Procurement and Information Feedback

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Abstract: A government that regularly procures the services of construction companies wants to minimize its costs. The instrument it can use is the level of information feedback given to the firms in the market. Theoretically, the competition between firms is supposed to drive prices to the lowest possibility, independently of the information feedback.

We design an experiment in which firms participate in a first price sealed-bid auction. Interaction takes place in 10 periods according to a random matching mechanism, and we control for the level of information feedback firms receive after each period. It turns out that when firms are informed about the losing bids in previous periods, prices are higher than the theoretical prediction. However, when firms do not receive this information prices converge towards the theoretical prediction. We suggest that a phenomenon of price signaling may be important for explaining these results.

Keywords: Procurement auction, experiment, information feedback, price signaling

JEL codes: C92, H57, L13

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1. Introduction

Suppose you are a government contractor who regularly procures the services of construction companies. For each task to be done you ask private firms to submit sealed bids specifying the price for which they are willing to execute the job. The firm submitting the lowest price wins the contract. Different firms compete on each contracting occasion. You would like to keep prices as low as possible. The firms' behavior can be influenced through your agency's policy on how to disclose information about prices submitted in *previous periods*. There are three possibilities: First, you may publicly announce the entire vector of submitted prices. Second, announce only the winning bid. Finally, you can announce only which firm won, without giving any information about submitted prices. Which policy should you opt for?

In this paper we investigate this question experimentally. In the basic game two players simultaneously make bids which are integers between 2 and 100. These bids can be thought of as profit levels or prices requested by two competing firms to perform some task desired by a procurement agency. The firm who bids the lowest number gets a dollar amount times the number (s)he bids and the other firm gets 0. Ties get split. These payoffs reflect the idea that the lowest bidder "wins the contract". This game has a unique Nash equilibrium in which each player submits a bid of 2 and gets a payoff of only 1 (times a dollar amount). This equilibrium is strict and it can be given a strong decision-theoretic justification since a bid of 2 is the unique rationalizable strategy (Bernheim 1984, Pearce 1984) of the game.[1]

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[1] Three comments about this game and its solution: (i) The assumption that the range of prices is bounded from above is realistic since it is clear that the government will not (can not) pay an infinite amount of money for the job. (ii) In a finite two-player game, a strategy is rationalizable iff it survives iterated

We wish to investigate whether this sharp prediction stands up in a laboratory test. We are primarily interested in the behavior of *experienced* participants, since in reality competitors for a procurement contract typically are experienced. Hence, we must let participants play the game several times. The most common method for catering for experience in experimental economics is to let a fixed group of participants interact over and over again. However, a drawback with this approach is that a confounding effect is introduced. Since *the same* firms interact repeatedly, opportunities for cooperation of the kind studied in the theory of repeated games may be created (see Pearce (1992) for a general overview, and Friedman (1977) for the application to games that bear a resemblance to ours). We wish to test the model described in the previous paragraph as it stands, and yet to allow for experience while avoiding repeated game effects. We attempt to achieve this by using a random matching scheme such that participants play the game several times *but typically not facing the same rivals in each period.* In the terminology of Jackson & Kalai (1997) our design approximates interaction in *recurring games*, as opposed to repeated ones.

Harking back to the story of the government contractor, this is where the issue of information feedback crops up. Since each firm interacts more than once, a history of prices will exist. This history may or may not be public information, and it is possible that this is controlled by the government contractor. In this experiment, we investigate how

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elimination of strictly dominated strategies. If for each player a unique strategy does so, the corresponding profile must be the game's unique Nash equilibrium which furthermore is strict. In our game, a bid of 100 is strictly dominated by a mixed strategy giving almost all weight to 99, and very low but positive weight to 2. Repeated analogous arguments reveal that 2 is the unique strategy surviving iterated elimination of strictly dominated strategies, and the desired conclusions follow. (iii) We do not include (the per se reasonable) choices 0 and 1 in the strategy sets since this would eliminate the uniqueness of the theoretical prediction while in terms of economic intuition little would change (*all* equilibria entail *small* profits).

important this matter is, and we have three treatments which differ in terms of the availability of information about historic prices. In the first treatment—*full information*—we publicly announce the entire vector of submitted bids at the end of each period. In the second treatment—*semi-information*—we announce only the winning bids. In the third treatment—*no information*—we announce at the end of each period only which participant won. It is crucial to note that the theoretical prediction, described above, is invariant to the information condition.

Our study overlaps with Dufwenberg & Gneezy (2000) on the full information treatment, and the results should be viewed as complementary. Both these studies deal with the same game and random matching set-up, but the investigation proceeds along different dimensions as Dufwenberg & Gneezy (given full information) consider the effect of increasing the number of competitors beyond two. It is shown that bids converge towards the Nash equilibrium with low profit when the number of competitors is three or four, but that bids remain much higher when only two firms are matched. See Baye & Morgan (1999) for an analysis of how these results may be accounted for theoretically. Our old results on market concentration and our new results on the role of information feedback may be combined to yield insights about optimal procurement auction design.

The random matching set-up used here and in Dufwenberg & Gneezy (2000) distinguishes these studies crucially from most other experimental studies of price competition, because the usual approach is to consider repeated interaction among a fixed group of firms. In such a setting, informational issues of various kinds (for example, information about cost structures or signals of future prices) have been investigated, but not the effect of information about historic strategic choices. The classic contribution is

Fouraker & Siegel (1963), and a collection of relevant other references include Dolbear et al (1968), Selten & Berg (1970), Hoggatt, Friedman & Gill (1976), Friedman & Hoggatt (1980), Grether & Plott (1984), Holt & Davis (1990), Cason (1994, 1995), Cason & Davis (1995), Mason & Phillips (1997), Gneezy & Nagel (1999). For overviews of some of the literature mentioned here, see Plott (1982, 1989) and Holt (1995). Two other studies of somewhat related games which, however, are not conceptualized as price competition games are Nagel's (1995) "guessing game" and Capra et al's (1999) investigation of the "travelers' dilemma". The last study uses random matching pairings.

In the next section we describe the experimental procedure. Section 3 reports the results. Section 4 contains a discussion. We describe a phenomenon of price signaling that may be important for explaining the results, and we close the paper by including a recommendation concerning optimal procurement design for government contractors.

2. Experimental procedure

The experiment was conducted at Tilburg University. Students were recruited using an advertisement in the university newspaper as well as posters on campus. The experiment consisted of three treatments with two sessions per treatment. The number of bidders was 12 in all sessions and an extra student assisted us. That is, in total, 72 students participated. Each session operated for 10 periods. In each period six pairs of participants were grouped together according to a random matching scheme, and then each pair played the above game.

In treatment F (full information feedback), participants were informed at the end of each period about the entire bid vector (that is, about all 12 bids). In treatment S (semi-full information feedback), only the vector of winning bids were communicated to the participants. In treatment N (no information feedback), participants were informed only about their personal payoff at the end of the period.

In each session, after all 13 students entered the experimental room, they received a standard-type introduction, and were told that they would be paid 7.5 Dutch guilders (*f*7.5) for showing up.[2] Then, they took an envelope at random from a box which contained 13 envelopes. 12 of the envelopes contained numbers (A1,..,A12). These numbers were called "registration numbers". One envelope was labeled "Monitor", and determined who was the person who assisted us and checked that we did not cheat.[3] We asked the participants not to show their registration number to the other students.

Each participant then received the instructions for the experiment (see the Appendix), and ten coupons numbered 1, 2,..., 10. After reading the instructions and asking questions (privately), each participant was asked to fill out the first coupon with her registration number and bid for period 1. The bids had to be between 2 to 100 "points", with 100 points being worth *f*5. Participants were asked to fold the coupon, and put it in a box carried by the assistant. The assistant randomly took two coupons out of the box and gave them to the experimenter. In treatment F (sessions F1 and F2), the experimenter announced the registration number on each of the two coupons and the respective bids. If one bid was larger than the other, the experimenter announced that the low bid won the same amount of points as she bid, and the other bidder won 0 points. If the bids were equal the experimenter announced a tie, and said that each bidder won one

[2] At the time of the experiment, $1=*f*1.7.

[3] That person was paid the average of all other subjects participating in that session.

half of the bid. The assistant wrote this on a blackboard such that all the participants could see it for the rest of the experiment. Then the assistant took out another two coupons randomly, the experimenter announced their content, and the assistant wrote it on the blackboard. The same procedure was carried out for all the 12 coupons. Then the subsequent periods were conducted the same way. After period 10 payoffs were summed up, and participants were paid privately.

Treatment S (sessions S1 and S2) was carried out the same way except that the experimenter did not announce the losing bids. Treatment N (sessions N1 and N2), was carried out the same way except that the experimenter did not announce bids at all (and hence only communicated the registration number(s) corresponding to the lowest bid for each matched pair).

3. Experimental results

The raw data of the respective sessions are presented in Tables 1a-f, in which the average winning bids and the average bids are also presented. Correspondingly, the average winning bids and the average bids are plotted in Figures 1a-f. We start with describing the behavior in period 1, at which stage no elements of learning or experience exist. From observation of the data it is clearly seen that the outcome predicted by theory was not achieved in this period.

The average bid (winning bid) was 33.5 (29.7) and 41.8 (23) in sessions 1F and 2F respectively, 31.5 (25.5) and 40.9 (28.0) in sessions 1S and 2S respectively, and 39.7 (21.0) and 42.6 (35.3) in sessions 1N and 2N. We also perform a statistical test of whether the bids in different sessions came from the same distribution. To this end, we consider each of the (15) possible pairs of sessions, and investigate whether the two concerned sets of observed bids come from the same distribution. We use the non-parametric Mann-Whitney *U* test based on ranks, and cannot, for any pair, reject (at a 95% significant level) the hypothesis that the observations comes from the same distribution (see Table 2). In this sense, in period 1 the different rules in the different markets did not influence behavior.

When comparing the convergence of bids in later periods, however, we observe great difference between treatments. See Figure 2 for the comparison of the average winning bids in the three treatments. In session 1F, we see a slow decrease of the average winning bid from 29.7 in period 1 to 16 in period 6. From period 6 to period 7, a jump in the average winning bid from 16 to 35.1 is observed. From this point on the averages are 25.8 in period 8, 33.8 in period 9, and finally 37.8 in period 10. It is clear that no convergence to bids of 2 is observed. In fact, the smallest bid in period 10 was 19. In session 2F, the average winning bid decreased constantly from 23 in period 1 to 16.2 in period 4. Then, however, the average winning bid started to rise, and in periods 8, 9, and 10 the average winning bids were 38.2, 37.2, and 36 respectively. An interesting observation is that participant number A12 in this session used a constant bid of 2 throughout the experiment. Of course, this bid of 2 was "strange" given the fact that the next lowest bid in period 10 was 38. This bid was not enough to move the other bids to the neighborhood of 2. Furthermore, the bids in both sessions of treatment F were much alike in period 10; the average bids were 49.6 and 49.3 in sessions 1F and 2F respectively, and the average winning bids were 37.8 and 36 in the respective sessions.[4]

In session 1S we see a decrease in the average winning bid from 25.5 in period 1 to 3.8 in period 10. Bids decrease steadily moving from period 1 to period 10. The lowest bid as well as the median bid in period 10 is 2. A similar behavior is observed in session 2S, in which the average winning bid decreased from 28.0 in period 1 to 6.2 in period 10. The lowest bid in period 10 was also 2, with 9 out of the 12 participants bidding 5 or less. When comparing the two sessions of treatment S we see that, like in the case of treatment F, the bids in both sessions were much a like in period 10.

In session 1N we see that the decrease in the average winning bid is not monotonic. The average winning bid fluctuate around its starting value (21) until the 7th period, and only then it starts to decline. The average winning bid in the final period is 6.9, and the median bid is 10 (as compared with a median bid of 29.5 in period 1). In session 2N the decrease in the average winning bid is more steady (though not monotonic), from 35.3 in period 1 to 6.3 in the final period.

Figure 3 presents cumulative distributions of the prices chosen in period 10 for each treatment, aggregated across the two sessions for each treatment.

To summarize, the market outcomes in period 1 are similar across sessions. It is also the case that in all sessions the outcomes converge, and relatively little fluctuation is observed at the end of the experiment. However, while the period 10 outcomes in the two

[4] Unlike the case of first round behavior, it is not appropriate to use the Mann-Whitney test, because the assumption that all observations are independent is not justified.

sessions of treatment F are far from equilibrium, the period 10 winning bids of the other two treatments are relatively close to the equilibrium.

4. Discussion

In this paper we consider the design of auctions by a government which seems to have very little power: it can only decide how much information feedback to give to the firms in the market.[5] The firms compete in prices in a recurrent competition environment. The theoretical prediction is clear cut for all possible information feedback; firms should submit the lowest bid possible.

However, when we test this model experimentally, we find that at the initial stage "firms" (the students participating) set prices higher than the Nash equilibrium. However, bids converged rapidly to the theoretical prediction in two out of the three information feedback treatments. This was the case when participants did not receive any information feedback but their own performance in previous periods, and when firms received information feedback only about their own performance and about the bids of the winning firms in previous periods. However, in a third treatment in which firms were informed about the entire bid vector in previous periods, prices remained much higher than the theoretical prediction.

Apparently, the information about the *losing* bids is of great importance for the competing firms. An attempt to rationalize this result may be done in terms of signaling behavior. The following intuitive argument is intended to be suggestive of what is going

[5] By contrast, the theoretical literature on optimal procurement typically considers the effects of *different* mechanisms (e.g. Luton & McAfee (1986), Laffont & Tirole (1987), Piccione & Tan (1996)) or market structure (e.g. Dana & Spier (1994), McGuire & Riordan (1995)), but does not address the issue of information feedback in recurrent interaction.

on: Assume each firm has two possible actions in time *t* and *t*+1 (when *t* is not the final period). The firm can either "compete" or "signal". If the firm chooses to compete, then it submits a bid which gives it the highest expected reward at time *t*, based on its belief about the bids of the other firms. Alternatively, the firm may choose to use its bid at time *t* to signal. Doing that, the firm bids "high" at time *t* sacrificing payoffs in that period in order to influence the beliefs of the other firms in time *t*+1. If the firm is successful in doing this, then it may expect higher payoffs at time *t*+1 than if it chooses to compete at time *t*.[6] Clearly, this kind of signaling may be profitable *only* when the other firms can observe the signals. That is, only in the treatment in which firms observe the entire bid vector, including the losing bids, they will be aware of signals.

Note that if this signaling story is relevant, the tradeoff between profits in the current period and overall profits may be more favorable to signals when bids at time *t* are expected to be very low. Moreover, in the current random matching context, this signaling explanation is not the same as the repeated interaction explanation in which firms are assumed to collude. To construct a formal model of signaling may be a feasible research task which could shed some light on how prices evolve in markets in which firms compete in prices. We hope that the findings we report in this study will serve to inspire such a line of inquiry. This, however, lies outside the scope of the present paper.

The experimental game we analyze has features reminiscent of both Bertrand price competition and first price auctions. However, the prime interpretation we have made

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[6] Observations of related kinds of price signals are made by Fouraker & Siegel (1963, pp 185-88), Hoggatt, Friedman & Gill (1976), and Friedman & Hoggatt (1980) for the case of repeated interaction among a fixed group of firms. See Plott (1982, pp 1513-17) for a discussion. Surprisingly, these interesting observations seem to have been "forgotten"; we have seen no post-1982 discussion of the matter in the literature.

concerns government procurement. What have we learned of relevance for optimal procurement auction design? Note first that the evidence reported by Dufwenberg & Gneezy (2000) suggests that a government contractor may be well-advised to strive to have at least three competitors in his procurement auctions; with only two competitors bids remain far away from the Nash equilibrium, while bids converge towards the equilibrium when the number is three or four. This result, however, was derived under conditions of full information about historic bids. The present paper shows that even with two competitors bids converge towards the Nash equilibrium if information about losing bids is not disclosed. Based on this observation, we now return to the story featuring you as a government contractor and venture upon the following piece of advice: *You may announce winning bids, but keep the losing bids secret!*

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Appendix: Instructions for the full information treatment

In the following game, which will be played for 10 rounds, we use "points" to reward you. At the end of the experiment we will pay you 5 cents for each point you won (100 points equals 5 Dutch guilders). In each round your reward will depend on your choice, as well as the choice made by one other person in this room. However, in each round you will not know the identity of this person and you will not learn this subsequently.

At the beginning of round 1, you are asked to choose a number between 2 and 100, and then to write your choice on card number 1 (please note that the 10 cards you have are numbered 1,2,...,10). Write also your registration number on this card. Then we will collect all the cards of round 1 from the students in the room and put them in a box.

The monitor will then randomly take two cards out of the box. The numbers on the two cards will be compared. If one student chose a lower number than the other student, then the student that chose the lowest number will win points equal to the number he/she chose. The other student will get no points for this round. If the two cards have the same number, then each student gets points equal to half the number chosen. The monitor will then announce (on a blackboard) the registration number of each student in the pair that was matched, and indicate which of these students chose the lower number and what his/her number was.

Then the monitor will take out of the box another two cards without looking, compare them, reward the students, and make an announcement, all as described above. This procedure will be repeated for all the cards in the box. That will end round 1, and then round 2 will begin. The same procedure will be used for all 10 rounds.

Tables 1a-f: The bids in the different sessions

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
A1	49	34	24*	22*	16*	15*	100*	100	60	20*
A2	15*	20*	25*	20	19	19	14*	9*	19*	19*
A3	39	39	30	35	40	19	100*	99	99	99
A4	40*	29*	28*	26	18*	16*	13*	80*	40	28*
A5	10*	20*	29	24*	19*	15*	14	100	79	79
A6	40*	30*	26	20*	21	15*	14*	19*	50*	60*
A7	23*	29	31*	24*	28	20*	14*	17*	40*	50
A8	46	32	24*	26	18*	100	20	35	88	66
A9	40	38	25*	25	20*	20	15	40	100	40*
A10	40*	40	35	19*	19*	18	40	39	35*	60*
A11	20	25*	20*	19*	17*	15*	12*	12*	20*	39
A12	40*	35*	30	23*	25	16	14*	18*	39*	35
Ave.bid	33.5	30.9	27.3	23.6	21.7	24.0	30.8	47.3	55.8	49.6
Ave.win bid	29.7	26.5	25.3	22.0	18.1	16.0	35.1	25.8	33.8	37.8

Table 1a: Bids in session F1 (full information feedback). * indicates a winning bid.

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
A1	66	50*	33*	66	44	85	98	96	50*	99
A2	30	24*	33*	22	30*	20	79	50*	54	40
A3	80	70	39	39	19	26	59*	69	67	46
A4	40*	50	40	20*	20*	80	79*	76	66	42
A5	85	85	85	20*	20	15*	20*	70	70	50
A6	22*	28*	18*	18*	28	20*	30*	49	48	39*
A7	98	40	84	85	99	99	99	99	99	99
A8	20*	30	28	20*	18*	80*	20	40*	40*	30*
A9	5	17*	20*	17*	17*	16*	13*	19*	35*	39*
A10	33*	29*	27*	26	17*	16	79*	49*	48*	38*
A11	21*	21	21	21	18*	16*	39	69*	48*	68*
A12	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*
Ave.bid	41.8	37.2	35.8	29.7	27.7	39.6	51.4	57.3	52.3	49.3
Ave.win bid	23.0	25.0	22.0	16.2	17.4	24.8	40.3	38.2	37.2	36.0

Table 1b: Bids in session F2 (full information feedback). * indicates a winning bid.

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
A1	40*	35	25	15	9*	15	5	20	50	50
A2	47	27*	13*	12	9*	7*	3*	3*	3	2*
A3	22*	27*	22	12*	11	10	8	6*	4*	2*
A4	15*	24	15*	18	11	9*	7	15	2*	14*
A5	19*	19	17*	9*	9*	7*	5*	4*	2*	2*
A6	37*	18*	17	12*	9	7*	5*	3*	2*	2
A7	48	27*	25	14*	48	40	48	48	48	38
A8	21	15*	17*	15	11*	8*	8*	5*	5	4*
A9	25	25	13*	13	8*	8*	6*	5	4*	2*
A10	40	19*	18	10*	9*	8	6	5	3*	2*
A11	20*	15*	10*	10*	10	10	5*	2*	2*	2*
A12	44	28	25	16	11	8*	8	28	6*	20
Ave. bid	31.5	23.3	18.1	13.0	12.9	11.4	9.5	12.0	10.9	11.7
Ave. win bid	25.5	21.1	14.2	11.2	9.2	7.7	5.3	3.8	3.1	3.8

Table 1c: Bids in session S1 (semi-information feedback). * indicates a winning bid.

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
A1	24*	39*	24*	19*	24	16	12*	9*	9	4
A2	75	50	75	25*	25	20	15	10*	10	99
A3	40	40	20	30	15*	15*	15	10*	8	4*
A4	28*	12*	21*	29	19	13*	11*	8*	10*	3
A5	49*	45	48	20*	19*	19*	13*	18	8	2*
A6	66	20*	35	20	16*	15	30	10	7*	20
A7	80	60	25*	28	22	14*	19	19	100	20*
A8	13*	45	19*	20*	22*	21	18*	10*	9	5*
A9	22	20	18*	23*	18*	15*	12*	11	7*	5
A10	25*	21*	30	20*	19	10*	14	10*	8*	5
A11	40	23*	24	24	15*	15*	14*	12*	7*	4*
A12	29*	39*	34*	23	17*	42	22	19	7*	2*
Ave. bid	40.9	34.5	31.1	23.4	19.3	17.9	16.3	12.2	15.8	14.4
Ave. win bid	28.0	25.7	23.5	21.2	17.4	14.4	13.3	9.9	7.7	6.2

Table 1d: Bids in session S2 (semi-information feedback). * indicates a winning bid.

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
A1	100	100	100	100	100	100	100	100	100	100
A2	35	50	95	20*	30	20	90	30*	80	80
A3	100	50	50	25*	25	25	20	10	20*	10*
A4	35*	30*	35	25	20*	20*	20*	15*	25	15
A5	30	25	10*	14*	19*	24*	24*	24*	24	14*
A6	23*	23*	23*	23*	23	23	2	2*	2*	2*
A7	2*	100	2*	100	2*	100	2	2*	2*	2*
A8	29*	29*	29*	50	29*	29*	29*	29	15	39
A9	12*	14*	17*	22*	35	32	25	25*	20	10
A10	25*	25*	40	30	20*	20*	20*	20	5*	5*
A11	60	49	20	20*	20*	18*	18*	18*	10*	10*
A12	25	10*	20*	20	15*	15*	10*	10	10*	5*
Ave. bid	39.7	42.1	36.8	37.4	28.2	35.5	30.0	23.8	26.1	24.3
Ave. win bid	21.0	21.8	16.8	20.7	17.9	21.0	20.2	16.6	8.2	6.9

Table 1e: Bids in session N1 (no information feedback). * indicates a winning bid.

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
A1	100	100	50	25	10*	10*	20*	50	20	20
A2	29*	19*	11*	9*	7	5*	4	9*	7*	9*
A3	21	98	99	2*	2*	2*	2*	2*	2*	2*
A4	45	25*	35	50	25	30	25	20	2*	20
A5	39*	27*	18*	13*	11*	9	3*	4*	20	2*
A6	25*	35*	40	40	30*	30	30	20	20	20
A7	46*	46	35*	40	33	24	15*	20	15*	20
A8	10*	10*	10*	10*	5*	10*	10*	10*	10*	10*
A9	49*	48	39	20	10*	6*	7	5*	5	5*
A10	49*	49	46*	42*	41	49	30	70	30	25
A11	29	20*	24*	27*	21	23	19	17*	22	30
A12	69	37	25	15	8*	10*	8*	10	8*	10*
Ave. bid	42.6	42.8	36.0	24.4	16.9	17.3	14.4	19.8	13.4	14.4
Ave. win bid	35.3	22.7	24.0	17.2	10.9	7.2	9.7	7.8	7.3	6.3

Table 1f: Bids in session N2 (no information feedback). * indicates a winning bid.

	Session F2	Session S1	Session S2	Session N1	Session N2
Session F1	.00 (1.000)	.29 (.7728)	-.61 (.5444)	.43 (.6650)	-.89 (.3708)
Session F2		.38 (.7075)	-.26 (.7950)	-.12 (.9081)	-.49 (.6236)
Session S1			-1.10 (.2727)	-.23 (.8179)	-1.39 (.1659)
Session S2				.38 (.7075)	-.26 (.7950)
Session N1					-.69 (.4884)

Table 2: A pairwise comparison of bids in the first period across sessions using Mann-Whitney *U* test based on ranks. The null hypothesis is that all bid vectors come from the same distribution. The numbers in the cells are the z-statistics. The Prob > |z| is given between brackets.

Figure 1a: Average bids and winning bids, session F1

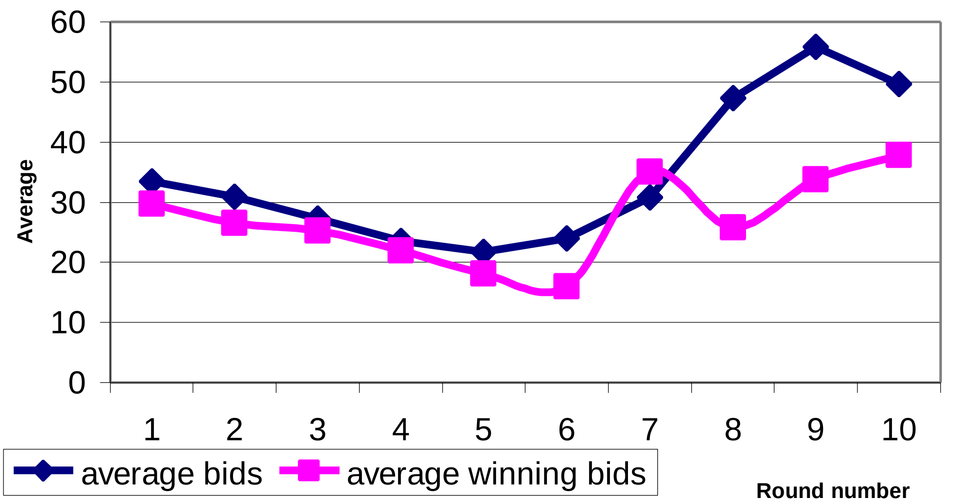
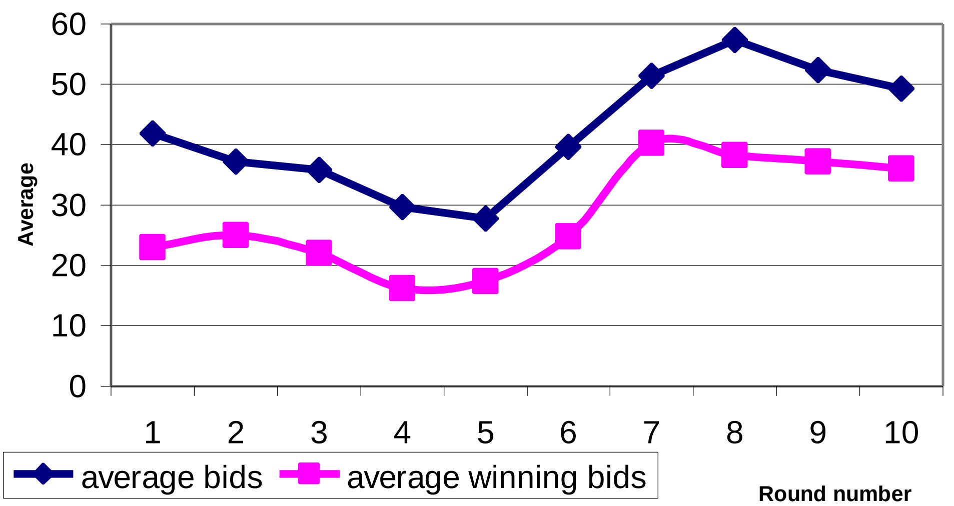


Figure 1b: Average bids and winning bids, session F2



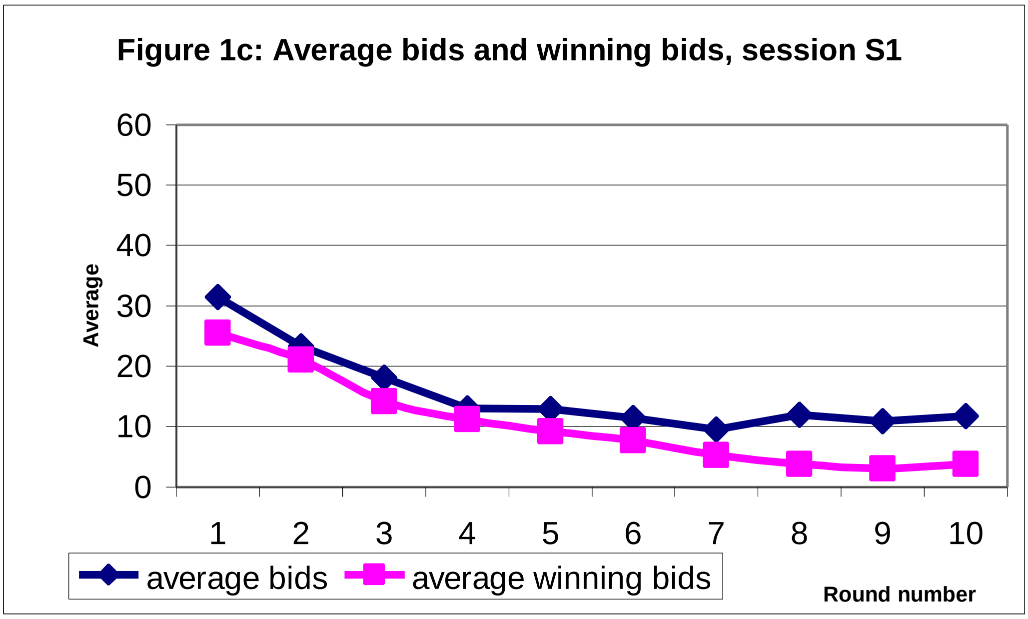


Figure 1c: Average bids and winning bids, session S1
Average
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
average bids
average winning bids
Round number

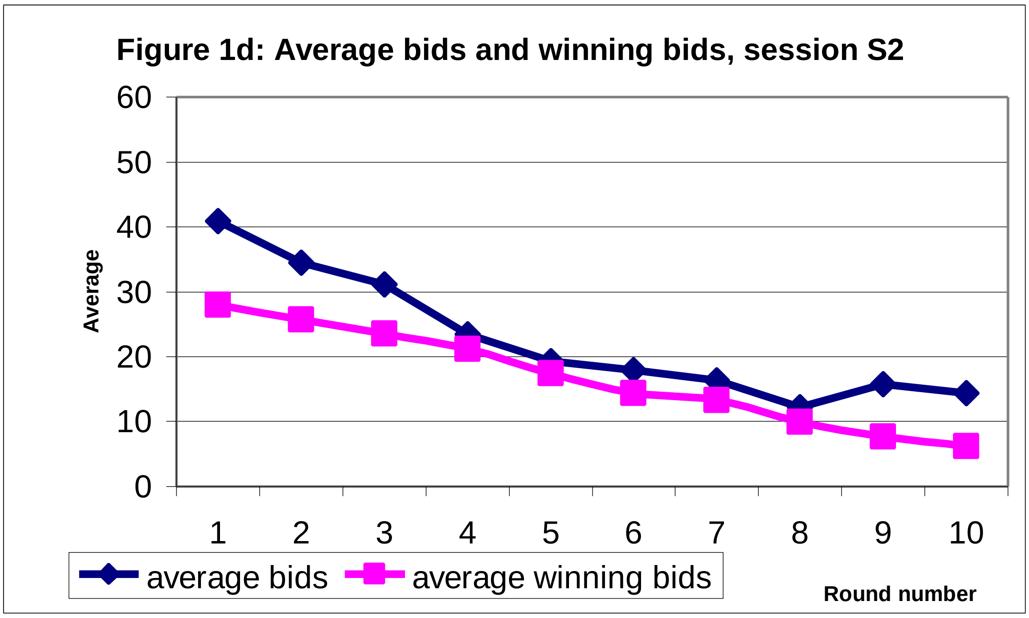


Figure 1d: Average bids and winning bids, session S2
Average
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
average bids
average winning bids
Round number

Figure 1e: Average bids and winning bids, session N1

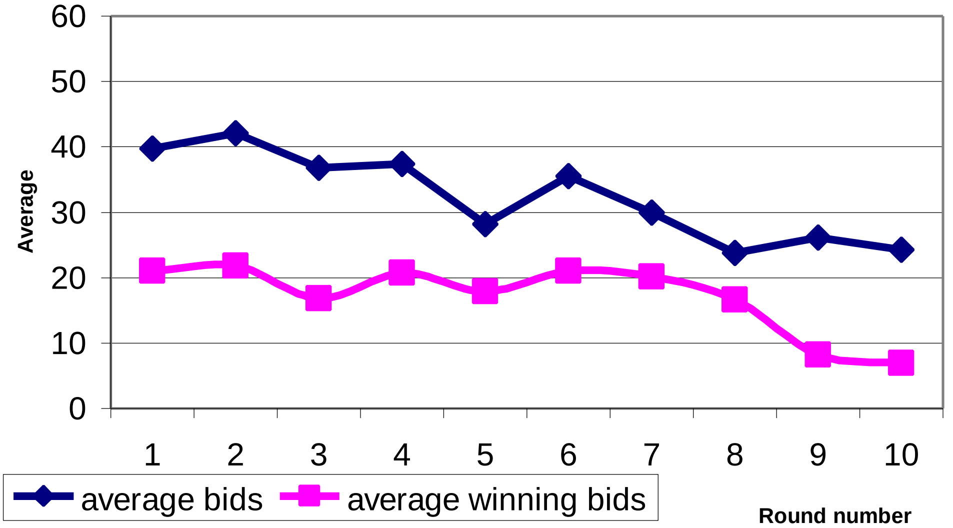
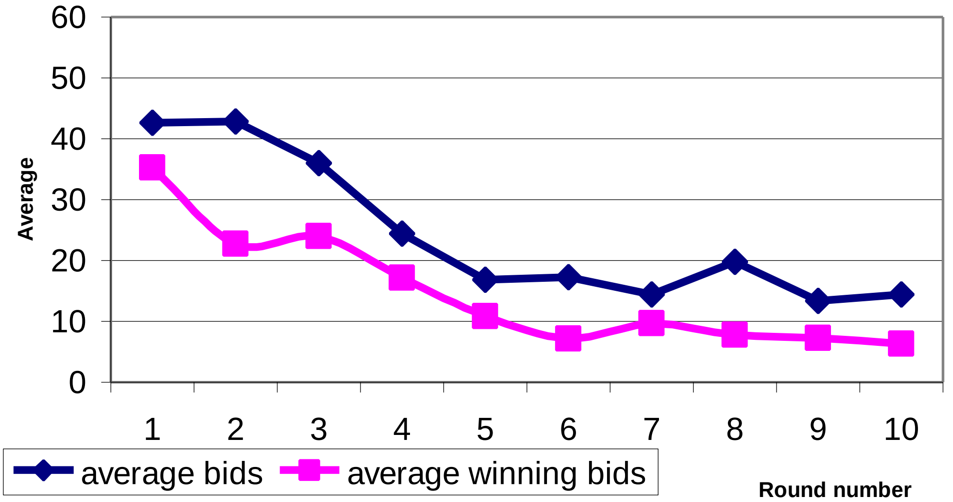


Figure 1f: Average bids and winning bids, session N2



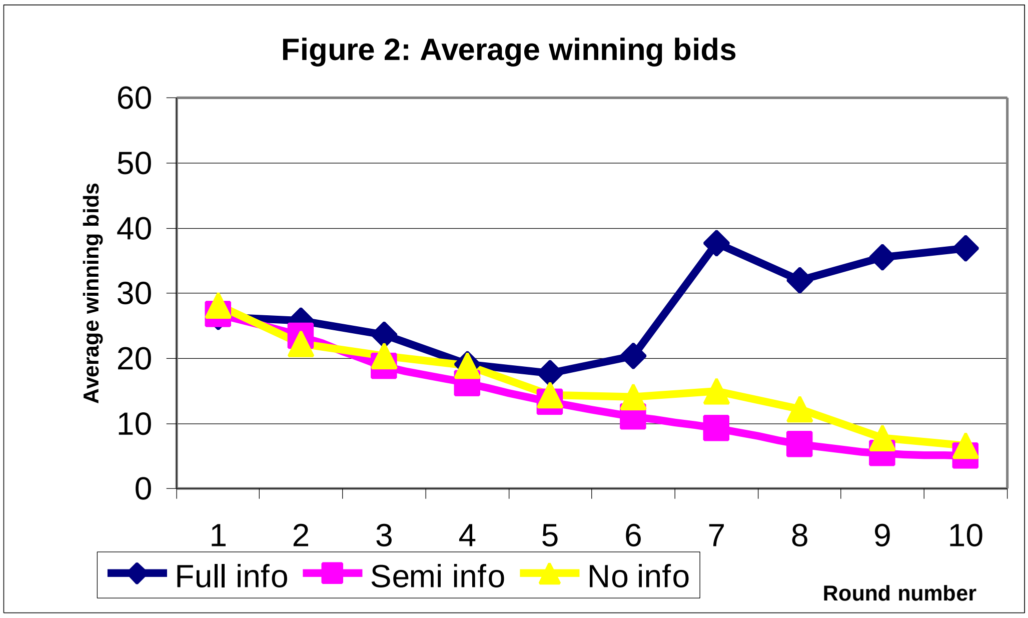


Figure 2: Average winning bids
Average winning bids
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
Full info
Semi info
No info
Round number

Figure 3: *c.d.f.* for the three treatments