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Role of Information and Communication on Spatial Conservation Auction Performance: Evidence from a Laboratory Experiment

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Market Report	Year Ago	4 Wks Ago	7-6-18
Livestock and Products, Weekly Average			
Nebraska Slaughter Steers, 35-65% Choice, Live Weight.	117.56	*	111.00
Nebraska Feeder Steers, Med. & Large Frame, 550-600 lb.	171.62	183.76	*
Nebraska Feeder Steers, Med. & Large Frame 750-800 lb.	173.38	158.13	*
Choice Boxed Beef, 600-750 lb. Carcass.	221.09	226.95	209.65
Western Corn Belt Base Hog Price Carcass, Negotiated	87.77	78.89	76.84
Pork Carcass Cutout, 185 lb. Carcass 51-52% Lean.	103.98	78.07	84.69
Slaughter Lambs, wooled and shorn, 135-165 lb. National.	185.44	162.85	162.89
National Carcass Lamb Cutout FOB.	425.01	379.29	377.52
Crops, Daily Spot Prices			
Wheat, No. 1, H.W. Imperial, bu.	4.57	4.78	4.56
Corn, No. 2, Yellow **Columbus**, bu.	3.63	3.49	3.36
Soybeans, No. 1, Yellow **Columbus**, bu.	9.47	8.79	7.83
Grain Sorghum, No.2, Yellow Dorchester, cwt.	6.20	5.40	5.18
Oats, No. 2, Heavy Minneapolis, Mn, bu.	2.78	2.90	2.87
Feed			
Alfalfa, Large Square Bales, Good to Premium, RFV 160-185 Northeast Nebraska, ton.	147.50	170.00	*
Alfalfa, Large Rounds, Good Platte Valley, ton.	75.00	100.00	107.50
Grass Hay, Large Rounds, Good Nebraska, ton.	*	102.50	100.00
Dried Distillers Grains, 10% Moisture Nebraska Average.	103.50	144.00	106.00
Wet Distillers Grains, 65-70% Moisture Nebraska Average.	42.00	40.50	37.10
*** No Market**			

Policy makers such as the USDA are interested in producers voluntarily adopting pro-environmental land use practices on their properties as these land uses deliver various ecosystem service benefits. As a result, they have implemented incentive based policies such as the Conservation Reserve Program (CRP) (Hellerstein et al., 2015). The CRP involves a reverse auction in which producers submit bids for adopting different land use practices. In running these auctions, agencies are interested in both cost-effectiveness i.e. procuring land use projects which yield the highest level of ecosystem service benefits for the money spent and specific environmental goals. One key goal is project procurement involving the same land use implemented on neighboring properties/parcels or those within some distance of each other. Such spatial contiguity is important as coordinated land management can magnify the production of different ecosystem service benefits such as water pollution reduction, lower habitat fragmentation and enhanced biodiversity conservation, and increased pollination services to name a few.

In this study, we focus on the impact of two features on the performance of a spatial conservation auction i.e. an auction that explicitly targets spatial contiguity. The first feature is the amount of information revealed to bidders and the second is the possibility for auction participants to communicate with each other. We are interested in the first feature since procurement auctions in general, and conservation auctions in particular, can be quite complex for bidders, as the items being procured are often evaluated based on multiple characteristics in addition to their price, including quality, quantity, delivery time, etc. In these settings, providing information can facilitate bidding. Yet, more information can also lead to higher rent premiums, an issue especially relevant for conservation auction policies given the extensive rent seeking that has been documented in the CRP auctions over multiple signups (Ulber et al., 2011). Next, our interest in studying the impact of communication stems from the fact that communication is a reality on agricultural landscapes. Moreover, for a spatial auction communication can be beneficial as it can coordinate bid submissions by neighbors especially if there are multiple land uses to choose from (which usually is the case for conservation auctions). Yet, communication can also lead to collusive bidding, low auction competitiveness and hence low cost-effectiveness, none of which are desirable outcomes.

Given this context, we conducted a laboratory economic experiment with university students to evaluate spatial conservation auction performance given communication and different information revelation strategies. For this purpose we focus on a multi-round auction in which bidders submit bids through multiple iterations or rounds before a final set of winners are determined. The results of our study provide some benchmark findings which can inform field experimental trials on spatial conservation auctions involving actual producers.

Experimental Design

Since we are interested in spatial coordination, in the experiment, twelve subjects are located on a circular geographical landscape on which each person has a left and a right neighbor. Subjects earn money depending upon whether they are selected as winners in the auction or not as well as whether their neighbors have been selected at the end of multiple bidding rounds. Each subject is endowed with three land use projects or items marked as Red, Green and Blue items. During the auction subjects select and submit a bid for one of these items. Terms such as conservation, ecosystem services and land use projects are not mentioned in the auction as these can impact subject behaviors in the lab which in turn would make isolation of the treatment effect (if any) challenging – i.e. it would be difficult to conclude whether subjects are responding to the treatment manipulation or to the environmental framing.

We implement three information treatments using a between subject format: NO-INFO, in which participants are not shown the magnitude of the environmental quality value of the three available items, VALUE in which subjects receive absolute environmental benefits information and RANK, in which only the relative ranking of the three items is revealed. The communication treatments are also implemented in a between subject format – NO-COMM in which subjects cannot communicate with each other and COMM in which a players communicates with their two neighbors in every round prior to bid submission. Thus, we obtain 6 different experimental treatments as presented in Table 1.

Table 1: Experimental Design

Communication Treatment	Information Treatment		
	Without Benefit Information	With Absolute Value Benefit Information	With Rank Value Benefit Information
Without Communication	NO-COMM-NO-INFO (5 sessions)	NO-COMM-VALUE (5 sessions)	NO-COMM-RANK (5 sessions)
With Communication	COMM-NO-INFO (5 sessions)	COMM-VALUE (5 sessions)	COMM-RANK (5 sessions)

We conducted five experimental sessions, each with 12 participants recruited from undergraduate student population at University of Nebraska-Lincoln. Participants earned a $9 show-up fee and money made during the experiment. Earnings were recorded in Experimental Currency Units (ECUs) and the experiment was conducted in Z-tree (Fischbacher, 2007). Within a session, subjects participated in nine multi-round periods, with a minimum of four and a maximum of seven rounds per period. Participants were not informed about the fixed budget of 4,500 ECUs that was used to procure projects and pay winners in each auction period. This figure remained constant across all treatments.

Each session included the four components: a paid risk preference elicitation exercise (Holt and Laury 2002), an unpaid practice auction to familiarize participants with the user interface, nine paying periods and a demographic survey. Before beginning the experiment, a presentation was made to the subjects about the different experimental features. Handouts were also provided to which subjects could refer during the experiment. In the COMM treatments, at the beginning of each auction round, subjects had the opportunity to message their neighbors for a duration of 30 seconds through two chat boxes displayed on their screen. Once 30 seconds were over, the chat content was displayed for an additional 10 seconds after which subjects proceeded to the item selection phase of the auction period. Instructions barred subjects from revealing their identity to neighbors and asked them to be civil to one another. All features of the auction could be discussed through the communication channels.

We used three different sets of cost and quality values to determine the cost and quality endowments for each subject in a period. Each set was used in three auction periods thus minimizing the influence of any possible scale effects. The values were randomly drawn from two uniform distributions –*cost* ~[0, 1000] and quality ~ [0, 100].. They were chosen such that in the absence of asymmetric information, the auctioneer would choose 6 out of 12 projects in all periods, involve the selection of multiple items of the same color and represent different spatial configurations. Figure 1 indicates the spatial configurations of the winning projects. The All Blue pattern is the Single Large reserve pattern with 5 shared borders between the selected projects, the All Green is the Several Small reserve pattern with a total of 4 shared borders and last, the All Red is the Asymmetric reserve pattern with 4 shared borders as well. The Single Large pattern was assigned to Periods 1, 4 and 7; Several Small to 2, 5 and 8; and Asymmetric to 3, 6 and 9. The parameters were assigned to subjects such that (*i*) even if neighbors exchanged cost and quality endowment information via chatting, subjects did not know that the endowments from the past periods were being repeated, (*ii*) never faced the same endowment in multiple periods, and (*iii*) if everyone bid at cost, then across all 9 periods, 6 people would win 4 times and the other 6 would win 5 times.

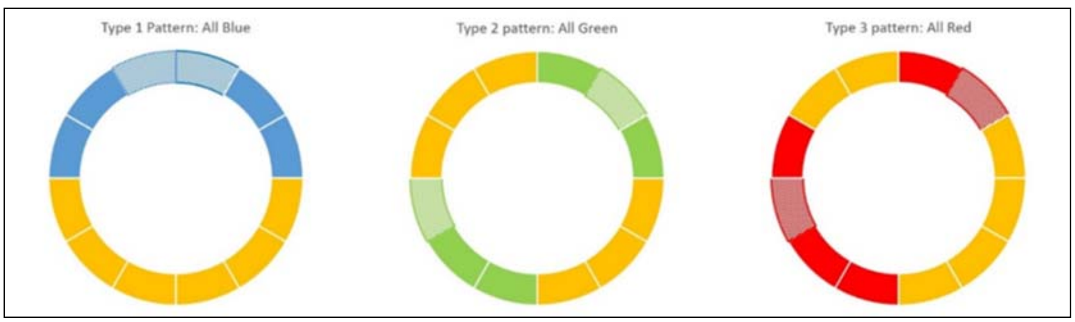

Figure 1: First-Best Spatial Configurations in 9 Auction Periods.

After all bids had been submitted in a round, combinations of bids were evaluated and were given a score equal to the sum of quality of the submitted items divided by the sum of bids. When calculating the total benefit, twice the value of an environmental premium (= 25) (once for each adjacent project if any) was added. Similarly, twice the value of the bonus (= 50 ECU) was added to the total sum of bids. The scores were then ranked in descending order and combinations of projects were provisionally accepted based on the scores until the budget was exhausted.

At this stage, a Results Screen was displayed on which subjects received feedback about auction outcomes. This included information about (*i*) whether their item had been selected, (*ii*) whether neighbors items had been selected and if yes, which colored item, (*iii*) their provisional earnings for the round or their actual earnings if they were winners in the period and (*iv*) the total bonus earned. For easy reference the cost and quality value (in VALUE-NO-COMM and VALUE-COMM sessions) of the submitted item was also provided. Finally, this screen included a History Table that recorded the above values for all rounds of a period and all auction periods. Subjects were informed whether or not their offer had been provisionally accepted at the end of the round and then could adjust their offers in response to the information about the provisional status of their offer from the previous round. However, submitted offers could only be reduced in subsequent rounds of the period. At the conclusion of each period, participants were informed about whether or not their offer had been accepted and winners' earnings were updated on the basis of the difference between their winning item's offer and its corresponding cost and bonus paid if one or both neighbors same colored item was also part of the winning allocation.

Metrics of Analysis:

In order to analyze auction performance, we consider the Percentage of Optimal Cost-Effectiveness Ratio (POCER) measured as the degree of cost-effectiveness of the conservation auction. POCER is defined as

$$POCER = \frac{\left(\sum_i q_i x_i + p\sum_i x_i\right) \Big/ \left(\sum o_i x_i + b\sum_i (x_j + x_k)\, x_i\right)}{\left(\sum_i q_i x_i^* + p\sum_i x_i^*\right) \Big/ \left(\sum c_i x_i^* + b(x_j + x_k)\, x_i^*\right)}$$

$x_i = 1$ if i[th] subject is a winner, 0 otherwise

$X^*_i = 1$ if i[th] subject is winner in the first-best allocation, O otherwise

First, consider the numerator of POCER. In the numerator of the fraction, $\Sigma_i q_i x_i$ represents the sum of environmental benefits of all items accepted by the auctioneer from set of winning bidders i and $p\, \Sigma_i\, x_i$ the sum of total environmental premiums. In the denominator of the fraction, $\Sigma\, o_i x_i$ represents the sum of selected bids from the set of winning bidders i and $b\Sigma_i(x_j + x_k)\, x_i$ the total bonuses paid for every shared border between a adjacent selected items of the same color. This amount represents the total expenditure of the auction. In a similar fashion the fraction in the denominator represents the total environmental benefits and expenses in the auction when the first best allocation is selected with bids submitted equal to costs so that there are no information rents.

Results:

Figure 2 presents a histogram of the number of shared borders between neighboring projects of the same color under the different treatments for each of the three spatial configurations. It is evident that the bonus payments are successful in procuring identical items representing the same land use projects from neighbors.

Figure 3 represents the average POCER values by treatment and spatial configuration and indicates that average cost-effectiveness is lower when subjects have to coordinate to create a large core than if they have to create two identical small reserves or two small but different sized reserves. This outcome is not surprising since creation of a large core requires coordinated effort of six players while the other configurations can be created by fewer people coordinating.

Since performance depends upon coordination, average performance is lower for all treatments when creating a large core relative to the other patterns. Moreover, for both Single Large and Asymmetric patterns, performance is the lowest in both the NO-INFO treatments compared to the VALUE and RANK information treatments for both communication conditions.

For a systematic analysis of these findings, we present the results of random effects regression model in Table 2 with POCER obtained in the final round of every period for each session as the dependent variable. The independent variables include dummy variables for the VALUE, RANK and COMM treatments, a Period variable capturing the effect of subject experience in the auction on performance, dummy variables for the two spatial configurations – Several Small and Asymmetric (with the Single Large pattern and NO-INFO-COMM condition being the omitted category) and interaction terms between these variables to control for the fact that the impact of the information and communication treatments can be different for the different periods in which the first best allocation involves different spatial configurations. The standard errors are clustered at the session level to control for unobserved heterogeneity across the sessions.

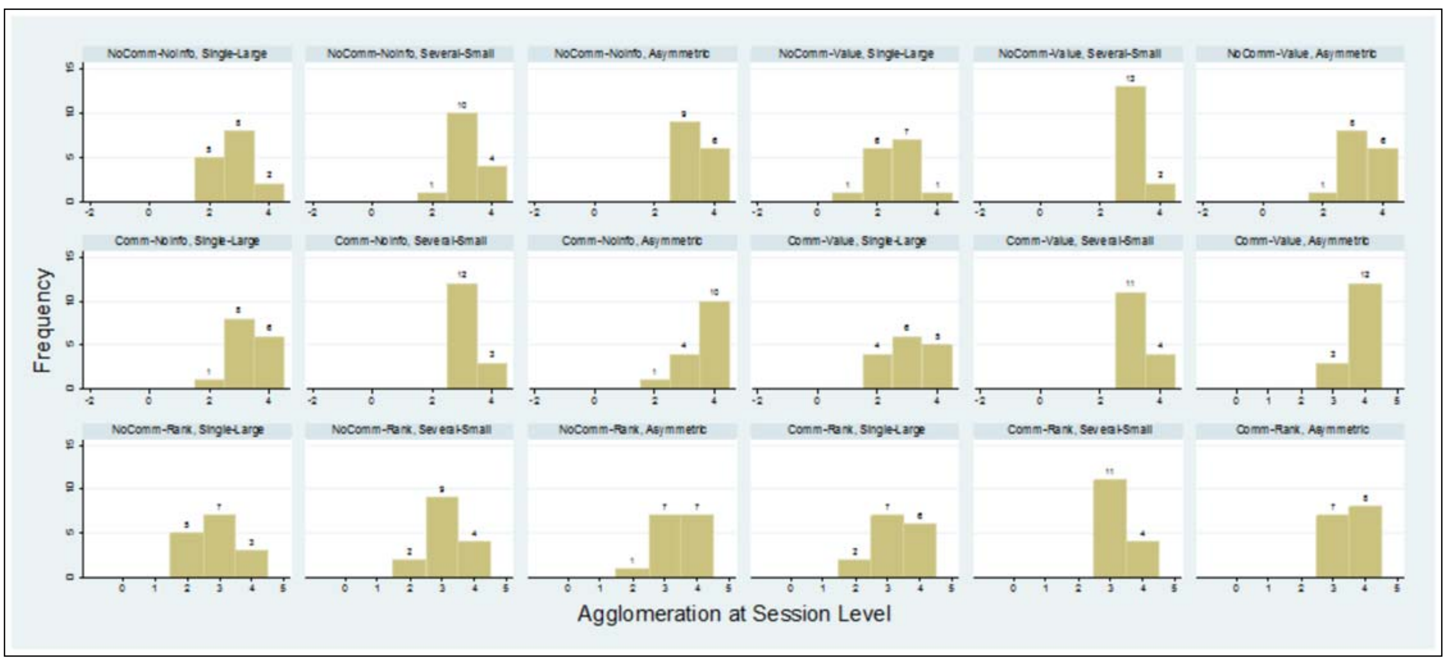

Figure 2: Histogram of Number of Shared Borders between Winning Projects of Same Color

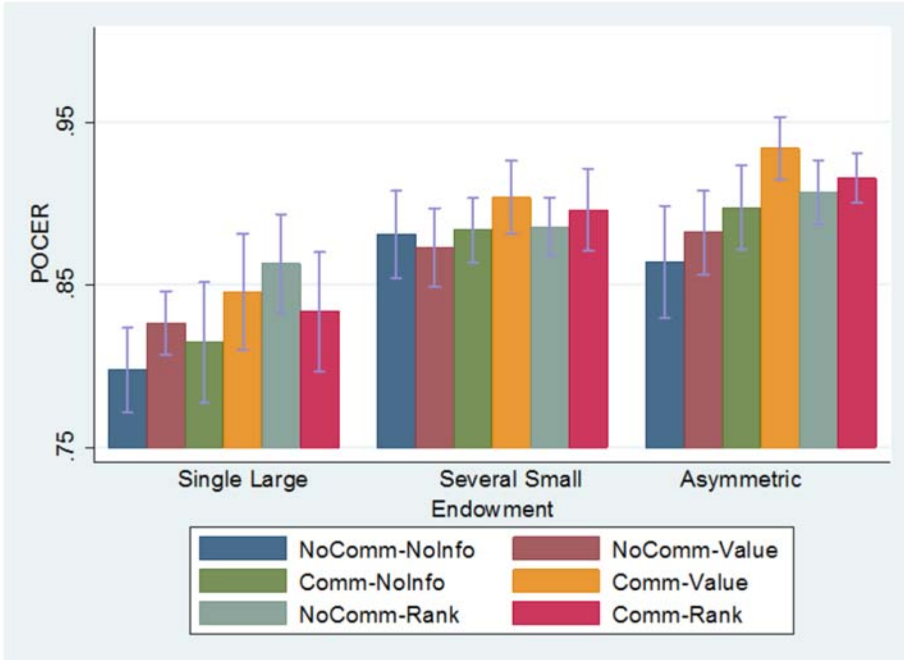

Figure 3: Average POCER by Treatment and Spatial Configuration

The positive and significant estimates for the VALUE and RANK Treatment dummy variables suggest that when the first best allocation constitutes a Single Large Reserve, auction performance is improved via higher cost-effectiveness when environmental benefit information (in either absolute or ranked format) is provided to subjects compared to when this information is suppressed. Moreover, the RANK condition performs better than the VALUE condition. Communication does not seem to have any impact on performance when no information or only VALUE information is provided although in the case of the RANK treatment, communication marginally reduces performance.

Focusing on the Several Small condition, VALUE information again improves efficiency over the NO-INFO condition although the effect is damped owing to the negative interaction effect between the information treatment and the Several Small dummy variable. Communication again has no impact on outcomes. Similar outcomes are obtained for the RANK treatment when no communication is permitted and like in the case of the Single Large condition, performance is higher relative to the VALUE treatment as well. However performance is higher for the COMM-RANK condition, an outcome different from that obtained for the Single Large Case.

Next, there seems to be no impact of the information and communication treatment on outcomes when considering the Asymmetric spatial configuration. However, the positive estimate for the Asymmetric dummy variable suggests that performance is better for this condition relative to SingleLarge case. However, this effect is only marginally significant. Finally, the estimate for the Period variable is positive and significant suggesting that auction experience improves efficiency. However, this result is to be interpreted with caution because there is some collinearity between the Period variable and the spatial configuration dummies since the configurations were assigned to periods in a sequential fashion leading to potential order effects.

Conclusion:

Our results show that providing ranked and absolute environmental benefit information improves auction performance relative to when no information is provided with ranked information having the greatest impact on efficiency. This is true regardless of the spatial configuration targeted. The impact of communication however seems to depend upon the information revelation and spatial configuration. In summary, by providing ranked information, the auctioneer can place checks on rent seeking while still facilitating the bidding exercise. Information provision can also promote auction transparency goals fostering producers' trust in the government, which could be useful in encouraging their participation in the auction. Subsequent analysis will explore the sources of these treatment differences through an examination of individual behavior and analysis of bidders' communications as well as delve deeper into factors impacting item selection.

Table 2: Results of Random Effects Regression Analysis for Percentage of Optimal Cost Effectiveness Ratio

Independent Variables	POCER
Value Treatment	0.0290** (0.0131)
Rank Treatment	0.0655*** (0.0201)
Communication Treatment	0.0170 (0.0117)
Period	0.00540*** (0.00105)
Several Small	0.0780*** (0.0102)
Asymmetric	0.0559* (0.0300)
Communication X Value	0.00225 (0.0172)
Communication X Rank	-0.0467* (0.0257)
Rank X Several Small	-0.0605*** (0.0170)
Value X Several Small	-0.0369*** (0.0138)
Value X Asymmetric	-0.0110 (0.0315)
Rank X Asymmetric	-0.0225 (0.0317)
Communication X Asymmetric	0.0164 (0.0315)
Communication X Several Small	-0.0142 (0.0117)
Communication X Value X Several Small	0.0257 (0.0172)
Communication X Rank X Several Small	0.0540** (0.0232)
Communication X Value X Asymmetric	0.0163 (0.0364)
Communication X Rank X Asymmetric	0.0218 (0.0353)
Constant	0.776*** (0.0107)
Observations	270
Number of Sessions	30

Robust standard errors in parentheses; ***p<0.01, ** p<.0.05, p<0.1

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