An Experimental Comparison of Reserve Price Auctions and Auctions with Renegotiation

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1. Research Question

Auctions are increasingly becoming a common mechanism for supply chain procurement. Two commonly used auctions processes in procurement are the English auction with a reserve price and the English auction with post auction renegotiations. When suppliers' costs are private and the auctioneer uses optimal decision rules, the Myerson optimal mechanism is the direct mechanism for both auction processes when utilized to maximize the procurer's expected benefit. Bulow and Klemperer (1996) demonstrated the form of post auction renegotiation that maximizes the procurer's expected benefit is for the procurement official to simply accept the auction outcome when the price is below some threshold, otherwise reject the auction price and make a take-it-or-leave-it offer equal to this threshold to the auction winner. Since they have a common direct mechanism, the optimal ex ante reserve price and the optimal ex post price threshold for renegotiation are the same.

The optimal ex ante reserve price has a counterintuitive property; it's is invariant to the number of bidders when individual costs are independent and identically distributed. Davis, Katok and Kwasnica (2011) test this counterintuitive prediction experiment and find this invariance doesn't hold. They found observed deviations are best explained by of model where the auctioneer's expected utility incorporates anticipated regret.

The optimal ex post price threshold has a different counterintuition property in the extensive form of the English auction followed by ultimatum bargaining; it's invariant to the realized auction price. Shachat and Tan (2012) reported laboratory experiments on this environment and found that while the theory reasonably predicts when individuals choose to bargain, their take-it-or-leave-it offers have a strong positive relationship with price. We found the observed deviations are best explained by a model of subjective posteriors that are simple distortions of the correct Bayesian ones.

In this study, we report on an experiment that makes a direct comparison of these two formats. The objectives are to identify under what settings we can expect each of the auction formats to better serve the auctioneer's interest, and to resolve the two quite different behavioral explanations of suboptimal behavior. Our experimental design adopts two treatment variables: auction format and the number of bidders. Our finding are summarized as follow: for the Reserve Price Auction treatment, that anticipated regret model is the best explanation of the negative relationship between reserve price chosen and the number of bidders. For the Auction and Bargaining treatment, the subjective posterior model prevails but we also see that the

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posterior belief regarding the auction winner's cost is influenced by the number of bidders. Thus, while in our experiment we do not observe an economically significant difference in the auctioneer's surplus between the two auction formats, we do provide some examples of cost distributions that lead to predictions of greater expected surplus for the auctioneer when using the auction with renegotiation format.

2. Experimental Design

In our experiment, the buyer's value v follows uniform distribution [50, 150] and the computerized seller i 's cost c_i is independently and uniformly distributed on [0,100]. We keep the realized values and corresponding costs the same between treatments. The buyer's value and seller's cost are all private information, and they are regenerated at the beginning of each round. Our auction treatment consists of between subject exposure to the Reserve Price Auction (RA) and Auction-Bargaining (AB). In the common English auction component, we inform subjects that there is an English clock auction between computerized sellers [2] who follow Nash equilibrium strategies and, in AB, accept any profitable take-it-or-leave-it offer.

In the RA treatment, a subject submits a reserve price before the auction begins in each round. When the auction completes, this reserve price determines whether there was a purchase and that transaction price. Specifically, if the submitted reserve price is not less than the auction price, the purchase will happen and the price is equal to the auction price. Alternatively, if the reserve price is lower than the auction price, the purchase still happen but price equals to reserve price when the reserve price is not less than the winner's cost, or there is no purchase when the reserve price is lower than the winner's cost.

In the AB treatment, a subject is informed of the number of bidders and the auction price. Then they can accept the auction price or send an offer instead. If he accepts the auction price, he will get profit of his value minus auction price. If he sends an offer, the computerized winner may reject it and get zero profit for both sides, or it may accept it and subject gets profit of value minus his offer.

The second treatment variable is the number of bidders, and is a within subject treatment. Within an experimental session, we varied the number of bidders between 1, 2 and 3. In each session, there are 90 rounds which are separated into 3 blocks with 3 possible numbers of bidders (30 rounds to be a block). To eliminate the sequence effect we changed the blocks' order, showing in Table 1. We recruited 16 subjects, who are undergraduate and graduate students in Xiamen University, to participate in a two hour experimental session. No subject was allowed to participate in more than one session. The computerized experiment was programmed and conducted with zTree (Fischbacher, 2007) and subjects were recruited using ORSEE (Greiner, 2004). Subjects were paid on average 60RMB for 2-hours session.

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[2] Shachat and Tan (2013) find that the human bidders do not deviate from Nash equilibrium strategies in Auction-Bargaining experiment.

Table 1: The setting of varying number of bidders in sessions

RA treatment		AB treatment	
Session 1	*N*={1, 2, 3}	Session 5	*N*={1, 2, 3}
Session 2	*N*={2, 1, 3}	Session 6	*N*={2, 1, 3}
Session 3	*N*={2, 3, 1}	Session 7	*N*={2, 3, 1}
Session 4	*N*={3, 2, 1}	Session 8	*N*={3, 2, 1}

3. Hypotheses

Designing two treatments has two main purposes; the empirical comparison of auctioneer welfare between the Reserve Price auction and the Auction with Renegotiation, and the identification of the buyer's behavior rule in these two processes. The theoretical benchmark for both purposes derives from the fact that the optimal reserve price r^* and the optimal offer o^* both are equal to one-half of buyer's value v. As a direct result the buyer's expected payoffs in two mechanisms should be the same. Thus, we have our two first hypotheses.

Hypothesis 1 *Buyers earn the same average surpluses in RA and AB treatments.*

Hypothesis 2 *Buyers' optimal offers in AB mechanism only depend on their own values, and buyers' optimal reserve prices in RA mechanism also only depend on their own values.*

4. Preliminary Results

In the experiment, the buyers' average surpluses do not statistically differ across the two treatments (p-values are 0.47, 0.92 and 0.99 when numbers of bidders are 1, 2 and 3), and both average are statistically significantly than the theoretical benchmark when the numbers of bidders are 1 and 2(with p-value 0.03 and 0.02), as shown in Table 2. We confirm Hypothesis 1 and obtain Result 1.

Result 1 *Comparing the Reserve Price auction with Auction-Bargaining treatments, there is no significant difference on average surpluses for buyer when they face the same number of bidders. However, all the average surpluses for buyer in two treatments are significantly lower than theoretical prediction.*

Table 2: Average Surplus for Buyer

	***N*=1**	***N*=2**	***N*=3**
Theoretical Surplus (TS)	27.11	43.59	55.32
Realized Surplus-RA treatment (RSR)	25.14	41.15	53.36
Realized Surplus-AB treatment (RSA)	24.55	41.04	53.35
T test (P-value)			
H0: RSR=RSA	0.47	0.92	0.99
H0: TS=RSR	0.03	0.02	0.08

Furthermore, we are interested in how the buyers make decisions for reserve prices or offers. We use two linear models to gain more quantized insight from our experiment. Table 3 shows the estimation results for RA treatment by linear regression. Model(1) is the simplest regression which only includes intercept term and variable of value to explain reserve prices. Then we introduce dummy variables about the number of bidder into Model (2), where $I_{\{N=2\}}$ and $I_{\{N=3\}}$ note the number of bidders N in auction. According to an F-test, we can reject the Model (1) and choose Model (2), p-value is less than 0.001. Varying N has no significant effect on buyer's decision in terms of intercept but the interaction effect with buyer's value is significant at the 1% level. The negative coefficients show that the buyer take more aggressive reserve price based on his value as the N increases. For example, if there is a buyer with value of 120, he will chooses 67.29 to be reserve price when only 1 bidder in auction, and choose 61.29 in 2 bidders-auction and 50.49 in 3 bidders-auction.

Table 3 Estimates of linear model for RA treatment

Variable	Model(1)	Model(2)
Intercept	17.94(0.74)***	16.89(1.26)***
Value	0.38(0.01)***	0.42(0.01)***
$I_{\{N=2\}}$	-	1.25(1.78)
$I_{\{N=3\}}$		1.40(1.78)
$I_{\{N=2\}}$***Value**		-0.05(0.01)***
$I_{\{N=3\}}$***Value**		-0.09(0.02)***
R^2	0.33	0.3531
F test(P Value)	-	<.0001

For AB treatment, the offer is right censor above auction price, so that we use linear Tobit model to do the estimate, shown in Table 4, where we use dummy variables $I_{\{N=2\}}$ and $I_{\{N=3\}}$ as the same as in Table 4. Comparing Model (2), we also reject the model (1) by LR test with the p-value smaller than 0.001. According to the estimation, auction price and the number of bidders N all play important roles in buyer's decision. And also, auction price becomes much more effective when the number of bidders goes larger.

Table 4 Estimates of linear Tobit model for AB treatment

Variable	Model(1)	Model(2)
Intercept	-5.73(0.96)***	-
Auction Price	0.38(0.01)***	0.07(0.01)***
Value	0.31(0.01)***	0.52(0.01)***
$I_{\{N=2\}}$	-	-8.29(1.47)***
$I_{\{N=3\}}$	-	-3.95(1.41)**
$I_{\{N=2\}}$***auction price**	-	0.28(0.02)***
$I_{\{N=3\}}$***auction price**	-	0.38(0.02)***
$I_{\{N=2\}}$***value**	-	-0.17(0.02)***
$I_{\{N=3\}}$***value**	-	-0.25(0.02)***
Log(scale)	2.55(0.01)***	2.53(0.01)***
Log(L)	-11410	-19040
LR test	-	<0.001

Depends on the two regression models for RA and AB treatments, we can conclude the Result 2 and reject Hypothesis 2.

Result 2 *Both in RA mechanism and AB mechanism, the reserve prices and offers do not only depend on buyers' value, but also depend on the number of bidders. In addition, offers in AB mechanism are related to auction prices.*

5. Simulations

While we found no economically significant differences in the realized buyers' surplus in our environment, we do find significant differences in buyer behavior. In this section, we provide an example of a family cost distributions that leads to significant economics differences with our two estimated behavioral rules. We show, using simulations, if we had adopted Cube and Cuberoot distributions buyers would gain more surpluses in AB mechanism than in RA mechanism when the bidders' costs draw from a Cube distribution and number of bidder is 3, as table 5 shown.

Table 5 Buyers' average surpluses in two mechanisms via Simulation

	1 Bidder(AB/RA)	**2 Bidders(AB/RA)**	**3 Bidders(AB/RA)**
Cube	11.41/10.84	18.69/18.04	25.39/21.15***
Cuberoot	35.68/35.89	66.38/66.74	81.53/82.16

*** Significant difference at 1% level

T=1000: the sample size has been simulated for each block