decisions were made for each of these in each round. Eras could have lengths of one, eight, or a random number of rounds. Eras with a random number of rounds had a 12.5% chance of ending after each rounds. Subjects were explicitly told during the presentation that this implied an average value of eight rounds. Actual round length for random rounds was determined ahead of time and constant across sessions, but was not told to participants. Each treatment had one of each of these era structures. Each session consisted of three treatments "blocks" of three eras each, for nine eras in total. Subjects' parcel characteristics and total program budget per era were held constant throughout each block so that single and eight rounds structure outcomes could be directly compared across eras. For the random rounds, the eight round values was used so that it was equivalent in expected value. Both eight and random round length eras were used to control for possible end of era effects.

Assets are defined by three properties; Agricultural Return, Opportunity Cost, and Social Benefit Score. Agricultural Return represents the agricultural value of a parcel; Opportunity Cost represents the opportunity cost of keeping the land in

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[2] This is the effectively the same a calculating benefit-cost ratios and selecting from highest to lowest. The cost effectiveness approach was selected here because it is a current practice in existing conservation programs such as the Baltimore County Agricultural Land Preservation Program.

agricultural use (as compared to a higher development value); and Social Benefit Score represents a measure of ecosystems services provided, similar to the scoring systems used in many conservation programs. Opportunity Cost is assumed to always be positive (i.e. there are no parcels with an agricultural return higher than development value). These properties are presented to subjects as the "Use 1" return (Ag Return), "Use 2" return (Ag Return + Opportunity Cost), and "Program Benefit Score" (Social Benefit Score). Subjects are told that the Use 1 and Use 2 returns represent the payments they will receive from employing the asset in the respective use, while the benefit score represents an external benefit to an outside entity from having them choose Use 1, but has no effect on subject payouts. There were three levels for each of these properties (high, medium, and low cost, value, and benefit; see Table 2) generating a total of 18 unique possible parcels. These were representative of per acre payments for typical 100 acre Mid-Atlantic farms. Parcels were distributed among subjects so that each parcel was allocated exactly twice during a session. Also, the benefit score is assumed to represent a flow of benefits that is accrued during each round that a parcel is enrolled in Use 1.

Three different treatments were presented to the subjects: No Auction, Reverse Auction, and Cost/Benefit Auction. All sessions participated in all treatments, with the order of presentation being varied between sessions. The Reverse Auction is a sealed bid, discriminative auction in which the buyer ranks offers based on cost and purchases from least to most expensive until the available budget for that round is exhausted. This cost based approach is similar to that used by the Delaware Agricultural Lands Preservation Fund (Messer and Allen, 2010). The Cost/Benefit

Auction is similar to the Reverse Auction, but ranks on the ratio of offer amount per benefit obtained, similar to the approach used in Baltimore County Agricultural Land Preservation Program (Allen et al., 2011).

The budget was set to be a total of $18,000 an era, or $2.250 per round for multiple round eras. Any money that was not spent during a round was rolled over into future rounds until the end of the era. Subjects knew the structure of the budget, but were not told how much of it was used or rolled over during a round. During each round subjects made decisions on each parcel and submitted offers via computer to the administrator. After all subjects had submitted for a round the administrator determined the winning offers and sent results back to the computers. This continued over nine eras, after which subjects were paid at a conversion ratio of $3,333 experimental dollars to $1 US.

Chapter 4

RESULTS

This experiment provided a dataset that includes information on all individual use decisions, entry timing, and bid amounts as well as aggregate group result data. We will consider the results first qualitatively using basic descriptive statistics, followed by more formal models and tests of the hypothesis in the following section. In analyzing the data it will be useful to define several measurements.

Recall that parcels provide a flow of benefits each round they are enrolled in Use 1. Then the Round-Benefits provisioned by a parcel will be used to refer to the number of rounds a benefit is enrolled in Use 1 times the environmental benefit provisioned by that parcel. So for parcel i, with Social Benefits b_i which converts to Use 2 in round t the Round-Benefits for the era will be:

$$RoundBenefits_i = \sum_{i=1}^{t} b_i$$

For example, if a parcel with a benefit score of 60 is preserved in the first round it will be locked into Use 1 for the entire eight round era and so will accrue 480 Round-Benefits. If, however, offers are submitted for the first two rounds (and hence the parcel is in Use 1), which are rejected, so the owner gives up and converts (permanently) to Use 2 in the third round it will only accrue 120 Round-Benefits.

The Terminal Status of a parcel refers to the employment of a parcel at the end of an era. A parcel that is Developed has chosen Use 2 at some point during the era and thus remains in this use for the remainder of the era. A parcel that is Preserved successfully participated in the auction at some point and in now permanently

contracted into Use 1. A parcel that is Undeveloped is neither developed or preserved, though conceivably could be converted into one of those states in the future had the era not ended.

Unpreserved Benefits refers to benefits that accrue to society that are not associated with a parcel that has been preserved by the buyer. This could be either from a parcel that is Undeveloped, or from a parcel that was in Use 1 for some number of rounds, but later converted to Use 2. This would represent the total Round-Benefits accrued in an acre for all parcels that are not preserved in the program.

The Offer Premium is the offer amount of an offer made exceeding the opportunity cost for that parcel. This represents that amount of rent premium that the participant is attempting to extract in an offer. For parcel i with use returns Use1i and Use2i, submitting an offer in round t, this would be:

$$OfferPremium_{it} = offer_{it} - (Use2_i - Use1_i)$$

Descriptive Statistics

The central question in this research is as to the relative effectiveness of these mechanisms. Figure 1 displays the average Round-Benefits procured during an era by each auction format. These are further broken down by single, random, and eight round eras. Not surprisingly, both auction formats perform substantially better than the baseline case of no auction. Further, the Cost/Benefit Auction does appear to do better than the Reverse auction, though the difference here is much smaller: on the order of about a 10% improvement. The two obvious possible explanations for this difference is that Cost/Benefit Auction is either able to protect more parcels, or

is able to protect higher benefit parcels, or some combination of the two. The multiple round format appears to do somewhat better for both the case of no program, as well as for both of the program treatments. The difference in the no auction case could be an artifact of the experiment[3]; however the consistent gain in the two auction cases could point to a source of increase in program effectiveness that arises in the case of dynamic competition.

To examine the difference in effectiveness between auction formats we next look at the composition of both the bids submitted and parcels purchased, followed by the bidding behavior of auction participants. Figure 2 and Table 4 display the composition of parcel terminal statuses by auction type. The percentage of parcels protected looks to be very similar for both the Reverse and Cost/Benefit Auctions. The only difference is that the Reverse Auction appears to protect slightly *more* parcels than Cost/Benefit, though this effect is very small and decreases in the multiple round eras.

Even though the amount of parcels protected appears to be the same across auction types, the number of bids submitted is not necessarily. Figure 3 show the offers submitted and accepted for each type. For single round eras it again appears to be identical across auction formats, but for the multiple round eras the Reverse

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[3] As there was no possibility of program enrollment, and Use 2 always provides a higher return than Use 1, there is no obvious reason that participants should have chosen Use 1 in this case. Enrollment in Use 1 for the no program treatments occurs almost entirely in sessions where the no program treatments were held first. This suggests that subjects were reacting in confusion without the context of an associated auction to frame the decision.

Auction has many more offers and successful purchases. Looking at the amounts of offers submitted (Figure 4), it again appears that in the single round case Reverse and Cost/Benefit Auctions produce very similar results. However, in multiple round eras Cost/Benefit Auctions receive substantially higher offers as compared to the regular Reverse Auctions. There are two effects that could be underlying this observation. First, in Cost/Benefit, owners of lower benefit parcels may self screen out; they have a reduction in their perception of their probability of winning so choose not to enter. Second, owners of higher benefit parcels may have an increase in their prior due to both the selection mechanism aligning in their favor, and an expected decrease in the number of competitors with lower benefit parcels. Thus, they would tend to place higher offers to extract additional rent premium. This idea will be explored further in the next section.

Offers in multiple round eras also tend to demand a much smaller premium than in single round eras. Figures 5 display histograms of the premiums for offers placed. The vertical axes is located at the point at which offers are at opportunity cost. Most of the positive bids are in the 800 to 2400 range (or submitting offers at about twice the opportunity cost), although there are many bids at or close to opportunity cost, and a minority of bidders who are bidding substantially above opportunity cost. Any bids that are below zero were placed below cost. This is fairly common behavior, which does not correspond to an immediately obvious rational strategy. Part of this may be due to people playing to "win" the auction rather than to maximize their payoff; however there is a more rational explanation for this in the multiple round eras. An additional motivation for this behavior could also be a

"salvage" strategy in the multiple round auctions. Recall that the opportunity cost, and hence the risk premium is calculated based on the aggregate eight round return potential. However a participant who has attempted to enter the auction several times and been unsuccessful will find themselves in a position where they could offer below their full (complete era) opportunity cost, and still do better than if they converted to Use 2 for the remainder of the era (their future opportunity costs). This explanation is consistent with the distribution of bids. Observe that the multiple round distribution has a much thicker negative tail than the single round distribution, suggesting that there is a much higher rate of underbidding in the multiple round format.

Figures 7 and 8 break down the rate of participation and the average premium rate offered by round. It would appear that in the first round or two there are many subjects who are bidding to "win" at substantially below cost. These clear out after the first round or two, and we see much lower number of offers, and offers averaging at around to moderately above opportunity costs. As we approach the end (or expected end) of the era we see the premium decreasing back below opportunity cost as would be expected with a salvage strategy.

A final factor that could differentiate results between single and multiple round eras is the accumulation of Unpreserved Benefits. These benefits are accrued from parcels without compensation by the purchasing program. This could be either because the parcel was never developed or preserved (although will ostensibly likely be developed at some point in the future if we assume that the program is discontinued at the end of the era), or because it spent several rounds in Use 1 before

converting to Use 2 (due, perhaps, to a reduction in their prior from information from past market attempts). Both Reverse and Cost/Benefit Auctions get more Unpreserved Benefits than the No Program treatment. Further, Cost-Benefit gets proportionately more from censored parcels than Reverse Auctions which likewise gets more from censoring than does the No Program case. This suggests that, even if parcels do not enroll in the program, they may be delaying development due to the existence of the program.

Models

Several models of the program performance and participant behavior observed in the experiment are considered to test the above observations. To consider the overall effectiveness of the different auction structures two one limit Tobit models are considered to compare the expected round-benefits achieved under each program structure. Tobit is used here instead of OLS to account for censoring of the benefits accrued by a parcel at zero. This arises from the assumption that all parcels start out in Use 1 at the beginning of an era. Conceivably, some of these parcels could have been converted to Use 2 prior to the beginning of the era and hence been provisioning unobserved "negative benefits" in the context of the era. These models include fixed effects for the order in which treatments were presented to control for error and learning, and have standard errors clustered at the era level. Models controlling for era attributes only and both era and parcel attributes are used. The baseline is a parcel in a single round with no option to enroll in a program. All of the variables of interest are quite significant in both models. Both of the

multiple-round variables have a significant positive effect, suggesting that the single round, static format will tend to understate the effectiveness of the program. There does not appear to be any difference between the eight and round and random round formats in either of the models. Both of the programs do much better than the no program treatments. Testing for the equality of the two programs fails to reject the null when looking just at era attributes, but rejects the null at P=0.0010 when controlling for parcel attributes. Therefore, Cost/Benefit is indeed more effective than the Reverse Auction, though this difference is conditional on parcel properties. As expected, higher opportunity cost and lower benefit parcels will tend to have a lower level of expected benefits provisioned.

Duration (or survival) models are used to examine the timing of development and entry into the program. These are similar to models use in the first stage of Athey et al.'s (2011) estimation procedure for dynamic auctions, and have been applied specifically to study land development by (Towe, et al. 2008). These model a survival function, or the expected time until an event occurs or the equivalent hazard function or probability of an event occurring in some interval given that is has not occurred before that interval, conditional on a set of covariates. Figures 8 displays the Kaplan-Meyer estimates for the time to development and time to enrollment for each treatment by benefit level. These are non-parametric estimates of the survival curve which are able to take into account the right censoring of those parcels that are not preserved or developed at the end of an era. Only the eight round parcels where used in computing these estimates.

In all three treatments we see a large amount of development in the first round, followed by a relatively small rate of development after that. When there is no program, a little over 75% of all parcels get developed in the first round, while by the end of the era there is less than 10% remaining. Both of the auctions see an immediate drop of about 30-40%, with an additional decrease of about 10% or so in the following rounds. The primary apparent difference between the two is that for Cost/Benefit, after the initial drop, development of high benefit parcels is nearly nil. The enrollment rates of the two auction formats is also quite similar, except that high benefit parcels enroll much more quickly in Cost/Benefit relative to both other quality parcels in Cost/Benefit and high benefit parcels in the Reverse Auction. Table 5 shows the results of Wilcoxon and Log-rank tests of equality across curves. Tests of equality across all three curves, and across only the two auction formats are both rejected at the 1% level of significance.

These tests for equality can be further broken down by attribute. Table 6 shows the tests of equality of Kaplan-Meyer curves for time to development by each attribute, within each treatment. None of the parcel attributes appear to play a significant role in time to development in the absence of a program. Cost appears to be the only significant factor in the Reverse Auction, while both Cost and Benefit are significant in the Cost/Benefit auction. This further reinforces the conclusion that the Cost/Benefit is more effective at protecting high quality parcels.

This basic conclusion is reinforced using a Competing Risks model. This is an extension of the classic Cox Proportional Hazard Model (Prentice et al., 1978) which considers the risk of some event in the face of some competing, exclusive

event. Table 11 presents several models of the risk of development, accounting for the competing risk of enrolling in the program. Proportial Hazard models estimates the hazard of some event occurring λ as a function of a baseline hazard function, $\lambda_0(t)$, and a function of some set of covariates, f(X). This is often expressed as:

$$\lambda(t, X) = \lambda_0(\mathrm{t}) * \mathrm{e}^{\beta' \mathrm{X}}$$

Competing Risk models consider the possibility of several possibly outcomes and their respective Sub Hazard Functions. The Sub Hazard Function for event j would be:

$$\lambda_j(t, X) = \lambda_0(\mathrm{t}) * \mathrm{e}^{\beta' \mathrm{X}}$$

and the total hazard over m causes is:

$$\lambda(t, X) = \sum_{i=1}^{m} \lambda_i(t|X).$$

This can be estimated via Maximum Likelihood to obtain Sub Hazard Ratios for the covariates. These compare the probability of an event relative to a baseline. A Sub HR of 1 suggests that the covariate has no effect relative to the base. A Sub HR < 1 indicates that the event is less likely to occur relative to the baseline, while a Sub HR > 1 indicates that the risk associated with the covariate is higher relative to the baseline. So, for example, the Sub HR of 0.615 for Reverse Auction suggests that a parcel is 48.5% less likely to be developed than if there were no auction. Proportional hazard model typically assume that the hazard ratios are constant over time. This can be generalized using a time varying covariate effect. Time varying effects were tested for all of the covariates, but were only found to be significant for the two treatments, so where not included for all parcel attributes. Three

variations of the form of the variation over time are considered. The first assumes that the treatment effects vary linearly over time. This model suggests that the baseline effect of both treatments is zero, but that it they show a significant decrease in the hazard over time. The second assumes that the effects vary logarithmically over time. This suggests a significant baseline decrease in hazard, with a significant decrease over time. The third considers the possibility that the large first round drop may be a separate process, so excludes the first round. The results here are similar to, but smaller in magnitude to than the linear case, except that the baseline effect of the Cost/Benefit Auction is now borderline significant.

It appears that the Cost/Benefit Auction is able to protect high benefit parcels significantly better than the Reverse Auction. It is not clear whether this is due entirely to the effectiveness of the selection mechanism, or if there is a behavioral difference in the entry decision between the two auction formats. Table 8 shows the results of a Heckman-Probit model for sample adjusted probability of placing a bid. This estimates the probability that a bid will be placed for some parcel in a given round, conditional on that parcel not being currently developed or preserved. The marginal effects suggest that, after controlling for the probability of having been preserved or developed in prior rounds, parcel with High Social Benefits are about 5% more likely to enter in the Cost/Benefit Auction than the Reverse Auction. This suggests that in an endogenous entry setting the advantage of the Cost/Benefit Auction format is not just mechanical. It has the potential to offer increases in benefits achieved both by making the selection process more efficient, and also by inducing the entry of higher quality parcels into the choice set of the social planner.

Chapter 5

CONCLUSION

This experiment demonstrated that bidder behave differently in static and dynamic conservation auctions when the entry decision is endogenous. We compared several auction formats over both single and multiple rounds. The institutional settings included a no auction baseline, one in which participants competed purely on cost (Reverse Auction) and one in which they competed on both costs and benefits (Cost/Benefit Auction). Results suggest that the Cost/Benefit Auction is more effective at securing external benefits under a constrained budget. Further, while the single round auctions in general tend to understate results across the board, they also understate the effectiveness of the Cost/Benefit Auction relative to the Reverse Auction, and can gloss over other important behavior like strategic underbidding that can arise in an endogenous entry setting. While Cost/Benefit Auctions do seem to receive fewer offers, have lower levels of competition, and allow the extraction of larger rent premiums, it also is able to more effectively target high quality parcels, attract bids from higher quality parcels, and most effectively delay the development of that are not contracted into the program from conversion to a competing use.

The magnitude of these differences tends to be in the range of 5-10%. For instance, the results form Tobit regressions of expected benefits from a parcel on treatment and a parcel property suggests that the Cost/Benefit Auctions could outperform Reverse Auctions by 5.2-15.8%. This is not huge, but is a quite substantial amount, especially in light of the billions of dollars spent annually by programs like CRP.

While these are some compelling results, there are many factors that still need to be investigated in this context. There are also several other program formats beyond the two presented here such as benefit targeting and binary linear programming which could offer different entry behavior. Future work on option value and price uncertainty; information and communication (Ferraro, 2008); and nonlinear and spatially explicit benefits (Wu et al., 2000; Parkhurst et al., 2001) could all provide fertile ground for inquiry. Further investigation of these issues will help to better inform policy makers on the optimal design of conservation programs.

TABLES

Table 1. Experiment Roadmap

<table>
<tr><td>Subjects</td><td colspan="4">144 Undergraduate Economics Students, 12 per session, 12 sessions</td></tr>
<tr><td>Setting</td><td colspan="4">University of Delaware Experimental Economics Laboratory for Policy and Behavioral Research</td></tr>
<tr><td>Average Earnings</td><td colspan="4">$20.00</td></tr>
<tr><td>Time</td><td colspan="4">1.5 Hours</td></tr>
<tr><td>Treatments</td><td colspan="4"><table><tr><td></td><td colspan="3">Era Length</td></tr><tr><td></td><td>Single</td><td>Eight</td><td>Random</td></tr><tr><td>Control</td><td>A</td><td>B</td><td>C</td></tr><tr><td>Reverse Auction</td><td>D</td><td>E</td><td>F</td></tr><tr><td>Cost/Benefit Auction</td><td>G</td><td>H</td><td>I</td></tr></table></td></tr>
<tr><td>Session Structures (two of each)</td><td colspan="4">1) ABCDEFGHI
2) CBAFEDIHG
3) DEFHGIABC
4) FEDIGHCBA
5) GHIABCDEF
6) IHGCBAFED</td></tr>
<tr><td>Asset Endowment</td><td colspan="4">Three non-identical parcels with Low, Medium, or High levels of Opportunity Cost, and Agricultural Return (See Table 2); and Low, Medium, or High levels of Social Benefits (60, 75, or 90).</td></tr>
<tr><td>Auction Entry Fee</td><td colspan="4">$20 for each parcel</td></tr>
<tr><td>Subject Decisions</td><td colspan="4">One choice per parcel per round:
Use 1 – Receive Low (Agricultural) Return
Use 2 – Receive and be locked into High (Development) Return
Offer – Participate in auction to be locked into Use 1 in exchange for the amount offered</td></tr>
<tr><td>Auction Structure</td><td colspan="4">Control – No Auction
Reverse Auction – Discriminative auction ranked on Offer Amount
Cost/Benefit Auction – Discriminative auction ranked on (Offer Amount/Benefit Score)</td></tr>
<tr><td>Buyer Budget</td><td colspan="4">$2,250 per round ($18,000 during a single round era). Unspent funds roll over into the following round within an era.</td></tr>
</table>

Subject Information	Own private values, distribution of others' values and of buyer's budget.

Table 2. Parcel Properties Matrix

		Opportunity Cost of Enrollment			
		High (300)	Medium (200)	Low (100)	
Agricultural Return	High (300)	600 300	500 300	400 300	Use 2 Use 1
	Medium (200)	500 200	400 200	300 200	Use 2 Use 1
	Low (100)	400 100	300 100	200 100	Use 2 Use 1

Table 3. Total Benefits Obtained by Source

	No Program	Reverse Auction	Cost/Benefit Auction
Total Unpreserved Benefits	100%	13.4%	17.0%
Undeveloped	59.4%	10.2%	14.8%
Developed	40.6%	3.2%	2.2%
Preserved	0	86.6%	83.0%

Table 4. Tobit Results for Expected Achieved Round-Benefits (with Censoring at 0)

	Era Attributes	Era and Parcel Attributes
Random Rounds	20.30***	19.93***
	(6.927)	(6.949)
Eight Rounds	12.57**	12.53**
	(6.232)	(6.145)
Reverse Auction	70.71***	56.39***
	(10.096)	(9.541)
Cost/Benefit Auction	74.37***	65.34***
	(9.881)	(9.703)
High Social Benefit	-	19.86***
		(3.280)
Medium Social Benefit	-	6.27
		(4.066)
High Ag Return	-	-6.528*
		(3.469)
Medium Ag Return	-	-6.601*
		(3.331)
High Opportunity Cost	-	-49.92***
		(4.410)
Medium Opportunity Cost	-	-30.27***
		(3.228)
F	29.24	33.26
df	(6, 2613)	(12, 2607)
N	2619	2619
Censored	1558	1558
Test H0 (P-Values):		
Random Rounds = Eight Rounds	0.2841	0.3054
Reverse Auction = Cost/Benefit Auction	0.9056	0.0010

***, **, and * indicate significance at 99%, 95%, and 90% levels. Standard Errors clustered by era are reported in parenthesis. Constant term and fixed effects for treatment order are omitted.

Table 5. Test for difference in expected development time between treatments

	Tests for Equality of Treatments	
	All Treatments Equal	Reverse Auction = Cost/Benefit Auction
Wilcoxon	191.73***	11.82***
Log-rank	241.28 ***	12.82***

Test statistics are chi^2 with 1 df. ***, **, and * indicate significance at 99%, 95%, and 90% levels.

Table 6. Test for effect of parcel attributes on survival rates across treatments.

	No Program		Reverse Auction		Cost/Benefit Auction	
	Wilcoxon	Log-rank	Wilcoxon	Log-rank	Wilcoxon	Log-rank
Benefit	0.04	0.04	0.24	1.63	2.93	3.57
Op Cost	0.025	1.24	9.78***	12.72***	13.92***	20.56***
Ag Return	0.05	0.22	1.09	1.62	5.63**	6.60**

Test statistics are chi^2 with 1 df. ***, **, and * indicate significance at 99%, 95%, and 90% levels.

Table 7. Competing Risks Duration Models

	Linear Time Varying Effects		Logarithmic Time Varying Effects		Linear Effects - 1st Round Excluded	
	Sub HR	P-Value	Sub HR	P-Value	Sub HR	P-Value
			Base Effect			
Treatment						
Reverse Auction	0.907	0.321	0.615	0.000	0.934	0.863
Cost/Benefit	0.910	0.329	0.584	0.000	0.546	0.107
Benefits						
High	0.914	0.079	0.915	0.084	0.791	0.194
Medium	0.982	0.736	0.983	0.737	0.748	0.120
Op Cost						
High	1.767	0.000	1.767	0.000	1.731	0.006
Medium	1.550	0.000	1.549	0.000	1.560	0.010
Ag Return						
High	1.130	0.016	1.130	0.016	1.323	0.115
Medium	1.070	0.172	1.072	0.160	1.153	0.441
			Time Varying Effects			
Treatment						
Reverse Auction	0.664	0.000	0.369	0.000	0.704	0.002
Cost/Benefit	0.625	0.000	0.314	0.000	0.773	0.012

Table 8. Probit Model with Heckman Selection for Conditional Bid Placement.

	Model Estimates		Average Marginal Effects	
	B	P-Value	MFX	P-Value
		Pr(Bid Placement|Eligible)		
Cost/Benefit	0.002	0.232	0.001	0.974
Benefits				
High	0.102	0.011	0.034	0.012
Medium	0.285	0.000	0.097	0.000
Op Cost				
High	-0.185	0.000	-0.060	0.000
Medium	-0.057	0.271	-0.018	0.268
Ag Return				
High	-0.125	0.100	-0.040	0.092
Medium	-0.101	0.017	-0.033	0.016
BenefitsXC/B				
High	0.145	0.011	0.049	0.013
Medium	-0.169	0.004	-0.053	0.003
Op CostXC/B				
High	0.030	0.581	0.010	0.584
Medium	-0.000	0.998	-0.000	0.998
Ag ReturnXC/B				
High	-0.137	0.083	-0.044	0.074
Medium	-0.063	0.365	-0.020	0.358
		Pr(Eligible)		
Cost/Benefit	0.064	0.117	-	-
Benefits				
High	-0.033	0.385	-	-
Medium	-0.018	0.662	-	-
Op Cost				
High	0.038	0.337	-	-
Medium	0.033	0.419	-	-
Ag Return				
High	-0.070	0.146	-	-
Medium	0.002	0.961	-	-

Round fixed effects are omitted for the first state equation.

FIGURES

Figure 1 Average Benefits Achieved per Era

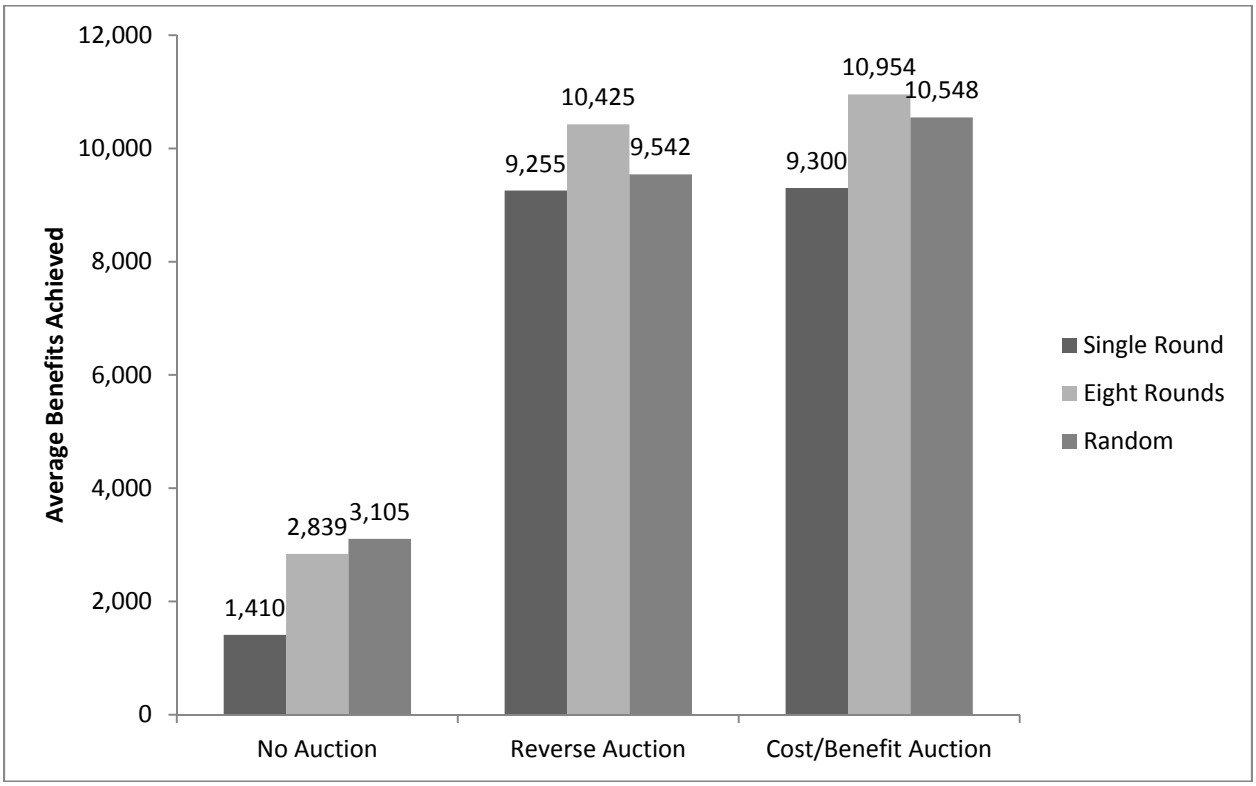


Figure 2 Percent of Parcels by Terminal Status

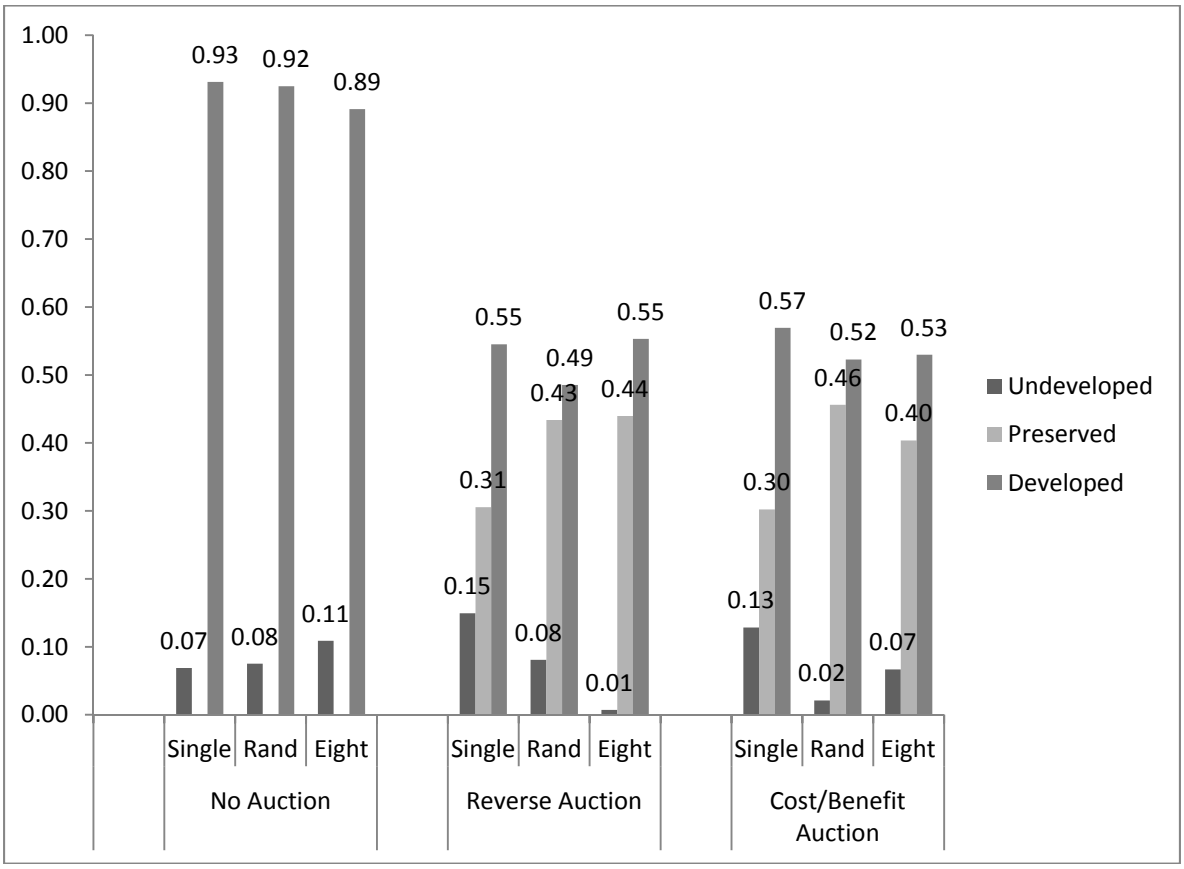


Figure 3 Number of Offers Submitted

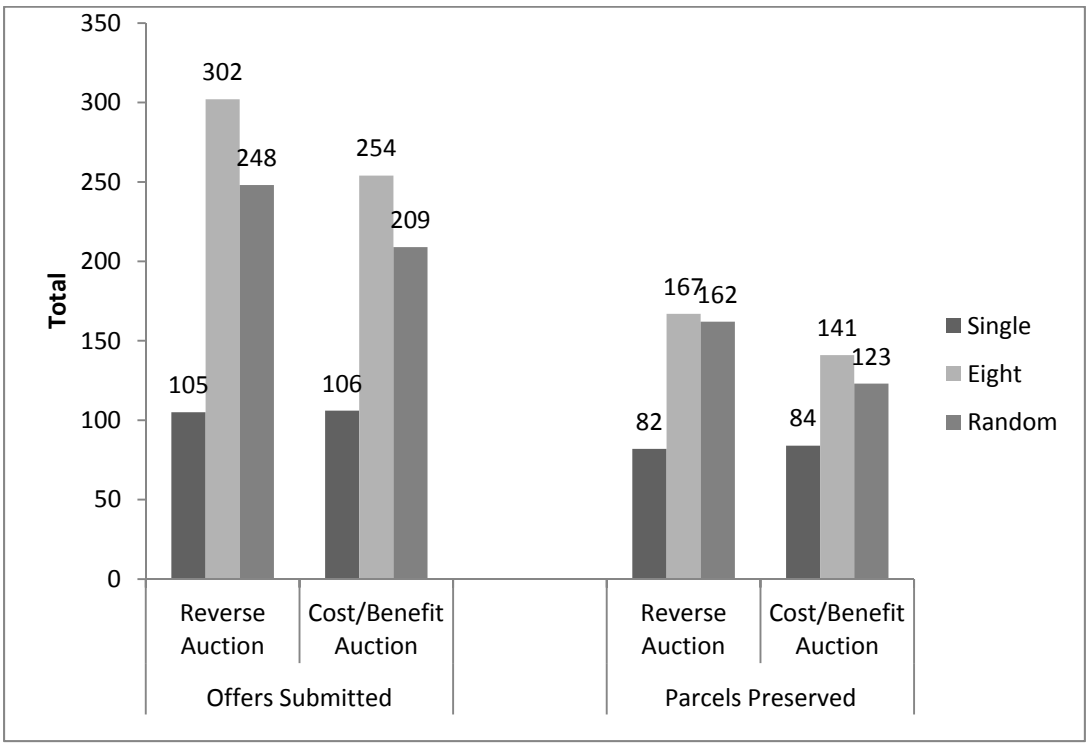


Figure 4 Amounts of Offers Submitted

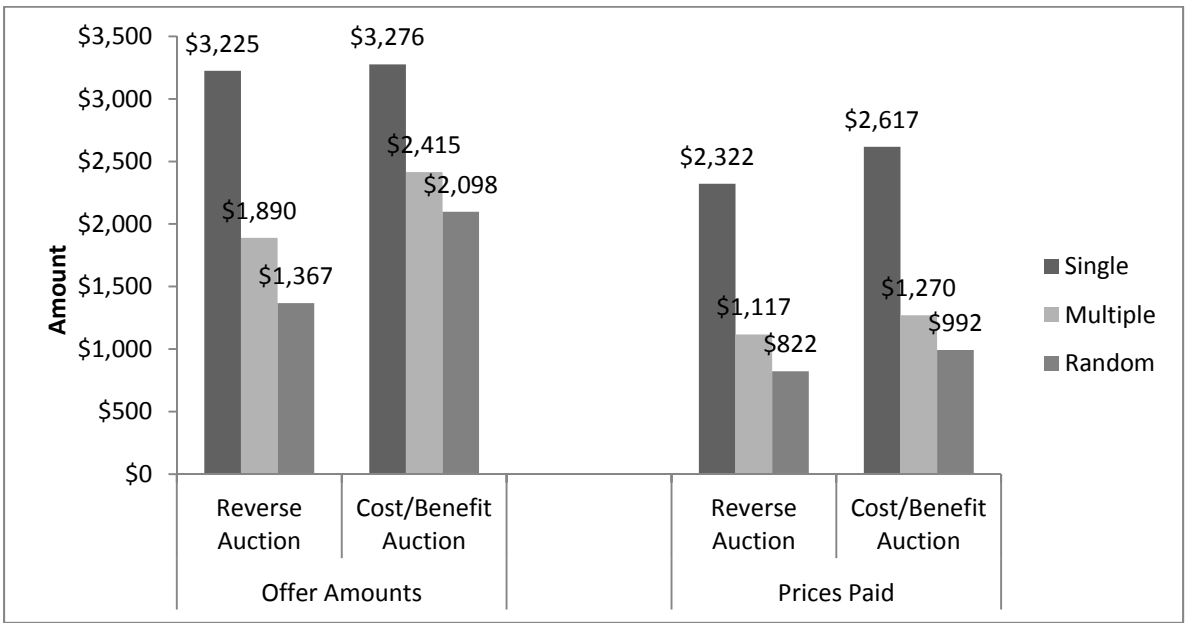


Figure 5 Histograms of Offer Inflation Amounts

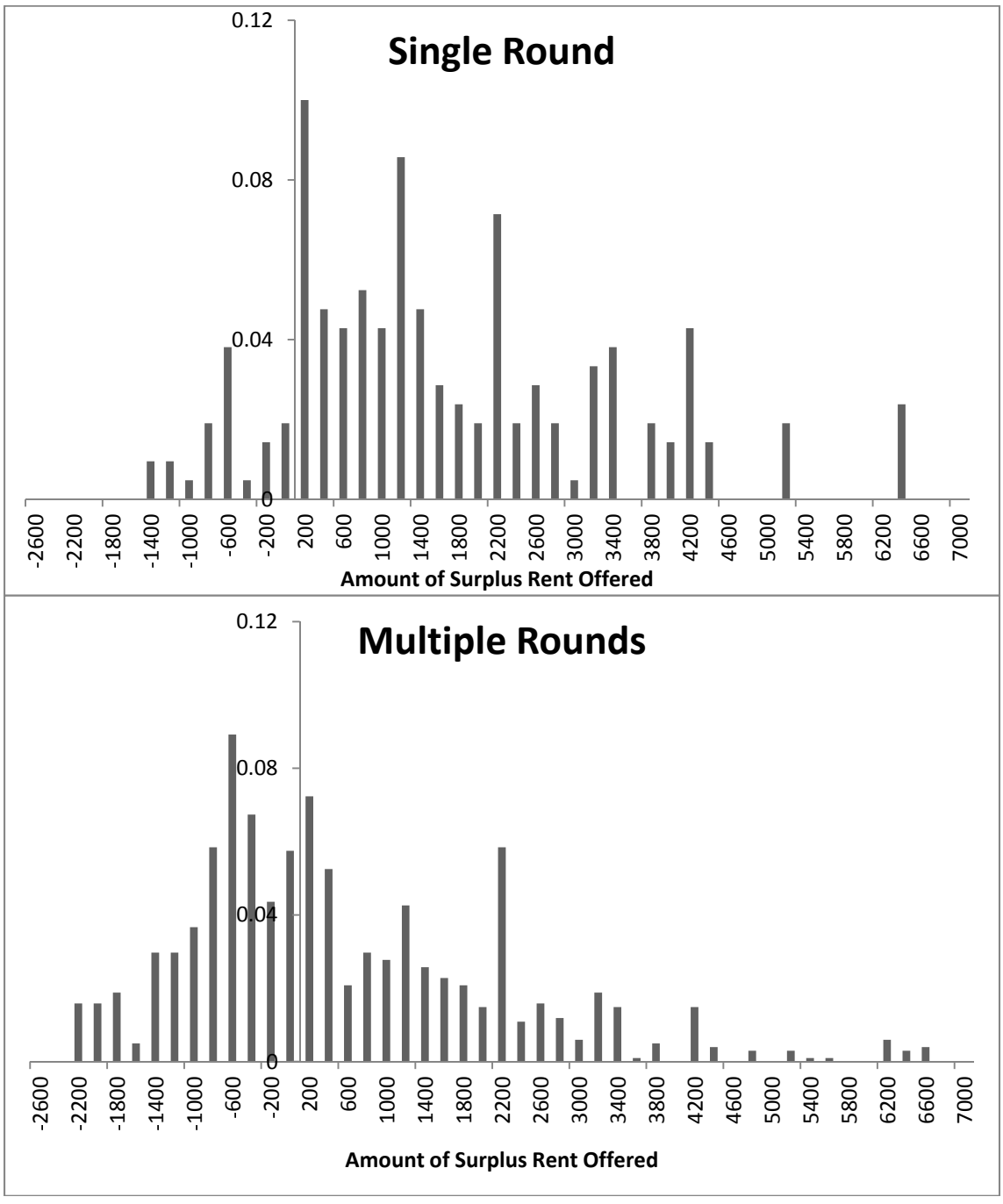


Figure 6 Number of Parcels Participating by Round

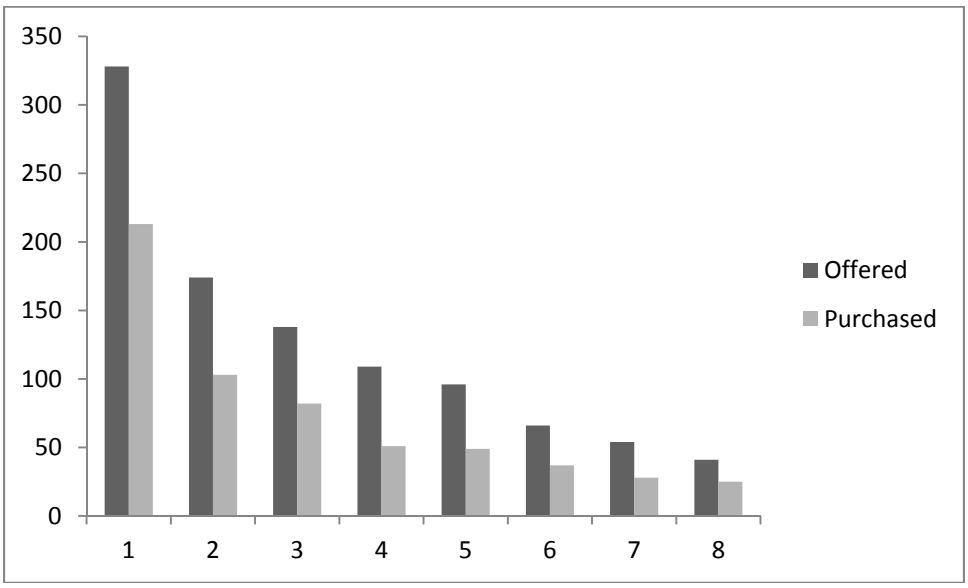


Figure 7 Average Premium by Round

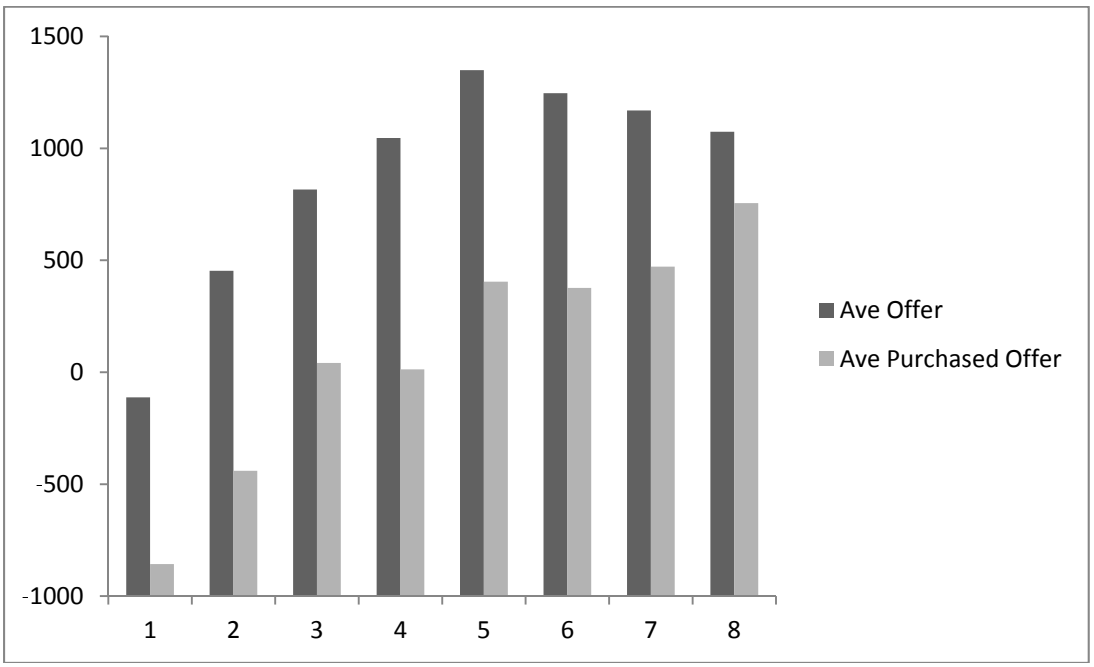
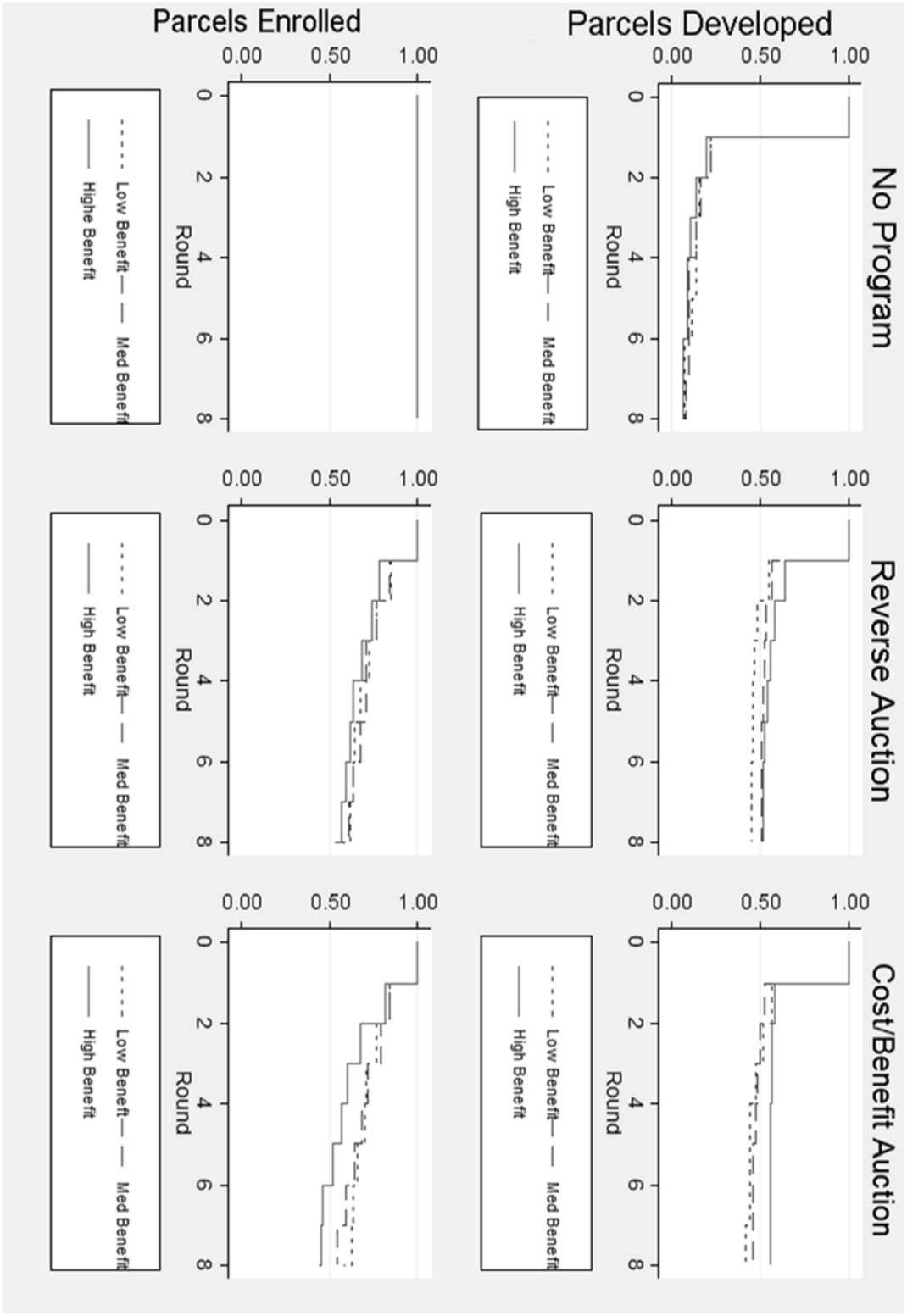


Figure 8 Kaplan-Meier Survival Curves for Development and Program Enrollment



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Appendix A.
EXPERIMENT INSTRUCTIONS

Instructions I – Use Selection

Welcome to an experiment in the economics of decisions making. During the course of this experiment you will have opportunities to earn money. Any money earned is yours to keep. Please read these instructions carefully and do not communicate with any other participants during the experiment. If you have questions at any time please raise your hand.

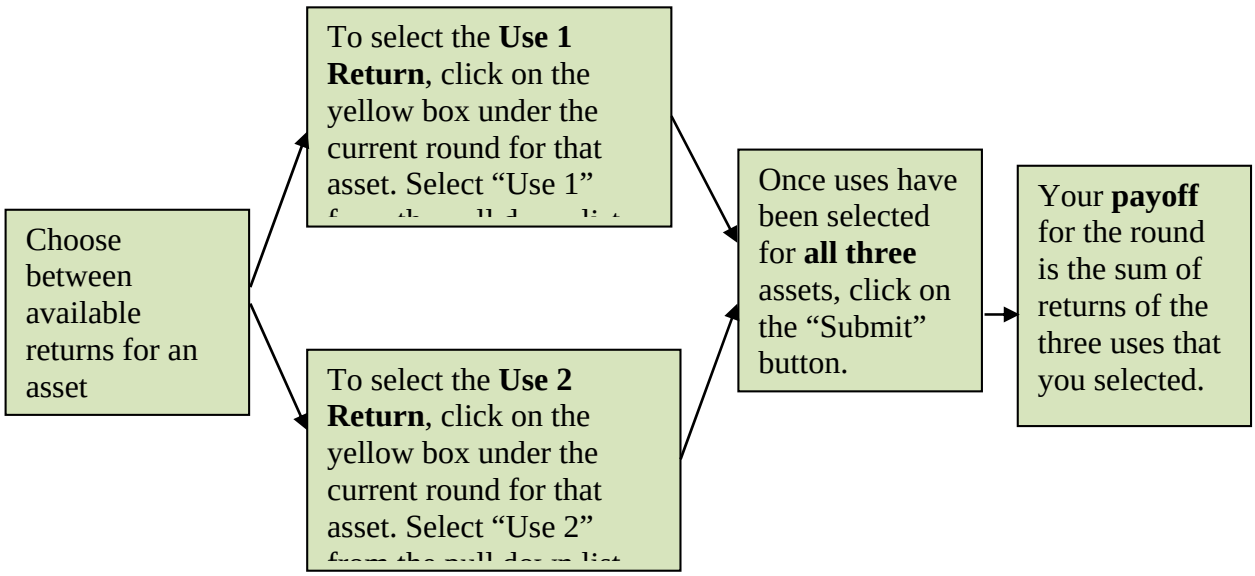
During this experiment you will assume the role of an **owner** of three **assets** over a series of **ownership eras**. Each era will consist of a number of **rounds** during which you will choose between competing uses in which you may employ these assets. Eras may have a length of one round, eight rounds, or a random number of rounds. If an era has a random number of rounds, each round has a 12.5% chance of being the last round. Therefore a random length era will have a minimum of one round, but no set maximum number of rounds. The actual random era lengths were determined before the start of this experiment.

During the course of a single era you will make decisions for the same three assets. You must choose between competing **Uses** for each of these assets. The use you choose will determine how much money you make from that asset. During the multiple-round eras, the decisions you make in early rounds may affect the choices available to you in later rounds. **At the beginning of a new era you will receive new assets and will not be bound by any choices from past eras.**

On the next page is a hypothetical example of a computer screen used in this experiment. All numbers displayed below are hypothetical. Each asset lists three attributes, the **Use 1 Return**, the **Use 2 Return**, and a **Program Benefit Score**.

- **Use 1 Return** indicates the monetary value you will receive in the current round from employing your asset in Use 1. If you employ Use 1 in during some round you are free to choose any use for that asset in later rounds.
- **Use 2 Return** indicates the monetary value you will receive in the current round from employing your asset in Use 2. An asset that is employed in Use 2 will be "locked in" to that use and will continue to receive the Use 2 return in all rounds for the remainder of the era.
- **Program Benefit Score** represents a benefit available to the program from your asset. This does not affect your earnings in any way and will be explained further later in the experiment.

In each round you must decide which of the available returns to accept (see figure below). **Your benefit and return values will not change during an era**, but may change at the beginning of subsequent eras.



Earnings in Each Round

After everyone has submitted their confidential decisions for the round the administrator records everyone's decisions. Once instructed by the administrator you may click the "Receive" button. This will update your earnings for that round. The earnings you receive for each asset will be the use return you selected for that asset. **The only thing that determines your earnings is the Returns for the Uses that you select.**

Subsequent Rounds

At the beginning of an era you will be told if the era consists of one, eight, or a random number of rounds. If you are in a multiple-round era, the choices available to you in subsequent rounds will depend upon your choices in prior rounds. If you

chose **Use 1** for an asset in prior rounds then you may choose either Use 1 or Use 2 in subsequent rounds. If you chose **Use 2** for an asset in a prior round, then Use 2 will automatically be selected for that asset in all subsequent rounds for the remainder of the era. In other words, once Use 2 has been selected then, for the remainder of the era Use 1 is no longer an option for that asset. You will be unable to choose Use 1 until a new era begins.

The figure below illustrates an example of a subject sheet at the end of the first eight round ownership era. The first asset has a Use 1 Return of 100 and a Use 2 Return of 300. The second asset has a Use 1 Return of 100 and a Use 2 Return of 400. The third asset has a Use 1 Return of 300 and a Use 2 Return of 600. In the first round, Use 1 was chosen for the first two assets, but Use 2 was selected for the third asset so that asset is "locked in" to use to for the rest of the era. Use 1 is selected for the second asset until round 3 and for the first asset until round 5, at which point all assets are in Use 2 for the remainder of the era.

		Subject 1		Era 2		Round 8			
	Round	1	2	3	4	5	6	7	8
Asset 1	Use 1	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100
	Use 2	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300
	Program Benefits	75	75	75	75	75	75	75	75
	Decision	Use 1	Use 1	Use 1	Use 1	Use 2	Use 2	Use 2	Use 2
	Earnings	$ 100	$ 100	$ 100	$ 100	$ 300	$ 300	$ 300	
Asset 2	Use 1	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100
	Use 2	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400
	Program Benefits	75	75	75	75	75	75	75	75
	Decision	Use 1	Use 1	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2
	Earnings	100	100	400	400	400	400	400	
Asset 3	Use 1	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300
	Use 2	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600
	Program Benefits	90	90	90	90	90	90	90	90
	Decision	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2
	Earnings	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	$ 600	

Total Earnings	Submit
$ 14,100.00	Receive
Exchange Rate	
0.0003	
Cash Earnings ($)	
$ 4.23	

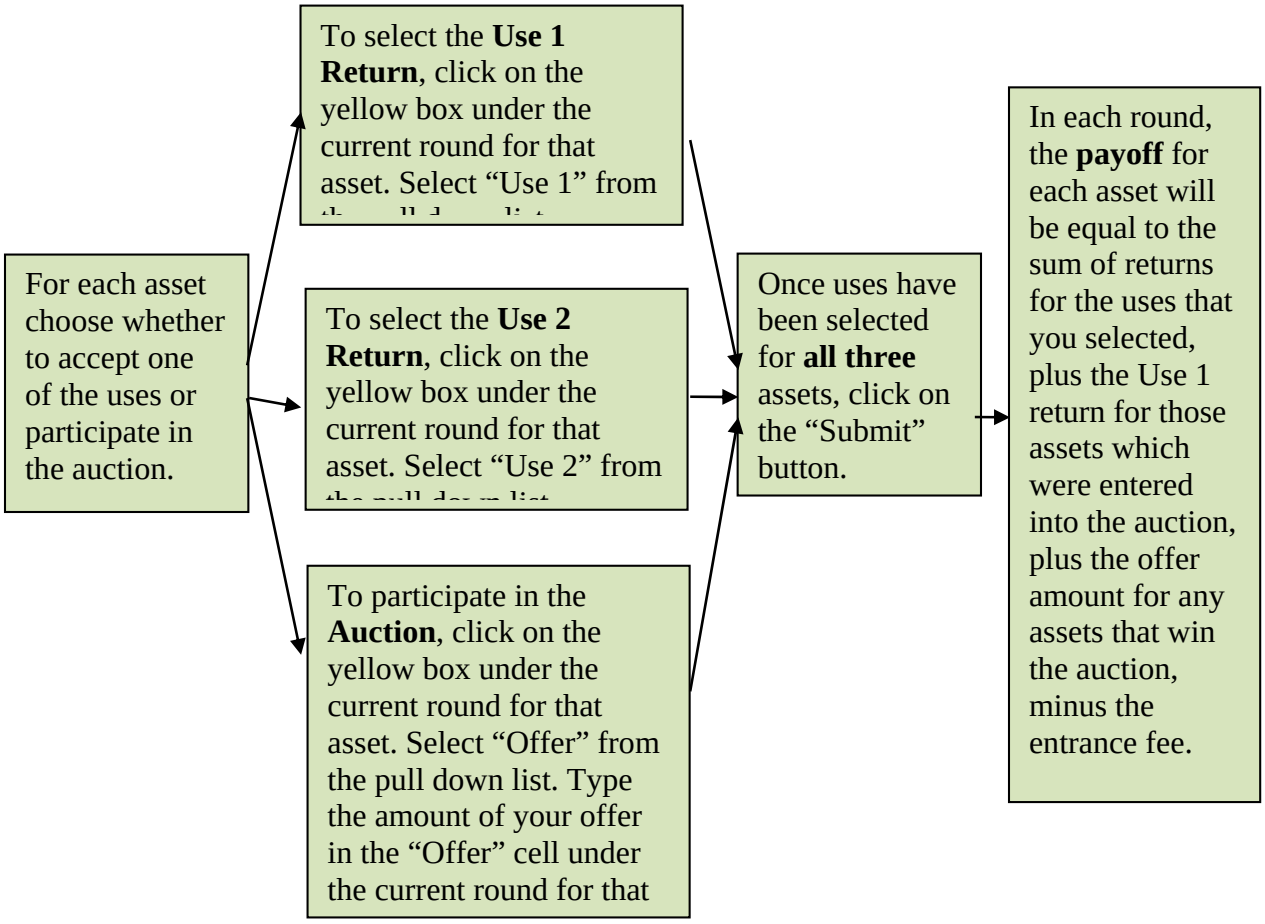
Final Earnings

Your computer will calculate your **earnings** in each round and keep track of your **total earnings** over all eras. An exchange rate of 3,333 to $1 will be used to convert your cumulative earnings from experimental dollars to US dollars. For example, if you earn 66,660 experimental dollars you will have earned $20 US to take home today.

Instructions II – Use Selection with a Contract Auction

This part is similar to the first part of the experiment (Use Selection), except that you have an additional option to consider for each asset. In each round, for each asset you may choose to: (1) employ the asset in Use 1; (2) employ the asset in Use 2; or (3) employ the asset in Use 1 and participate in a **Contract Auction**. If you participate in the auction you are competing to receive a onetime payment from a **Contracting Program** to employ that asset in Use 1 for the remainder of the era, foregoing the Use 2 option for that asset.

The Use 1 and Use 2 options operate as in prior eras. If you choose to participate in the auction, you must pay a $20 **Entrance Fee**. You will then submit an **Offer Price** for any assets that you choose to enter into the auction. Which assets are selected by the Contracting Program during a round will depend on the program's **budget** during the round, the number of assets entered into the auction during the round, and the offer amounts for each asset entered into the auction during the round. If an asset is contracted then that asset will receive the Offer Price plus the Use 1 Return for that round, and will receive the Use 1 Return for all subsequent rounds in the era.



How the Auction Works

After everyone has submitted their confidential decisions for the round the administrator records all decisions. For all assets which were chosen to participate in the auction, the offers will be ranked from lowest to highest based on the **Offer Amount**. The program will contract as many assets as possible, starting from the lowest Offer Amount and moving up until the available budget is exhausted. For example, imagine a round in which seven offers were submitted (ranked from lowest to highest):

Asset #	1	2	3	4	5	6	7
Offer	$100	$100	$150	$150	$190	$200	$300

Assets are purchased in order (from left to right) until the auction buyer does not have enough money to purchase another contract. For instance, if the buyer had an available budget of $600, then parcels 1, 2, 3, and 4 would be purchased for a total of $500. Parcel 5 would not be purchased since that would cost the agency $690, and exceed their available budget.

During the one round era the contracting program will have a budget of $18,000. During an eight round era any portion of the budget that is not spent by the Contracting Program will be added to the budget for the subsequent round. On top of any remaining budget from previous rounds, the contracting program gets $2250 of additional budget at the beginning of each round during the eight round eras. So, for example, if in round 1 $1,250 is spent on contracts, in round 2 there will be a total budget of $3,250: $2,250 in new budget for round 2 and $1,000 left over from the previous round.

To submit a offer for an asset, click on the yellow box under the current round for that asset. Select “Offer” from the pull down list. Then enter the amount of your offer in the “Offer” cell for under the current round. Then submit as you would for the other use options.

The figure below illustrates an example of a subject sheet at the end of an eight round ownership era. The first asset has a Use 1 Return of 30 and a Use 2 Return of 500. The second asset has a Use 1 Return of 300 and a Use 2 Return of 500. The third asset has

a Use 1 Return of 300 and a Use 2 Return of 400. In the first round, Use 1 was chosen for the first two assets, and a offer of $150 was placed for the third asset, but was not accepted. In round 2, the first asset is locked into Use 2, and a offer of $125 is submitted for the third asset, which is accepted, so that asset is locked into Use 1 for the remainder of the era. Offers of $150 are placed in rounds 3, 4, and 5 for the second asset. The offers are rejected in rounds 3 and 4, but accepted in round 5, locking that asset into Use 1 for the remainder of the era.

		Subject	1	Era	5	Round	8		
	Round	1	2	3	4	5	6	7	8
Asset 1	Use 1	300	300	300	300	300	300	300	300
	Use 2	500	500	500	500	500	500	500	500
	Benefits	60	60	60	60	60	60	60	60
	Decision	Use 1	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2
	Bid								
	Bid Accepted								
	Earnings	300	500	500	500	500	500	500	500
Asset 2	Use 1	300	300	300	300	300	300	300	300
	Use 2	500	500	500	500	500	500	500	500
	Benefits	90	90	90	90	90	90	90	90
	Decision	Use 1	Use 1	Bid	Bid	Bid	Use 1	Use 1	Use 1
	Bid			150	150	150			
	Bid Accepted			No	No	Yes			
	Earnings	300	300	300	300	450	300	300	300
Asset 3	Use 1	300	300	300	300	300	300	300	300
	Use 2	400	400	400	400	400	400	400	400
	Benefits	60	60	60	60	60	60	60	60
	Decision	Bid	Bid	Use 1	Use 1	Use 1	Use 1	Use 1	Use 1
	Bid	150	125						
	Bid Accepted	No	Yes						
	Earnings	300	425	300	300	300	300	300	300

Total Earnings	Submit
19350	Receive
Exchange Rate	
0.001	
Cash Earnings ($)	
19.35	

Earnings in Each Round

After everyone has submitted their confidential decisions for the round the administrator will conduct the auction to determine which assets are contracted. These, along with all other use decisions are recorded. At that point you may click the “Receive” button. If you submitted an offer you will learn whether or not your offer was accepted and your earnings will be updated. There are four possible outcome scenarios:

i) Sellers who choose to employ Use 1 will receive their Use 1 Return for that round, and will be able to choose any use option in future rounds.

ii) Sellers who choose to employ Use 2 will receive their Use 2 Return for the current and all future rounds.

iii) Sellers who choose to participate in the Contract Auction and are successful will receive earnings equal to their Use 1 return, plus their offer, minus the $20 entrance fee. In all future rounds they will receive only the Use 1 Return.

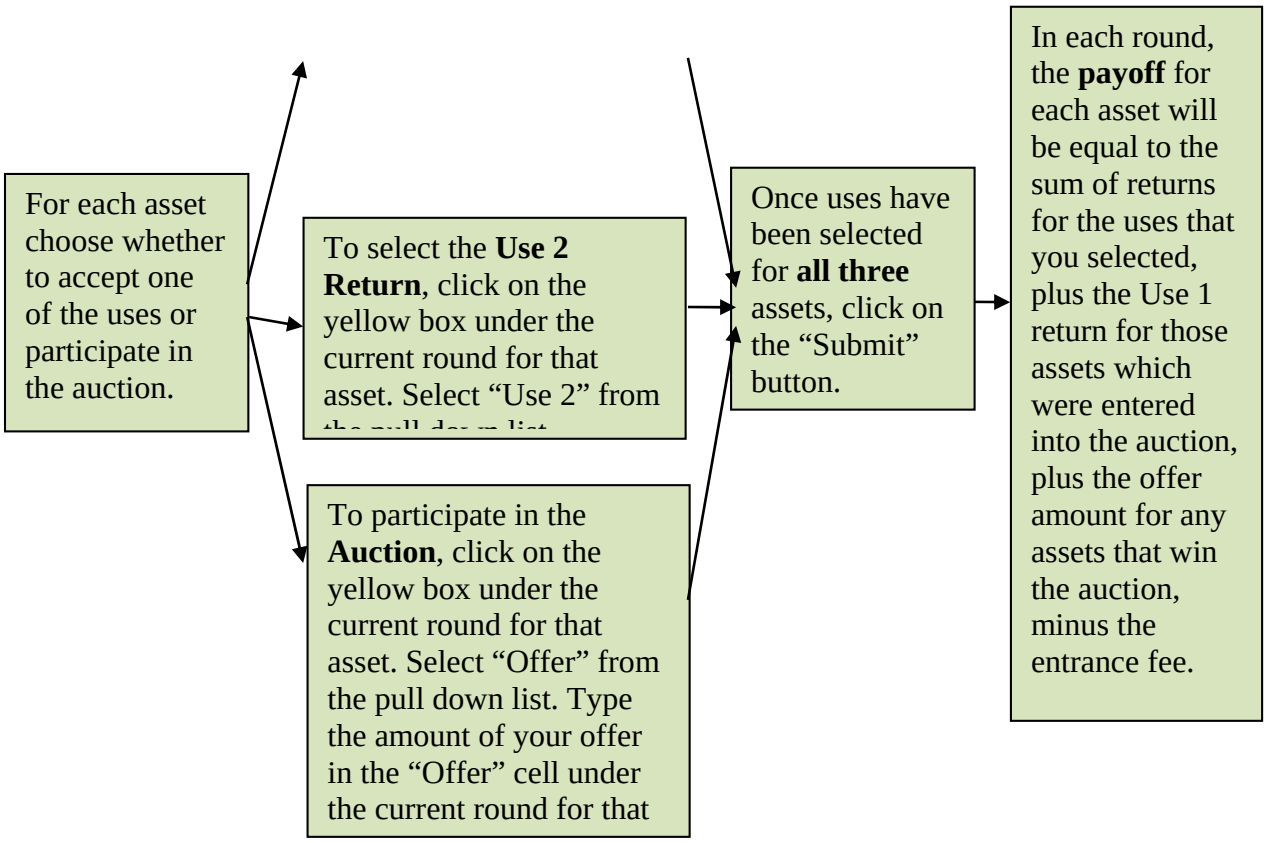
iv) Sellers who choose to participate in the Contract Auction but submit an offer that is too high for the available budget receive their Use 1 Return for that round minus the $20 entrance fee, and will be able to choose any use option in future rounds.

Instructions III – Use Selection with Cost Effectiveness Auction

This part is similar to the first part of the experiment (Use Selection), except that you have an additional option to consider for each asset. In each round, for each asset you may choose to: (1) employ the asset in Use 1; (2) employ the asset in Use 2; or (3) employ the asset in Use 1 and participate in a **Cost Effectiveness Auction**. If you participate in the auction you are competing to receive a onetime payment from a **Contracting Program** to employ that asset in Use 1 for the remainder of the era, foregoing the Use 2 option for that asset.

The Use 1 and Use 2 options operate as in prior eras. If you choose to participate in the auction, you must pay a $20 **Entrance Fee**. You will then submit an **Offer Price** for any assets that you choose to enter into the auction. Which assets are selected by the Contracting Program during a round will depend on the program's **budget** during the round, the number of assets entered into the auction during the round, and the offers and Benefit Scores of the assets entered into the auction during the round. If an asset is contracted then that asset will receive the Offer Price plus the Use 1 Return for that round, and will receive the Use 1 Return for all subsequent rounds in the era.

To select the **Use 1 Return**, click on the yellow box under the current round for that asset. Select "Use 1" from



How the Auction Works

After everyone has submitted their confidential decisions for the round the administrator records all decisions. For all assets which were chosen to participate in the auction, the offers will be ranked from lowest to highest based on a **Cost-Effectiveness Ratio**. The Cost-Effectiveness Ratio is calculated by dividing the Offer Price of the asset by the Benefit Score, giving a cost per benefit obtained measure. For instance, if an offer of $100 is submitted on an asset with a benefit score of 60, the Cost-Effectiveness Ratio will be 100/60 = 1.66 benefit points per dollar. The administrator will rank the Cost-Effectiveness Ratios for all submitted offers from lowest to highest and determine which

assets will be contracted based on the budget available for that round. The program will contract as many assets as possible, starting from the smallest Cost-Effectiveness ratio and moving up until the available budget is exhausted. For example, imagine a round in which seven offers were submitted (ranked from lowest to highest):

Asset #	1	2	3	4	5	6	7
Cost	$100	$100	$150	$200	$150	$190	$300
Program Benefit	90	60	75	90	60	75	75
Cost-Effectiveness	1.11	1.66	2	2.22	2.5	2.533	4

Assets are purchased in order (from left to right) until the auction buyer does not have enough money to purchase another contract. For instance, if the buyer had an available budget of $600, then parcels 1, 2, 3, and 4 would be purchased for a total of $550.

During the one round era the contracting program will have a budget of $18,000. During an eight round era, any portion of the budget that is not spent by the Contracting Program will be added to the budget for the subsequent round. On top of any remaining budget from previous rounds, the contracting program gets $2250 of additional budget at the beginning of each round during the eight round eras. So, for example, if in round 1 $1,250 is spent on contracts, in round 2 there will be a total budget of $3,250: $2,250 in new budget for round 2 and $1,000 left over from the previous round.

To submit a offer for an asset, click on the yellow box under the current round for that asset. Select “Offer” from the pull down list. Then enter the amount of your offer in the

“Offer” cell for under the current round. Then submit as you would for the other use options.

The figure below illustrates an example of a subject sheet at the end of an eight round ownership era. The first asset has a Use 1 Return of 300, a Use 2 Return of 500, and a benefit score of 60. The second asset has a Use 1 Return of 300, a Use 2 Return of 500, and a benefit score of 90. The third asset has a Use 1 Return of 300, a Use 2 Return of 400, and a benefit score of 60. In the first round, Use 1 was chosen for the first two assets, and a offer of $150 was placed for the third asset, but was not accepted. In round 2, the first asset is locked into Use 2, and a offer of $125 is submitted for the third asset, which is accepted, so that asset is locked into Use 1 for the remainder of the era. Offers of $150 are placed in rounds 3, 4, and 5 for the second asset. The offers are rejected in rounds 3 and 4, but accepted in round 5, locking that asset into Use 1 for the remainder of the era.

		Subject	1	Era	5	Round	8		
	Round	1	2	3	4	5	6	7	8
Asset 1	Use 1	300	300	300	300	300	300	300	300
	Use 2	500	500	500	500	500	500	500	500
	Benefits	60	60	60	60	60	60	60	60
	Decision	Use 1	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2	Use 2
	Bid								
	Bid Accepted								
	Earnings	300	500	500	500	500	500	500	500
Asset 2	Use 1	300	300	300	300	300	300	300	300
	Use 2	500	500	500	500	500	500	500	500
	Benefits	90	90	90	90	90	90	90	90
	Decision	Use 1	Use 1	Bid	Bid	Bid	Use 1	Use 1	Use 1
	Bid			150	150	150			
	Bid Accepted			No	No	Yes			
	Earnings	300	300	300	300	450	300	300	300
Asset 3	Use 1	300	300	300	300	300	300	300	300
	Use 2	400	400	400	400	400	400	400	400
	Benefits	60	60	60	60	60	60	60	60
	Decision	Bid	Bid	Use 1	Use 1	Use 1	Use 1	Use 1	Use 1
	Bid	150	125						
	Bid Accepted	No	Yes						
	Earnings	300	425	300	300	300	300	300	300

Total Earnings

19350

Submit

Receive

Exchange Rate

0.001

Cash Earnings ($)

19.35

Earnings in Each Round

After everyone has submitted their confidential decisions for the round the administrator will conduct the auction to determine which assets are contracted. These, along with all other use decisions are recorded. At that point you may click the “Receive” button. If you submitted an offer you will learn whether or not your offer was accepted and your earnings will be updated. There are four possible outcome scenarios:

i) Sellers who choose to employ Use 1 will receive their Use 1 Return for that round, and will be able to choose any use option in future rounds.

ii) Sellers who choose to employ Use 2 will receive their Use 2 Return for the current and all future rounds.

iii) Sellers who choose to participate in the Cost-Effectiveness Auction and are successful will receive earnings equal to their Use 1, plus their offer, minus the $20 entrance fee. In all future rounds they will receive only the Use 1 Return.

iv) Sellers who choose to participate in the Cost-Effectiveness Auction but submit an offer that is too high for the available budget receive their Use 1 Return for that round minus the $20 entrance fee, and will be able to choose any use option in future rounds.

Appendix B.
IRB APPROVAL LETTER

UNIVERSITY OF DELAWARE
RESEARCH OFFICE
210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: April 18, 2011

TO: Kent Messer, PhD
FROM: University of Delaware IRB

STUDY TITLE: [235937-1] Decision Making in Multi-round Conservation Auctions

SUBMISSION TYPE: New Project

ACTION: APPROVED (E. Peloso)
APPROVAL DATE: April 18, 2011
EXPIRATION DATE: April 17, 2012
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # 7

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.