RESOURCE ECONOMICS AND ENVIRONMENTAL SOCIOLOGY

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Staff Paper #12-01

Staff Paper

UNIVERSITY OF ALBERTA
DEPARTMENT OF RESOURCE ECONOMICS AND ENVIRONMENTAL SOCIOLOGY

AN EXPERIMENTAL EXAMINATION OF TARGET BASED CONSERVATION AUCTIONS

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ABSTRACT: Conservation auctions (CA) are typically employed to increase the provision of Ecological Goods and Services (EG&S) for achieving environmental goals. This paper examines the ability of a CA to meet an environmental target. Previous research on this topic used the number of contracts as a target rather than some specified environmental goal. We used experimental economic methods benchmarked to a wetlands restoration case study to examine a target constraint that must be met by bidders rather than a budget constraint. However, since no budget constraint is employed, agencies with limited resources might have to use other auction design procedures to ensure that financial outlays to pay winning bidders are not too high while meeting the target. Accordingly we utilized a reserve price experimental treatment to address this question. The research compares the various levels of budget and target approaches focusing on efficiency, environmental improvements, and rent seeking metrics.

Keywords: conservation auctions, environmental target, experimental economics
JEL Classification: Q52, Q58, D44

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Introduction

The use of auctions in agri-environmental policy and natural resource management is growing in popularity. The use of this market based mechanism involves the application of reverse or procurement auction formats because the environmental issues at play generally involve many individuals or businesses providing the good or service of interest to a central agency or buyer. Given that these auctions involve conservation issues of interest to governments or special interest groups, and that the providers of conservation services are typically private land owners, these auctions are called conservation auctions.

The conservation auction mechanism uses competitive bidding to reduce information asymmetry and can potentially be a price discovery mechanism. Winning offers or bids are selected using a ranking process where the conservation effort to bid ratio plays an important role. With competition as the driving force, participants are induced to reveal their costs (or close to their costs) of providing conservation services through the bidding process. This arises from tradeoffs between a bid being accepted and the resultant payoff (Latacz-Lohmann and Schilizzi 2005). The appeal of this bidding approach for policy makers arises from its potential to acquire a greater quantity of conservation actions for the same budget that would typically be spent in a fixed price or cost share scheme.

Following field trials of auctions in Australia (e.g. Stoneham et al. 2003) and the experience of the Conservation Reserve Program in the US a number of researchers have been examining various issues around the design of conservation auctions. These have involved choice of the payment format (e.g. Cason and Gangadharan 2005), concerns with bidder learning (e.g. Hailu and Schilizzi 2004), bid evaluation mechanisms, and issues around information provision (e.g. Cason et al. 2003). One aspect of conservation auction design that has not been well studied, however, is the choice of a budget constraint or a target constraint. In the former, the agency accepts offers until a predetermined fixed budget is exhausted; while in the latter, the agency predetermines the size of the conservation effort required and accepts offers until this target is achieved.

Most conservation auctions are conducted under a fixed budget cap. This is ideal when there are limited funds to dedicate towards a particular conservation effort. However, there can be uncertainty with regards to the impact a small budget would have in significantly improving environmental conditions. The target based approach could be used to ensure a certain level of environmental improvement is acquired. However, as Latacz-Lohmann & Schilizzi (2005) point out, under a target constrained auction scenario, the required budget to pay successful bidders is unknown prior to the auction taking place. Thus, while a target based approach may be useful in cases where the agency must achieve its environmental objectives, the funds required to complete the job are uncertain.

Environmental/conservation targets can be a useful tool to identify what environmental amenity is being conserved or protected and the quantity that should be conserved or protected. According to Possingham et al. (2006) an environmental target is a clear objective that quantifies the minimum level of an environmental asset that is to be conserved through one or more actions or policies. Targets can be determined in a variety of ways for a variety of different environmental assets, usually according to urgency and importance (Carwardine et al. 2009). For example, the need to meet a particular target could relate to certain human health impacts that require agricultural producers to change or adopt practices to reduce fertilizer or chemical use, or to adopt specific manure management practices. Failing to meet the target could result in significant human health impacts.

Despite the potential usefulness of the target based conservation auction, the only empirical research conducted on the approach is by Schilizzi and Latacz-Lohmann (2007) [henceforth called SLL]. Their study involved a comparison of the budget (BB) and target based (TB) approaches for the adoption of farm technologies to reduce non-point source pollution using experimental economic methods. SLL used the number of conservation contracts as a target (or the number of successful bidders). This number was arrived at by conducting budget constrained auctions previously and selecting as the target the number of winning bidders under the budget cap. One might think of this approach as endogenous as the target arises directly from the budget based auction.

However, in most instances an agency would not have the luxury of having information from a prior auction to set a target that arose from a previous budget based auction. Furthermore, the selection of the number of contracts as a target may not be closely linked to a particular desired environmental outcome.

SLL utilized multiple bidding rounds in their experimental study for both auction formats. They found that that the choice of format did not have much effect on auction performance. The BB auction performed slightly better than the TB auction in early rounds of repeated auctions, but that this was reversed in the last round. They also reported that performance, in terms of the proportion of bids submitted higher than opportunity costs of adoption, eroded with repetition but that there was no significant difference in this regard between the two auction formats.

The purpose of this present paper is to explore the efficacy of TB auctions in achieving conservation goals. We compare the TB with the BB format but choose an environmental target exogenously with no linkages to BB outcomes. The target involved a particular level of conservation action among the group of bidders rather than the number of contracts. We also explore the effect of including a reserve price in TB auctions as a means to reduce potential budget outlays. We utilize experimental economic methods to examine these issues which allowed us to also examine and compare the effect of repeated auction rounds in both the TB and BB formats.

The Applied Policy Setting

The conservation action examined in this paper involves the restoration of wetlands in a prairie watershed in southern Manitoba Canada. Wetland conservation is an important issue in Canada, with approximately 20 million hectares drained or lost since 1800 (Environment Canada 2009). Drainage is of particular importance in the prairie pothole region, which is a landscape containing many small wetland basins embedded in lands suitable for agricultural production. This overlap results in high levels of wetland conversion to agriculture. Due to the topography, agriculture in the area does not suffer from seasonal drought as in other regions in the Prairie Provinces, but rather must deal with flooding and excess water. Scientists estimate that up to 70% of wetlands that existed in some areas of Manitoba prior to human settlement have been drained (DUC 2008).

Awareness of wetland loss has led to a number of policy initiatives, the most successful being the North American Waterfowl Management Plan (NAWMP). Manitoba lies in the Prairie Habitat Joint Venture (PHJV) which has the stated objective to "restore waterfowl to levels enjoyed in the 1970's" (MIP 2008). Specific wetland restoration objectives for the most recent implementation plan involve target restoration activity of about 10,800 wetlands which is expected to be met by the direct purchase of sensitive lands and the use of conservation easements and other initiatives (MIP 2008). Many of these initiatives have been undertaken by the nongovernmental organization Ducks Unlimited Canada.

Drainage of wetlands allows agricultural farm operators to realize additional private economic returns on these lands (van Kooten and Schmitz 1992). Thus given this economic association between agriculture and wetland loss there is need to provide incentives to landowners to restore drained areas. Ducks Unlimited Canada have been leaders in studying various incentive programs, and has explored the use of conservation auctions to understand the costs of restoration and the delivery of programs to promote restoration (e.g. Brown et al. 2011; Hill et al. 2011). These auctions have been budget based and in at least one case were unsuccessful (Brown et al. 2011).

Given that targets are being defined in the various policy approaches to promote wetland restoration, it would seem that a target based conservation auction is worthy of exploration. In order to do this we utilize information in a specific Manitoba watershed where extensive research on the efficacy of and management changes is being examined in the context of increasing the provision of ecosystem services.

Methods

Wetland restoration is a worthy conservation activity to use in testing conservation auctions. There are a number of reasons for this. First, each potential bidder would know about the location of wetlands they drained and something about their costs of restoring them. Thus, as long as the auction involves activity levels involving the area of wetlands restored, there is no need for the use of complex environmental benefits such as pollution abatement or biodiversity metrics which may not be available or that landowners may not understand. This is not to say that using environmental benefits arising from restoration would not be useful.[1] Second, restoration is an activity that can be easily observed which reduces issues of compliance. Third, restoration would involve time horizons longer than a year which would reduce the potential for short run repeated auctions within a specific land unit.

There a number of challenges, however. The most important of these is that it would be unlikely for a landowner to restore every drained wetland on their property. In other words, there is a choice of the level of participation a landowner could consider in adopting this conservation practice.

In order to develop experimental auction platforms information we followed the approach of Tisdell (2007) by bringing actual biophysical and economic information into the economic laboratory. Utilizing information from research in the South Tobacco Creek watershed in southern Manitoba we determined the quantities of wetlands to be restored for each of the 36 agricultural producers operating in the watershed, as well as the costs of doing this.

Given that virtually all wetlands in the watershed had been drained it was necessary to first identify where these drained areas are located. Yang et al. (2009) identified suitable areas for restoration in the watershed using Lidar Digital Elevation Models to identify depression cells on the fields and then used this to generate depression polygons with areas from 0.1 to 7.0 acres.[2] This information determined that 31 of the 36 producers operating in the watershed had wetland basins that could be restored. These potential wetland sites were linked using a GIS with ownership data and producers' field boundaries provided by the Deerwood Soil and Water Conservation Association (DSWCA) and then linked with historic crop yield and production data collected by the DSWCA for each field.

[1] We note that the auction employed by Ducks Unlimited Canada for wetland restoration in Saskatchewan used estimates of hatched nests for waterfowl as the environmental benefit (Hill et al. 2011).

[2] These areas are consistent with the size range for Ducks Unlimited Canada (DUC) wetland restoration projects in the region.

Boxall et al. (2009) describe how this linkage provided the ability to develop estimates of the costs of restoration of each drained wetland in the watershed. These costs consisted of three components: the onetime costs of construction related to restoration (moving earth and removing ditch plugs), the nuisance costs of driving farm machinery around the restored wetland obstacle, and opportunity costs estimated as foregone income from crop production on the lands removed from production. The latter two components were estimated over a 12 year period which represents three crop rotations in the watershed. For our study the mean total cost per acre restored was estimated to be about $1,780.74/acre in the watershed with a standard deviation of $516.80/acre (Boxall et al 2009).[3] They show that there is considerable variation in number of wetlands to be restored as well as heterogeneity in their restoration costs across the producers in this watershed.

Since it is highly unlikely for each producer to restore 100% of their drained wetlands, a simplified process for providing options for fewer wetlands to be restored by each producer was required. Yang et al. (2009) developed up to three additional restoration scenarios using a spatial random selection of 50%, 25%, and 12.5% of potential wetlands in each producer's lands. This involved the exclusion of some of the full suite of wetlands on each producer's property in order to maintain an equal distribution of wetlands among the producers in the watershed. In each restoration scenario, it was assumed that a producer would restore all of the identified wetlands and the associated costs of doing this were developed using the individual wetland specific restoration costs discussed above. Not every farm had four scenarios available – some farms with fewer wetlands to be restored would only have three, two or one scenario available. Thus there heterogeneity in the quantity decisions existed in the sample of farms included in the experiments.

Experimental Auctions

[3] Boxall et al (2009) reported the mean total cost per acre restored in the watershed to be about $1,396/acre in the watershed with a standard deviation of $1085.81/acre. The costs used in the experiment differ for two reasons: i) the farms used represent a subsample of the complete set of farms in the watershed; and ii) the 2009 estimates involved some reinterpretation of the wetlands areas to be restored. The costs reported by Boxall et al. (2009) are the more accurate ones.

Economic experiments in a controlled laboratory setting were used in the collection of data for the target and budget based auctions. Essentially the same set-up was used for both types of auctions, where the primary difference was the decision rule surrounding who would receive contracts. The experiments were held at the University of Alberta during 2011. Students, both undergraduate and graduate from various academic disciplines, were recruited to participate in the experiments using ORSEE software, an online program used to manage the subject pool (Greiner 2004). All experiments utilized ZTREE software (Fischbacher 2007).

Each auction session consisted of 12 subjects, each subject "representing" a different farm in the watershed described by a set of restoration costs for up to four wetland scenarios. The 12 experimental producers were selected from the full set of 31 to accurately portray the cost function. Each participant was presented with information regarding the number of acres of wetlands that they could restore on their land and their associated costs for restoration for the different restoration scenarios on their lands. The number of restored wetland acres was referred to as "environmental benefits" and the act of wetland restoration was referred to as an "environmentally friendly practice" in order to prevent any "warm glow" affect associated with wetlands, which are widely understood as an important environmental issue in prairie Canada.

In each experiment there were 15 periods, each consisting of an auction. In each period participants were endowed with "net farm income" of $15 and faced the decision to submit an offer to restore wetlands or not. If they decided to submit an offer, this consisted of a required payment and choice of the number of acres to be restored in terms of the choice of one of the available restoration scenarios. The costs of restoration for each quantity choice were scaled to match the $15 endowment by dividing the actual restoration costs by a factor of 800. These costs ranged from $1.24 to $4.38 experimental dollars per wetland acre restored across the 12 farms. Each offer was in the form of a sealed bid and was thus unknown to other participants in the experiment. At the end of each period, participants were informed if their offers had been accepted and were told how much total cash they earned that period (i.e. income plus offer minus restoration costs).

After every fifth period the 12 experimental farms were redistributed at random among participants. Thus, participants were told they would "restart" the experiment with a new farm (and associated costs and quantities of restoration potential) for another five periods. This aspect of the design provided several advantages. First, this approach allows detailed examination of the effects of repetition, both within and among the 12 participants. However, it also ensured that each participant had a chance during the 15 periods to have a high cost or a low cost farm – for example some would have been "endowed" with a farm that had a low probability of being selected in an auction due to high costs per restored acre. Furthermore the switching of farms alleviated boredom and kept the participants engaged in the experiment.

The cash payments for the subjects involved a random selection of one of the 15 periods and included their farm income adjusted for adoption costs and offers if accepted in the auction. This ensured that each period was relevant in determining a participant's cash payout.

Budget based Auctions

We utilized two different sized budgets in our budget based experiments. The small program budget constraint was equal to 50% of the summed costs of wetland restoration under the 100% restoration scenario. This would allow one third of the wetland acres to be restored at cost. This choice of percentage was broadly based on a former Canadian Government program called the National Farm Stewardship program which would pay 50% of the costs associated with wetland restoration up to some maximum cost.[4] The large program budget constraint was equal to 75% of the summed costs of the 100% wetland restoration scenario which would permit half of the wetlands to be restored at cost.

In each period the offers were ranked by cost per acre and were selected until the budget was exhausted. Note that the variable offers and quantities chosen to be restored did not necessarily exhaust the entire budget in each period. This arises because the

[4] Note that this is not a fixed payment scheme as the costs of restoration or adoption of a practice would vary among individual producers.

lowest unsuccessful bid, if chosen, would have required more than the budget available. The subjects were aware of the existence of the budget constraint, but the size of it was unknown to them.

Target based Auctions

The 12 participants in total had 82 acres of wetlands that could be restored. We utilized two different targets: one termed a "small program" and the other a "large program." In the small program, the restored acres target was initially 30 acres and then in later experiments was adjusted to 25 acres.[5] These targets represented about a third of the total acres to be restored on the 12 farms. In the large program the acreage target was 45 acres, about half of available acres to be restored. For each program offers from participants in each period were ranked according to the cost per acre and the offers were accepted until the target was reached. In periods where the target was not reached, the auction was deemed to be a failure and no offers were accepted.

For those treatments where a reserve price was employed an acceptable bid had to be less than or equal to the reserve price per acre. The reserve price for the large target was chosen to be $2000/acre and for the small target was $1800/acre.[6] For the large target the reserve price would be higher than about 25% of the cost/acre combinations available to the subjects, while for the small target the reserve price would be higher than about 40% of the combinations. The reserve price was not communicated to participants, although they were informed that a reserve price would be employed in selecting offers. The subjects were aware that a target and a reserve price would be used when appropriate in a treatment. However they were not informed about the size of the target or the reserve price.

In summary, the experiments we employed consisted of six different treatments. For the budget based and target based auctions we ran two program sizes each. Additional

[5] We initially started with 30 acres and found several instances in pilots where the target was never met in the auction. Thinking this was a problem with the setting of the target, we reduced it to 25 acres to make it more achievable.
[6] We initially tried $1600/acre for the small target and found this too constraining.

target based treatments included the use of a reserve price or not. Each experimental session of 15 periods only included one of these six treatments.

Auction Procedures

During each auction session participants were first given time to read through an instruction powerpoint and were invited to ask questions. The instructions outlined how the auction mechanism worked and how contracts would be selected. The first decision required was whether to participate in the auction. If the decision was positive, then each participant was required to choose a level of participation (acres to be restored) from a list of options provided[7] and then an associated bid representing the total amount of compensation required to provide the chosen level of "environmental benefits". Once all bids were collected and "scored" participants were informed if their bids were chosen and were told what their earned income in that period was. The next period of the experiment then began.

Results

We report information from 17 experimental sessions. We strived to conduct three sessions for each treatment, but have only conducted 2 thus far for the small target with a reserve price.

Table 1 provides information on the success of the target based approach employed in terms of the number of periods in which the target was met for each of the two program sizes and whether a reserve price was used in determining winning bids. The results suggest that bidders had difficulties with the reserve price, as for each program size the percentage of rounds in which the target was met is much smaller than when a reserve price was not employed. However, using the reserve price lowered the costs of acquiring restored wetland acres and the budget outlays as expected.

Table 1. A summary of the success of the target based auctions under two program sizes (size of the target).

[7] The distribution of choices across the 12 farms was: 7 farms had 4 choices; 2 had 3 choices; 2 had 2 choices and 1 farm only had a single choice.

	Small program		Large program	
	No reserve price	Reserve price	No reserve price	Reserve price
Total auction periods	45	30	45	45
Target met (% total periods)	76%	40%	73%	51%
Mean budget spent ($)[1]	52312	44584	88976	80408
Mean cost ($/acre) [1]	1534	1435	1780	1567

[1] Note scaled to "actual" dollars, not experimental dollars

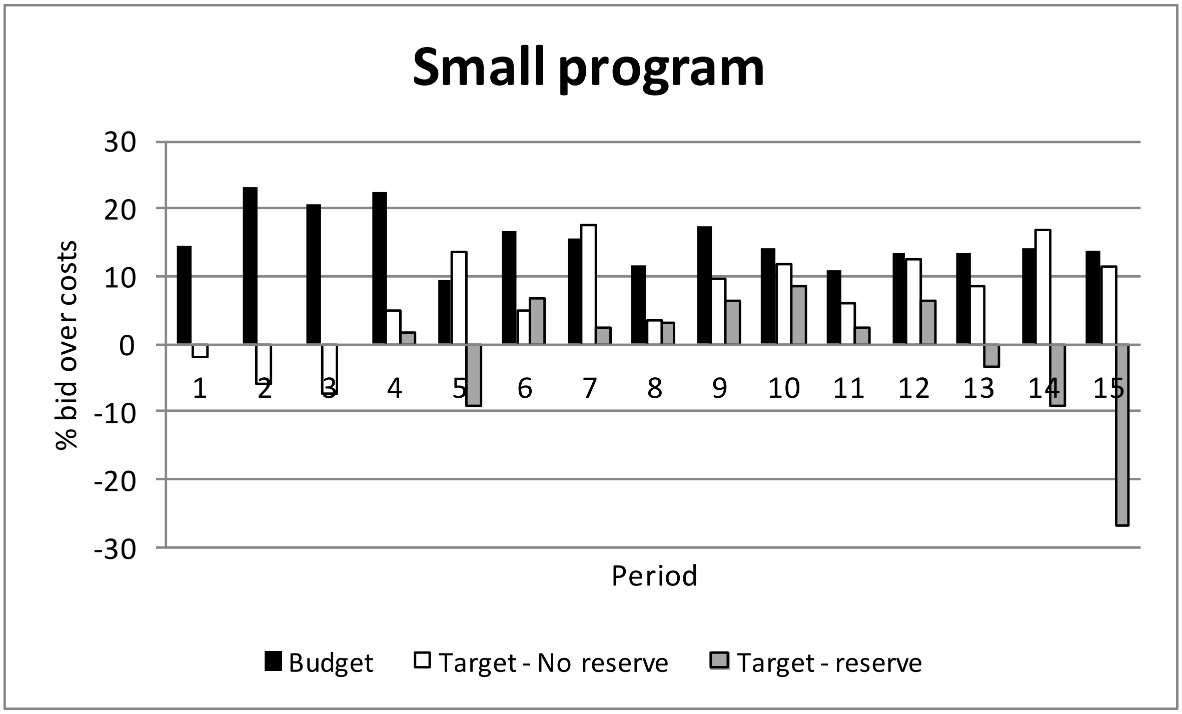
Since each session included 15 periods, a considerable amount of data results because each period represents an individual auction. However, in order to consider each period within an experiment an individual auction, one must examine whether the periods within an auction are independent since we used a repeated auction approach. We first summarize the auction results across the treatments using two performance measures. These measures included a measure of information rent or the percentage of the money obtained by the winning bidders from each auction above their costs (e.g. $\left[\frac{\text{Budget}}{\text{Cost}}-1\right]*100$), and the cost per acre to be restored generated from the auction. These measures were calculated for each successful auction period across the treatments. In describing these results we look for evidence of independence across the periods.

Figure 1 shows the average percentage successful bidders obtained above their costs for the budget and target treatments holding program size constant. For the small program the information suggests that the budget based treatments generated the highest information rents over the 15 periods. The mean percentages were 15.43% for the budget based auction and 7.29% and 2.87% for the target based without reserve and with reserve respectively. Similar findings emerge for the large program: with the mean percents being 35.03% for the budget based and 19.62% for the target without reserve and 6.63% with a reserve price. Note that the percentages for the large program are much higher than the small program within each treatment, suggesting that small programs with comparatively higher levels of bidder competition are more effective. Within and across program size the mean percentages for the treatments are statistically different (*t*-tests, $P<0.05$).

There appears to be no discernible pattern of rent obtained across the periods except for the target based auction without a reserve price. For this treatment within each round of five periods where the farm costs of restoration were held constant, there is an apparent rise in rent obtained. This is especially apparent for periods 1-5 and 11-15 for the large program (Fig.1b) and to a lesser extent for all three rounds in the small program (Fig. 1a).

Figure 2 shows the mean costs per acre for the wetland restoration contracts obtained from successful bidders in the auction for each treatment across the 15 periods. For the small program, the costs per acre were lower for the target based auctions than the budget based ones, but it is not obvious that the reserve price yielded more efficient auction performance except in the last round. However, the mean price is $1534/acre for the non reserve treatment and $1391/acre for the reserve price treatments and these means are significantly different (*t*-tests, $P<0.03$).

For the large program, a similar pattern emerged – the budget based auction provided the highest costs per acre restored at $2000/acre. However, using the reserve price in the target based auctions clearly yielded lower costs at $1567/acre compared to $1780/acre without the reserve price. The differences between these three means are significantly different than 0 (*t*-tests, $P<0.001$).



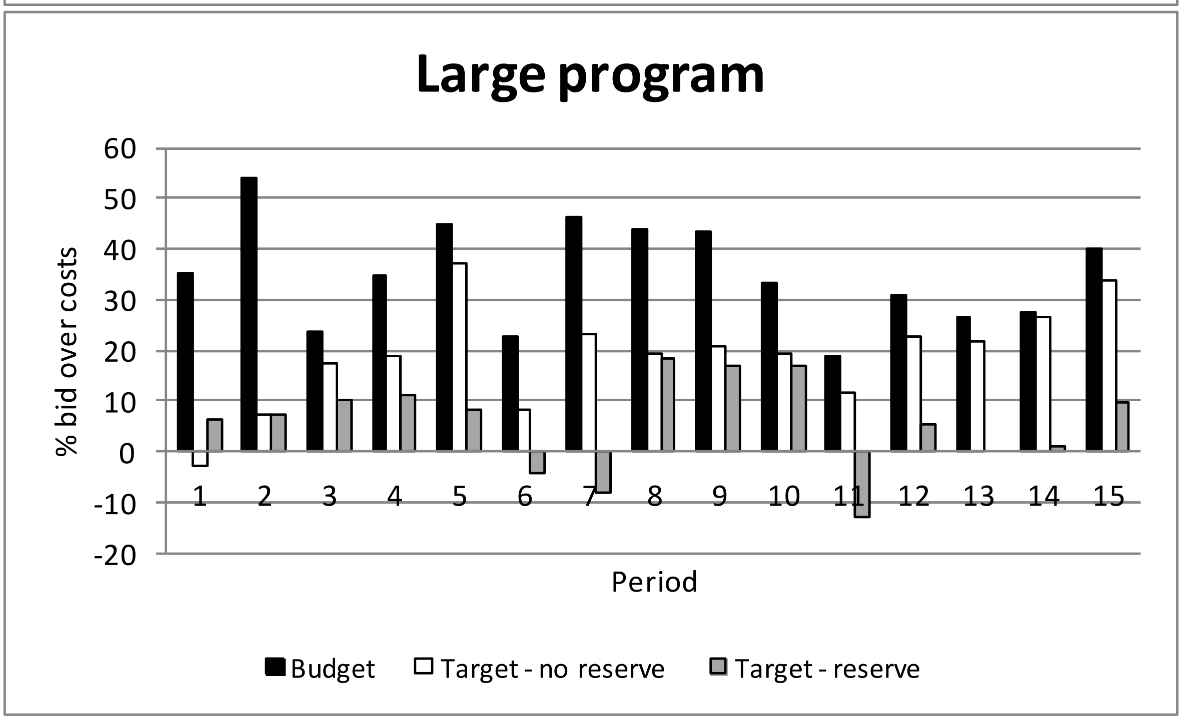


Figure 1. The average percent successful bidders obtained in each period above their actual costs of restoration for two program sizes.

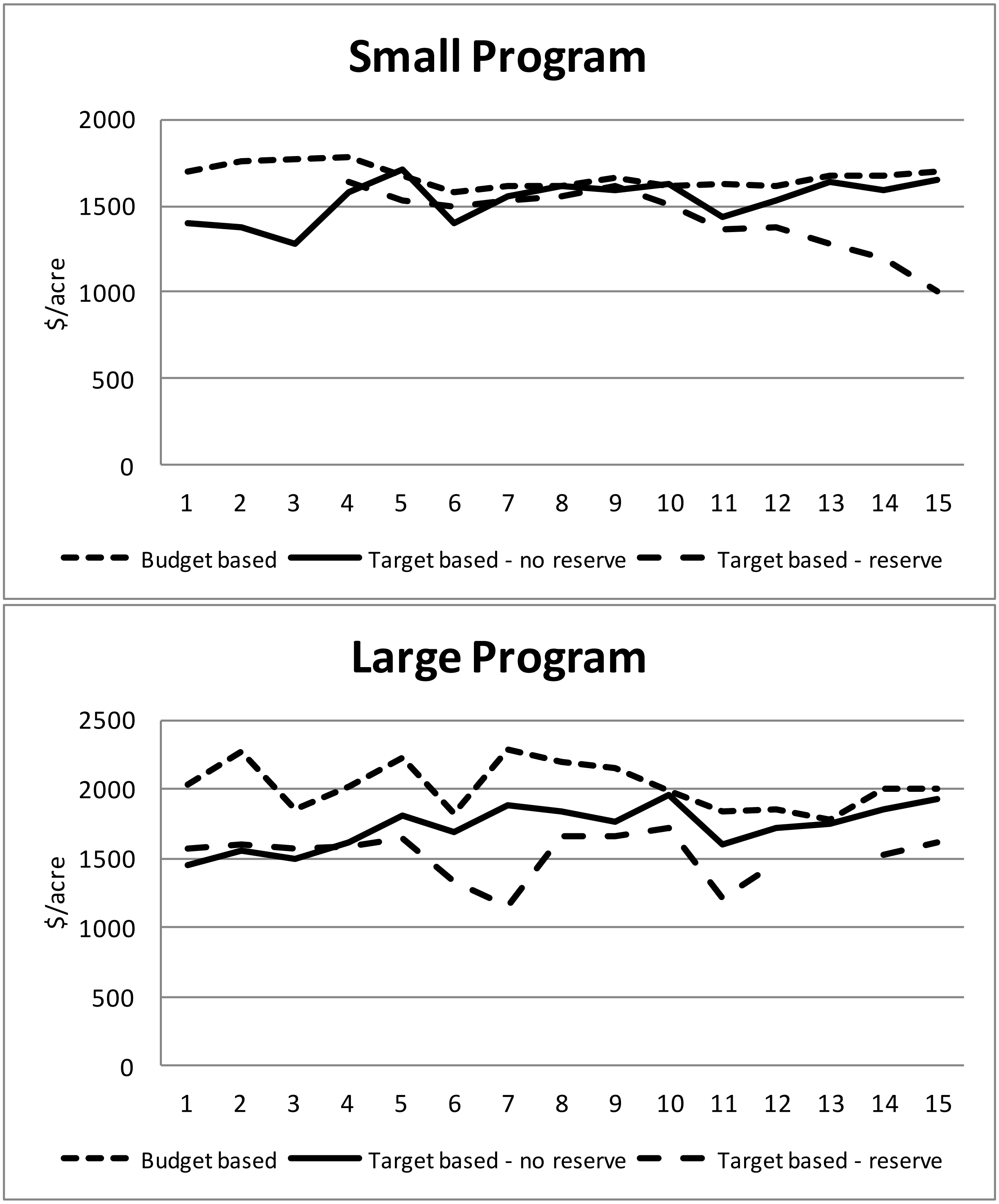


Figure 2. The average cost per wetland acre restored for each period for two program sizes.

The average budget outlays across the various treatments and periods are shown in Figure 3. Since the required budget to pay successful bidders is uncertain prior to the auction taking place, a comparison of the target no reserve with the budget based treatment is instructive. The information in Figure 3 suggests that the average outlay for the target approach is often higher than the budget approach, particularly in the small program treatments. However, this effect is not seen across all periods. As expected, the use of a reserve price reduced the budget outlay and in our designs, this combination of treatments led to the smallest budgets spent across most of the periods with either program size.

Having examined these findings with the assumption of independence across periods, we now turn to relaxing this assumption. This involves the use of random effects panel regression techniques where it is possible to control for the repeated auction approach we used. We developed two specifications, one for the % rent and the other for the $/acre, in each case employing nonlinear specifications for the period and round effects. Independent variables included dummies for the various treatments (target vs budget; nonreserve vs reserve price; large vs small program size). In developing parameters estimates we tested for both heteroscedasticity and autocorrelation as well as employed Ramsey reset tests for specification. The final parameters we present in table 2 have been corrected for heteroscedasticity and autocorrelation by using the Huber/White sandwich estimator (Huber 1967; White 1980).

The estimates for the percentage rent collected by successful bidders are shown in column two of Table 2. On average the rent collected was about 13.5% as shown by the value of the constant. However, the target dummy suggests a reduction in rent by about 23% when the target based auction approach was employed. While this reduction must be modified by the sequence of auction rounds, as shown by the negative parameter on ln(Round), for the target based auctions the reduction of the target based effect is modified upwards as suggested by the significant and positive interaction between the target dummy and round. Thus while both the budget based and target based auctions exhibit decreasing rent collected by successful bidders as the repeated auctions proceed, the target based auctions are characterized by less of this rent seeking behaviour.

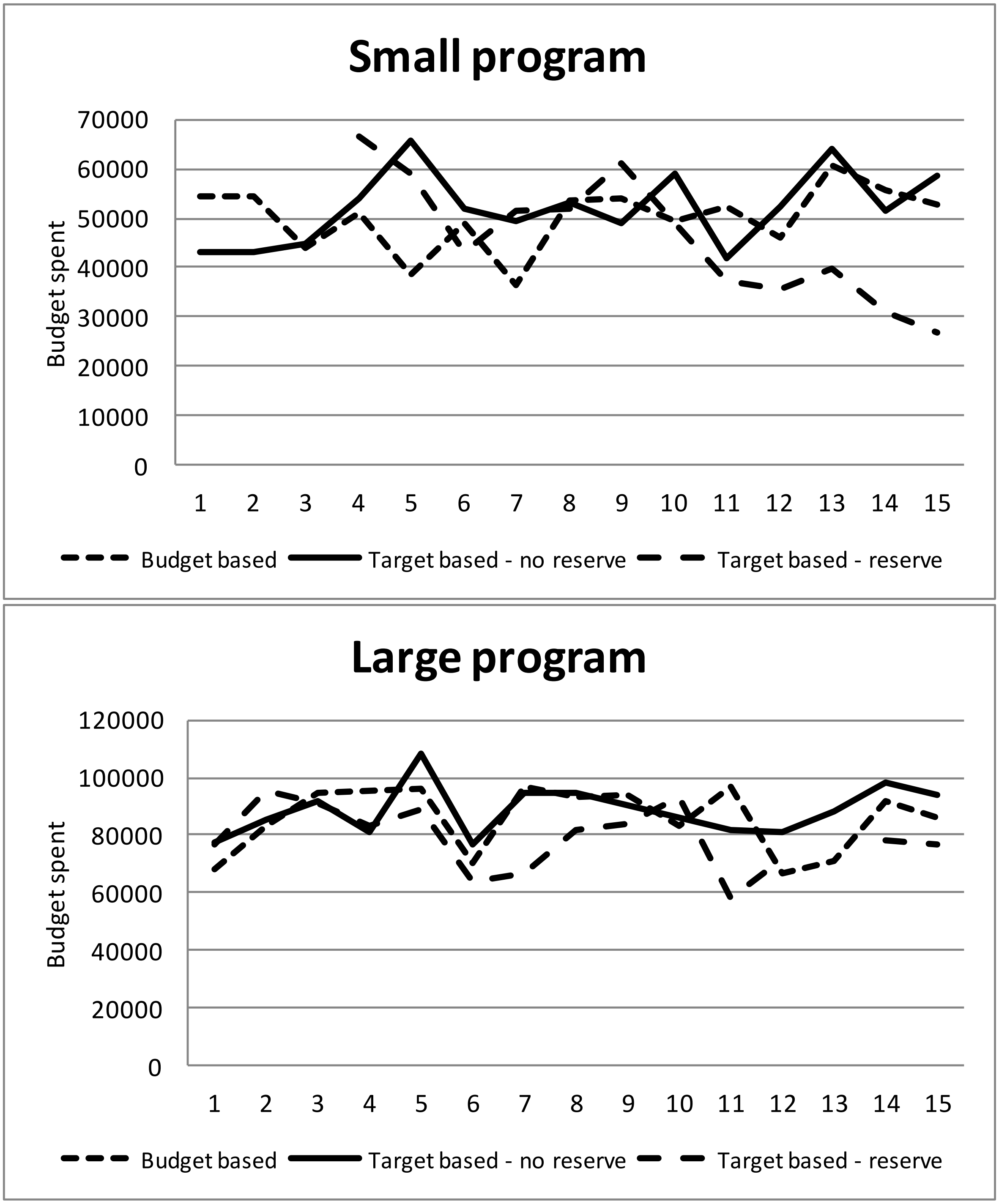


Figure 3. The average auction budget expenditure for each period for two program sizes.

Table 2. Parameter estimates for random effects GLS regressions (with robust standard errors) of the percentage successful bidders received above their costs of restoration and the costs per acre restored on various experimental design variables.

Variables	% rent	$/acre
Constant	13.496***	1601.185***
Lag Y	0.254*	0.049
Ln(Period)	1.416	50.598
Ln(Round)	-5.153***	-104.059*
Target dummy (TD)	-22.898***	-230.285
Reserve Price dummy (RPD)	-8.196**	-191.834***
Large Program dummy (LPD)	14.853***	335.253***
TD*Period	6.908	83.307
TD*Round	5.019*	15.618
LPD*TD	-5.142	-101.364
R^2 (overall)	0.475	0.501

*** P≤0.001; ** P≤0.01; * P≤0.05

Employing a reserve price in the target based auctions led to a further reduction in rent received by the bidders of about 8% on average. This effect is statistically significant. Thus, our experimental results suggest that the effect of the target based approach in concert with a reserve price would reduce the rent received by bidders over their costs by about 31% on average. However, in our large program treatments this reduction in rent is reduced by 15% yielding a 16% rent reduction for the target with reserve treatments in the large program experiments.

The results are less clear for the economic efficiency measures as there were fewer statistically significant parameters (column 3 Table 2). The average cost per acre paid across all treatments is about $1600/acre. In later rounds this acquisition cost is reduced. While the target based dummy is only statistically significant at P=0.11, the parameter estimate is large and negative suggesting that target treatments acquired acres cheaper than the budget based auctions. We may need to conduct more experiments to confirm this possibility. It is also noteworthy that the reserve price dummy is relatively large and negative suggesting further efficiency gains when employed using the target based approach.

Finally we note that the parameter for the large program dummy is large, positive and statistically significant. In fact its magnitude almost completely cancels the target with reserve effect. However, even in the budget based auction this large program effect suggests a loss of efficiency when either budgets or targets are large relative to the size of the market that can supply the services desired.

Discussion

The contributions of this research (thus far) can be summarized as follows. First we find perhaps surprisingly that target based auctions can outperform similar budget based auctions. Our budget based experiments led to higher information rents gained by successful bidders as well as higher acquisition costs regardless of the program size. This result is different than that obtained by Schilizzi and Latacz-Lohmann (2007), although the fact that they linked their target and budget based auctions in their design, or utilized a different definition of the target, may explain this discrepancy. Furthermore since our choice of a target was not linked to the budget results, we compared the budgets spent in each auction and found that while the target auctions with no reserve price required higher budgets, the outlays were not appreciably higher, nor were they higher across all periods within a treatment (Figure 3).

Second, as expected, the use of a reserve price increased the efficiency of the target based approach even further. It is important to note that this price was not revealed to bidders[8] and the treatment appeared to generate confusion among bidders as evidenced by the number of auction rounds in which the target was not reached when a reserve price was used (Table 1). Failure to meet the target in the auction would be equivalent to failure of a government or NGO environmental program as no environmental benefit would be achieved. The use of a reserve also reduced budget outlays and decreased the unit acquisition cost as expected, but the effect was not dramatic in all periods.

Third, our experimental approach used repeated auctions. While Schilizzi and Latacz-Lohmann (2007) found that repeated auctions generated increased rent seeking and

[8] Perhaps for good reason as if this price was revealed one would predict every bidder with costs below this price to bid this price.

reductions in efficiency, we found that these effects were not appreciable even though we utilized 5 repetitions within 3 different rounds where bidder costs were held constant in each round. Perhaps the one significant effect we did uncover was that while the target based approach outperformed the budget based one, this performance eroded over the repetitions despite the fact that subjects were provided with different costs every fifth period. In other words, it appears that the learning effects are more apparent in the target based auction approach. This is not surprising if subjects gradually learn that there is no budget cap and submit higher bids as the auction periods progress until they are not successful.

Finally, we note that program size has an important influence on the results. Smaller programs in terms of budgets or targets in our study led to superior results. Perhaps this is not surprising given that small programs have the effect of increasing competition amongst bidders, and this competition leads to higher auction efficiency. This is supported by the findings of Iftekhar (2010) who also found that increasing competition generated improvements in auction outcomes.

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