Morten Søberg

Voting rules and endogenous trading institutions: An experimental study

Abstract:
This paper reports on recurring laboratory elections in which buyers and sellers choose institutional rules to govern a subsequent trading round. The bid auction (buyers propose prices), offer auction (sellers suggest prices) and double auction (both trader types initiate price quotes) make up the electoral candidates. Both plurality rule and approval voting are used as vote-counting schemes. The former allows each trader to vote for, at most, one auction, whereas approval voting permits voters to either abstain or to vote for one, two or all three institutional alternatives. The main result is threefold. First, plurality rule induces a Duverger effect in the sense that only the bid and offer auctions emerge as viable auctions. Approval voting instead leads to close three-way races with each of the three auctions winning approximately one third of the elections. Second, buyers (sellers) in the plurality-rule sessions concordantly vote for the bid (offer) auction. Approval-voting behavior is comparatively more heterogeneous. Third, bid-auction prices are significantly lower than double-auction prices, which again are significantly below offer-auction prices.

Address: Morten Søberg, Statistics Norway, Research Department. E-mail: morten.soberg@ssb.no

Discussion Papers	comprise research papers intended for international journals or books. As a preprint a Discussion Paper can be longer and more elaborate than a standard journal article by including intermediate calculation and background material etc.

1. Introduction

Price formation lies at the core of economic exchange in as much as mutual acceptance of contract prices is a prerequisite for voluntary trade amongst economic agents. However, price formation does not take place in an institutional void, but generally occurs within some form of institutional context. Any such institutional framework may be defined as explicit or implicit rules that specify the messages agents are allowed to send, the dissemination of such messages and how they may be converted into enforceable contracts (Friedman, 1993). A considerable body of experimental evidence suggests that the empirical properties of price formation tend to vary with alternative trading institutions (Plott, 1988 and Holt, 1995 survey this literature). The conventional method employed to generate such evidence is to superimpose trading rules upon laboratory market environments, and to juxtapose at least two different sets of exogenous rules in order to facilitate clear-cut institutional comparisons (see, e.g., Plott and Smith, 1978, Ketcham et al., 1984 and Bronfman et al., 1996). This methodology has come to dominate experimental analyses of trading institutions.

This paper adopts an alternative approach by examining institutional competition. Specifically, three different trading institutions compete for votes over the course of repetitive laboratory elections. Voting in each election is secret and confined to one round, after which a victor is decided. The participants subsequently trade using the chosen trading rules. The payoffs earned by subjects are not, therefore, directly determined by their voting behavior, but ultimately depend upon the prices agreed to during trading rounds.

The set of competing institutions is constant across sessions, and consists of the bid, double and offer auction. Bid (offer) auction rules allow buyers (sellers) only to initiate prices. Each price quote is disseminated to all market participants. During bid (offer) auction trading a transaction occurs if a seller (buyer) chooses to accept a proposed price. Confirmed prices are common knowledge. The double auction combines the bid and offer auctions. Each of these auction types is sequential in the sense that traders negotiate prices continuously during real-time sequences. Hence, the three auctions primarily differ in terms of whether buyers and/or sellers may instigate the price formation process.

Voting systems constitute the treatment variable in this study. Two variants are implemented. First, plurality rule is chosen as a benchmark case. This voting mechanism corresponds to the Anglo-American first-past-the-post system, which is the most widespread method of ranking candidates in an election (Levin and Nalebuff, 1995). Plurality rule allows each voter to abstain or to vote for one of

the three trading institutions. The institution with the most votes wins the election and governs the subsequent trading round. Second, approval voting is employed. This is a regularly proposed and adopted alternative to plurality rule (Brams and Nagel, 1991 and Mueller, 1989). Approval voting permits voters to either abstain or to vote for one, two or all three institutional alternatives. Approving of all three auctions is equivalent to casting a blank vote since it has no differential impact. The trading institution with the most votes is selected for the subsequent trading round.

Previous experimental analyses of plurality rule versus approval voting have considered electoral outcomes in laboratory environments in which the payoffs derived from winning candidates are exogenous and voter types' preferences over candidates common knowledge (Rapoport et al., 1991 and Forsythe et al., 1996). A chief aim of these papers has been to compare voters' behavior with theoretical predictions derived from various models of strategic voting. The present study is comparatively less theory-driven, and mainly seeks to probe empirically whether, and possibly how, the two voting mechanisms affect the endogenous implementation of bid, double and offer auctions. This exploratory objective may be concretized in the form of the following research topics:

1. Effective number of auctions

All three auctions are considered effective electoral candidates if each of them receives 33.33% of the vote in a laboratory election. The number of effective auctions falls below three if voters concentrate their votes on two or one of the alternative auction types. Specifically, the effective number of candidates is defined as the reciprocal of the Hirschman-Herfindahl index used to quantify the degree of concentration of sales in an industry (Cox, 1997). Hence, it is a measure of how concentrated vote shares are in electoral contests, and in a three-candidate race necessarily varies between one and three.

In elections with three candidates and just one winner, Duverger's law asserts that plurality rule tends to yield two effective candidates only (Duverger, 1967). The reason is that (strategic) voters seek to avoid wasting votes on candidates with low chances of winning. Thus, it is likely that a three-candidate race may degenerate into a serious race between the two candidates considered to be capable of winning the election. No such prediction applies to the approval voting mechanism (Weber, 1995).

The relevant empirical issue addressed below is whether plurality rule induces discernible Duverger effects when voters choose amongst bid, double and offer auctions, as well as which auction alternative the electorate in that case winnows out. A related aim is to investigate whether the number

of effective institutions during plurality rule deviates negatively and significantly from the quantity of effective auctions induced by approval voting.

2. Voting behavior and trader type

The participants in every laboratory session are randomly assigned a trader identity as either buyer or seller. The trading role of each subject is private knowledge and remains constant across voting and trading rounds. However, the demographics of the electorate - identical proportions of buyers and sellers - are common knowledge. Preferences over the three electoral alternatives are induced by means of written information defining the different trading rules as well as through test trading on each auction.

Plurality rule permits buyers and sellers to vote for just one auction. Hence, plurality election rules effectively aggregate preferences based upon the first choices of buyers and sellers. Approval voting aggregates preferences that may include second choices as well, and thereby ranks candidates on the basis of more complete individual preferences.

A second objective of this examination is to describe the institutional preferences of buyers and sellers as revealed in the plurality rule and approval voting laboratory elections. A linked intention is to investigate the extent to which individual buyers and sellers cast votes concordantly.

3. Auction prices

A final intention of this study is to gauge whether the level of contract prices generated during the trading rounds is affected by session-specific bargaining characteristics, time effects and the preceding laboratory elections.

The election stage of the experiment may exert an observable effect on prices in as much as at least two auctions are chosen. If so, the adopted null hypothesis asserts no significant differences across auction types. The reason is twofold. First, economic theory does not predict any specific ordering of bid-double-offer auction prices in the case of multiple buyers and sellers (Davis and Holt, 1993). Second, the existent laboratory evidence is inconclusive. In a seminal study, Smith (1964) reported laboratory data that supported his empirical *a priori* hypothesis that (mean and equilibrium) bid-auction prices tend to be greater than double-auction prices, which again tend to be greater than offer-auction prices. These institutional differences were statistically significant. Nevertheless, Walker and Williams (1988) reexamined Smith's results, and initially observed an ordering of prices whereby

double-auction prices are greater than offer-auction prices, which tend to be greater than bid-auction prices. Additional experiments revealed a ranking of prices that was weakly consistent with Smith's conclusion, but none of the observed institutional differences were statistically discernible at conventional significance levels.

The remainder of this paper is organized in four sections. Sections 2 and 3 describe the experimental design and the results. Section 4 discusses the findings and the last section concludes.

2. Experimental design

2.1. Voting stage

Each experimental session contained eight laboratory elections using one voting mechanism only. During the plurality rule sessions a subject could vote for one of the three auctions. Approval voting enabled each experimental subject to vote for one, two or all three of the alternative trading institutions. In addition both voting rules allowed for abstention.

The three electoral alternatives - offer, double and bid auction - were explicitly listed alphabetically on the voter ballots as "Ask auction", "Ask and bid auction" and "Bid auction". Each ballot included a subject identification number for data-collecting purposes. Subjects voted in private and used pens to mark their preferred alternative(s). After each laboratory election the results were listed on the blackboard. In the event of ties, a dice was thrown to determine a winner. The sole purpose of the elections was to decide upon common trading rules. No financial incentives applied to this part of the experiment.

2.2. Trading stage

Trading on the chosen auction type followed each laboratory election, and occurred on a computerized market where traders communicated with each other via computer terminals[1]. No additional interaction between traders was permitted. Each trading round lasted three minutes. During each trading stage four buyers interacted with as many sellers. Their trading roles were specialized meaning that a buyer (seller) could not buy and resell (sell and repurchase). Equivalently, speculation was disallowed. The subjects retained their trader roles throughout the entire experimental session.

---

[1] The utilized software (ESLDA 1.43) was downloaded from the Economic Science Laboratory, University of Arizona.

Endowing the four buyers with equal individual unit valuations for four units of a fictitious homogenous good induced market demand. A transaction gave a buyer a profit in experimental dollars equal to the value of the difference between the assigned value of the traded unit and the agreed price. Alternately, assigning each seller unit costs over four units of the good induced market supply. A seller's profit from any transaction equaled the difference between price and cost of the traded unit. Each buyer (seller) obtained information regarding his own demand (supply) schedule only. Trading was sequential in as much as each buyer (seller) could buy (sell) one unit at a time. Neither demand nor supply schedules were altered between trading rounds. The aggregated individual demand and supply schedules are depicted as market demand and supply in Figure 1. Demand and supply are nominated in experimental dollars and units are measured along the horizontal axis.

Figure 1. **Market demand and supply**
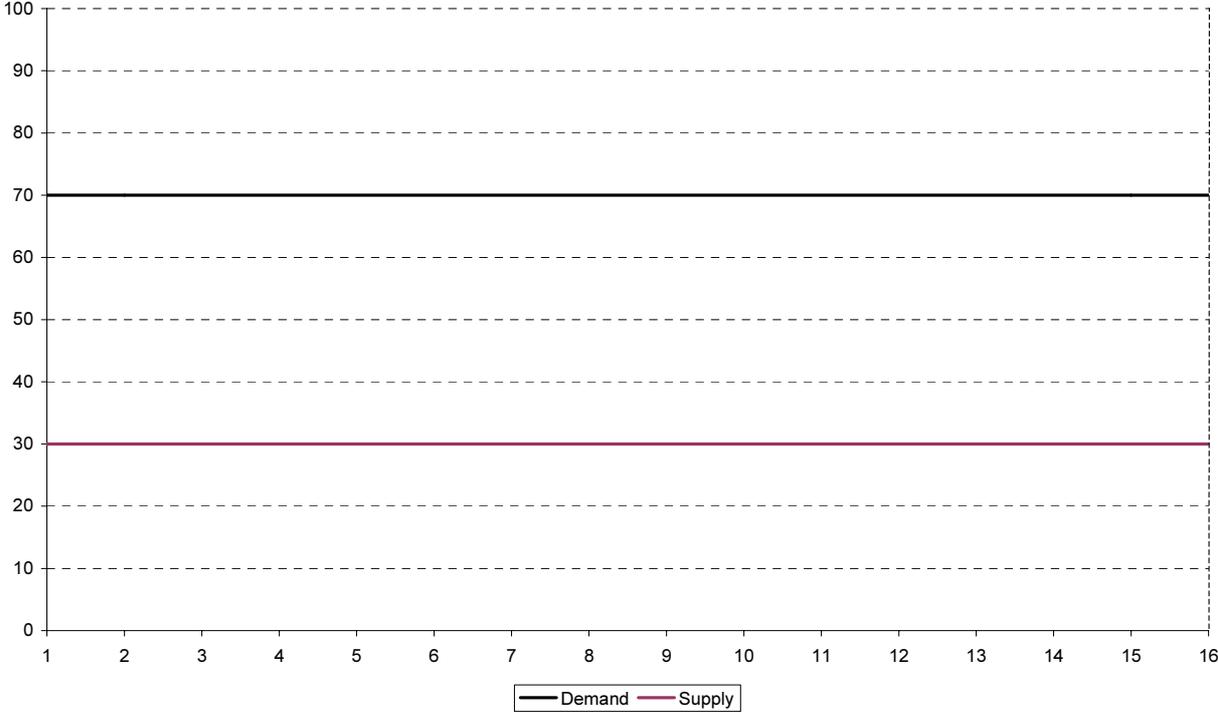
The efficient trading volume outcome was 16 units. As can be seen from the figure, there was a range of price equilibria because all transactions could be conducted at prices in the interval [30,70] experimental dollars. The outlined market environment was invariant with regard to auction type.

The double-auction trading rules allowed buyers (sellers) to post offers to buy (offers to sell) at any time during a trading period[2]. Buyers' (sellers') offers were called bids (asks). A lexicographic improvement rule required any buyer (seller) to specify higher (lower) prices in order to replace a former bid (ask) of his. The best bids and asks, as well as a list of the residual bids and asks, were shown on the computer screens of all traders. A buyer (seller) could accept the best ask (bid) at any time before the end of the trading period, and thereby trigger a transaction. If a buyer (seller) tried to propose or accept a bid (an ask) implying a negative profit, he was warned by the program and given an opportunity to alter his message. Moreover, there was a continuously updated listing of confirmed prices on all computer screens as well as a clock showing seconds remaining of the trading period. Each buyer (seller) could also see his demand (supply) schedule and profits derived from transactions during the prevailing trading period. The computerized bid and offer auctions were similar to the described double auction procedures except that the bid (offer) auction permitted buyers (sellers) only to announce bids (asks).

2.3. Experimental procedures

Table I shows the experimental design and gives information about mean payoffs denoted in U.S. dollars. The first two sessions were run at the University of Oslo, whereas the last two were conducted at the University of Nottingham. The Norwegian sessions used post-graduate students in economics and political science as subjects. The participants in the English sessions were masters and doctoral students in economics. Students were invited to sign up for the experiments via e-mail messages.

Table I. **Session plan and payoffs**

Session	Date	Voting rule	Mean payoff: Buyers[*]	Mean payoff: Sellers[*]
AV1	10/31/2001	Approval voting	46	120
PR1	10/31/2001	Plurality rule	99	55
AV2	11/15/2001	Approval voting	79	54
PR2	11/16/2001	Plurality rule	105	30

[*] Denoted in U.S. dollars

The Norwegian (English) session mean payoffs include individual show-up fees equal to 11 (7) U.S. dollars[3]. For comparison, efficient trading conducted at the mid-point of the feasible price range

---

[2] Asks and bids were required to be non-negative and strictly lower than 100 experimental dollars. The software generated error messages that were displayed on the computer screen if a subject violated any of these constraints.

[3] The subjects' profits denoted in experimental dollars were originally converted to, and paid in, Norwegian kroner and British pounds. The listed values in U.S. dollars are based on the exchange rate that prevailed at the time of the experiment.

implies an expected payoff of 83 (71) U.S. dollars to each trader in the Norwegian (English) sessions. The implemented nominal discrepancy in expected payoffs are taken to reflect inter-country differences in costs of living.

Each experimental session ran as follows: Upon arriving at the laboratory subjects were randomly assigned a computer terminal and a trader role. After reading the written instructions and answering test questions, they participated in a test election with hypothetical alternatives labeled "X", "Y" and "Z"[4]. They were then taken through a self-paced computerized introduction to the offer, bid and double auction, and practiced trading in each of these trading institutions. The shapes of market demand and supply were similar to those depicted in Figure 1, but the values differed in that the feasible price range in the offer, bid and double action test rounds was (15, 85), (20, 80) and (25, 75), respectively. Finally, subjects voted in eight elections and traded over the course of eight subsequent trading rounds. Each laboratory session lasted roughly two and a half hours. At the end of each session the participants were privately paid their aggregate earnings in cash.

3. Experimental results

3.1. Effective number of auctions

Table II gives an overview of the laboratory elections. In the plurality-rule sessions the double auction is chosen only once and receives approximately 15% of the aggregate vote. The residual votes are more or less evenly split between the bid and offer auction, which win 15 out of 16 elections. Given the aggregate vote shares, the effective number of auctions is 2.6[5]. A strictly Duvergerian outcome would yield two effective auctions only.

The switch to approval voting induces a topsy-turvy effect, moving the last-place double auction into first place with 34.43% of the total vote. In the approval-voting sessions each auction receives roughly an equal share of the vote. Accordingly, the pooled effective number of auctions is marginally below three.

---

[4] The instructions are reproduced in the appendix.

[5] Let v_i denote the share of the total vote received by auction i, $i \in$ (bid auction, double auction, offer auction); $\forall i\ v_i \in [0,100]$ and $\propto v_i = 100$. Then the effective number of auctions, EN, is defined as follows: $EN \equiv 1 / \sum v_i^2$; $EN \in [1, 3]$.

Table II. **Election results**

Voting rule	Bid auction		Double auction		Offer auction		Effective no. of auctions
	# wins	% of vote	# wins	% of vote	# wins	% of vote	
Plurality rule	7	40.94	1	14.96	8	44.09	2.60
Approval voting	4	33.88	6	34.43	6	31.69	2.99

Figures 2 and 3 display time series of each auction's vote share in the two plurality-rule sessions, PR1 and PR2, respectively. The effective number of auctions variable is denoted as EN, and is calculated for each election then listed at the bottom of the figures. Solid vertical lines delineate the laboratory elections, and the winner of each election is identified near the top of the figures.

The voters' in session PR1 primarily support the bid and offer auctions, although the vote shares of these auctions oscillate and do not appear to converge to stable vote shares over time. In the seventh election, a tie between the bid and offer auction is broken to the advantage of the former.

The double auction does not win a single election, but comes second in the third election with almost 40% of the vote. However, in the main, it is the least popular auction type, and obtains zero votes in five of the eight elections. Consequently, the effective number of auctions fluctuates around two.

Figure 2. **Vote shares, session PR1**

The second plurality rule session PR2 is similar to PR1 in as much as the bid and offer auctions are the leading institutional candidates, winning seven out of eight elections. A particularly striking outcome is recorded in the first election in which the offer auction attracts nearly 90% of the vote.

As can be seen in Figure 3, the double auction fares comparatively better in this session - on average attracting 20% of the vote - and wins the sixth election after initially being tied with the bid auction. Nonetheless, its vote share then decreases dramatically, and equals zero in the last election. This is reflected in the marked decrease in the number of effective auctions.

Figure 3. **Vote shares, session PR2**
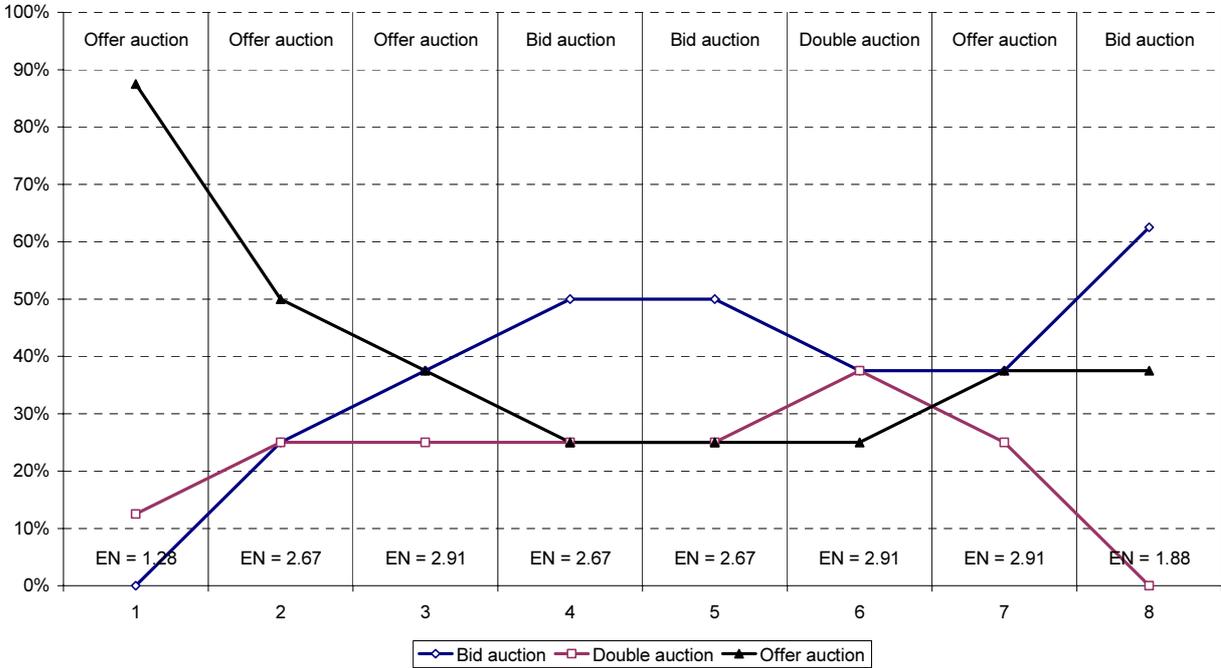
Next consider the election results from the approval-voting sessions. An initial impression is that each of the three auctions generally receives between 20% and 50% of the vote. This pattern persists over time in both sessions, even though vote shares diverge distinctly during the fourth and fifth elections.

The figures reveal that voters do not coordinate their voting behavior on any specific auction type. All three auction types are in contention throughout, and the effective number of auctions remains by and large in the vicinity of three. The average value of EN in session AV1 (AV2) is 2.99 (2.94).

One consequence of the high number of effective institutions is that auctions usually win the elections with less than a majority of the cast votes. During session AV2 the double auction receives almost 56% of the vote in the sixth election. This constitutes the only observation of a strict majority during the two approval-voting sessions.

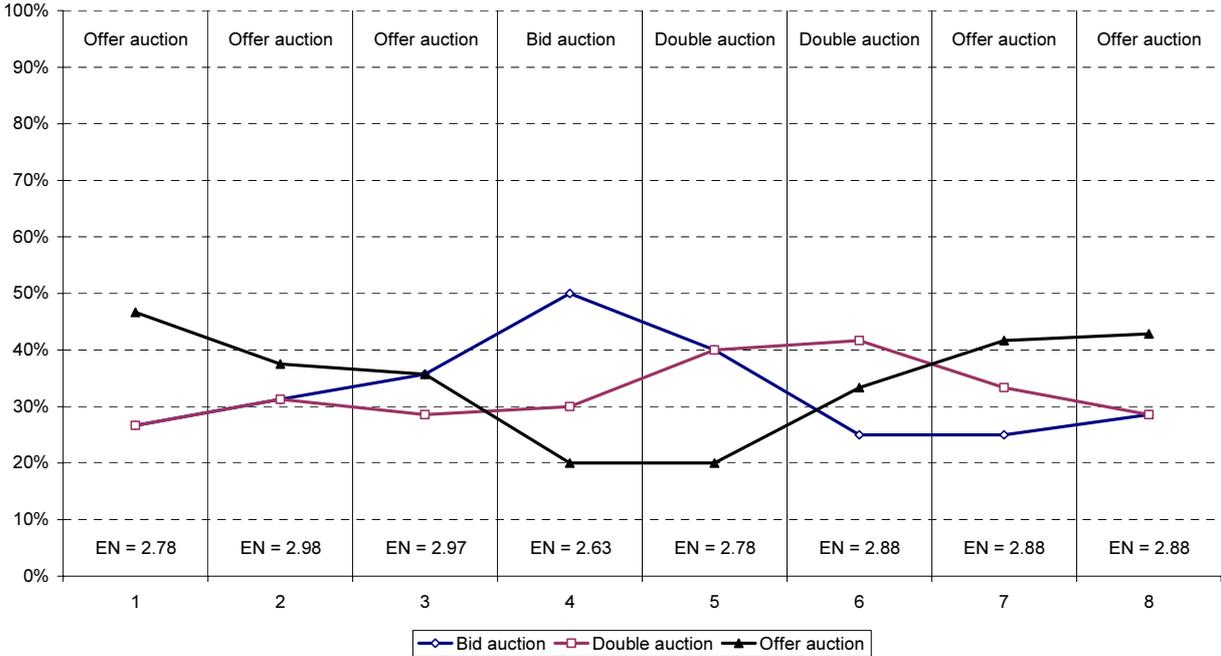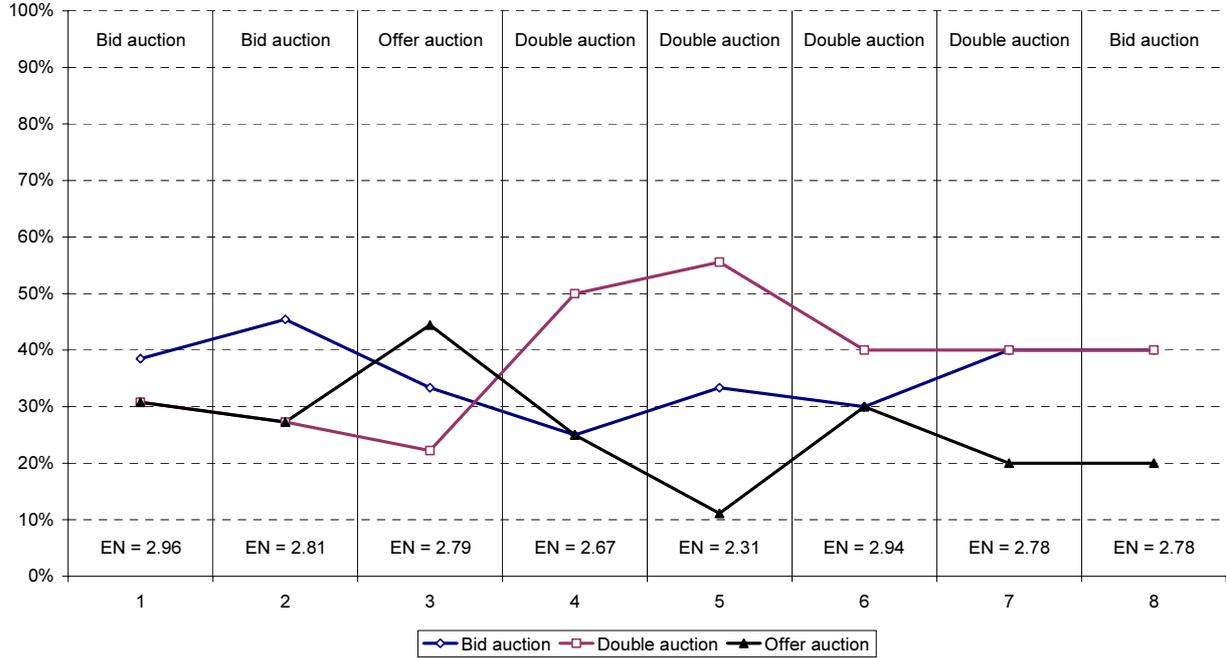*Figure 4*. **Vote shares, session AV1**

Figure 5. **Vote shares, session AV2**

The EN values listed above indicate that approval voting yields an increased number of effective auctions relative to the plurality rule benchmark. The following random-effects panel data model is used to evaluate whether this effect is statistically significant:

$$(1) \quad EN_{i,t} = \alpha + \beta_{Voting\ rule} D_{i,t}^{Voting\ rule} + \varepsilon_{i,t} + u_i$$

where subscript i denotes session (i $\in$ {AV1, PR1, AV2, PR2}), and t signifies election number within any one session (t $\in$ {1, 2, .. , 8}).

The dependent variable EN measures the effective number of auctions in an election, and α is a constant term. The binary variable $D^{Voting\ rule}$ measures the qualitative shifts of voting rules, and assumes the value 1 under approval voting. u_i is a random disturbance pertaining to the *i*th session. Both u_i and the classical error term $\varepsilon_{i,\,t}$ are assumed to be identically and independently distributed with zero mean and constant variance. The covariance between the two disturbance terms is supposed to be zero across both sessions and election rounds (Greene, 2000):

$$(2) \quad \varepsilon_{i,t} \sim iid\left(0, \sigma_\varepsilon^2\right)$$

(3) $u_i \sim iid\left(0, \sigma_u^2\right)$

(4) $E[\varepsilon_{i,t}u_j] = 0, \forall i \, \forall t \, \forall j$

Table III contains the regression estimates. The principal result is that substituting approval voting for plurality rule causes a statistically significant increase in the number of effective auctions. The point estimate of the number of effective auctions under approval voting is 2.8 as compared to 2.27 when plurality rule applies.

Table III. **Estimated parameters for the model** $EN_{i,t} = \alpha + \beta_{Voting\,rule}D_{i,t}^{Voting\,rule} + \varepsilon_{i,t} + u_i$

Parameter	Estimate	t-ratio	P-value[*]
α	2.269	14.517	0.0000
$\beta_{Voting\,rule}$	0.532	2.405	0.0081
Mean value of EN:	2.55	Standard deviation of EN:	0.47
Number of observations:	32	R^2:	0.33

[*] The P-value for α ($\beta_{Voting\,rule}$) is the value for a two-tailed (one-tailed) test of the hypothesis that the parameter equals zero.

Result 1:

Plurality rule induces a Duverger effect in the sense that just two of the three alternatives – the bid and offer auction – win 15 of the 16 laboratory elections. When pooling across the plurality rule elections, the double auction receives 15% of the total vote only. Under approval voting each auction wins approximately one third of the elections, and the vote share of each auction is in the region of 33%. Accordingly, the number of effective auctions is comparatively higher under approval voting. The difference in the number of effective auctions across voting rules is statistically significant.

3.2. Voting behavior and trader type

The number of votes cast for each auction type during the plurality rule sessions by buyers and sellers is depicted in Table VII. Each buyer and seller casts eight ballots during a session.

After pooling across sessions, the buyers' first choice is the bid auction, attracting 37 ballots, the equivalent of 58.73% of the buyers' votes. This auction type receives the highest vote share amongst buyers in both sessions. The double and offer auction obtains around one fifth of the total buyer vote.

On the other hand, the sellers appear to vote overwhelmingly for the offer auction, which receives 65.63% of their aggregate vote. Again the double auction comes last, polling just a single vote during

session PR1. In sum, plurality rule buyers' and sellers' first choice is the auction type that restricts the ability to initiate price quotes to their own side of the market.

Table IV. **Plurality-rule voting behavior, by trader type**

Session	Buyers			Sellers		
	Bid auction	Double auction	Offer auction	Bid auction	Double auction	Offer auction
	# (%)	# (%)	# (%)	# (%)	# (%)	# (%)
PR1	20 (64.52)	4 (12.90)	7 (22.58)	8 (25.00)	1 (3.13)	23 (71.88)
PR2	17 (53.13)	8 (25.00)	7 (21.88)	7 (21.88)	6 (18.75)	19 (59.38)
Total	37 (58.73)	12 (19.05)	14 (22.22)	15 (23.44)	7 (10.94)	42 (65.63)

Next, consider the degree of similarity of individual voting behavior. This may be measured by means of Kendall's W (Kendall's coefficient of concordance). Kendall's W is defined on the unit interval, with W = 0 (1) signifying perfect disagreement (agreement) (see, for instance, Hollander and Wolfe, 1999).

Table V depicts the individual votes cast by buyers during the plurality rule elections. Including abstention, there are four feasible voting options. In each session there are four participating buyers; the third buyer in session PR1 is identified as PR1-3, etc.

Buyer PR1-1 consistently votes for the bid auction. Buyers PR1-2 and PR2-3 cast bid-auction votes in seven of the eight elections in which they participate, whereas three buyers cast between three and five votes for the offer auction. Nevertheless, the bid auction receives 37 of the total 64 ballots and the point estimate of Kendall's W is 0.578. The low probability value implies that the null hypothesis of no agreement can safely be rejected. Hence, plurality-rule buyers appear to cast votes in a fairly consistent manner.

Table V. **Plurality rule: Individual voting behavior, buyers**

Buyer ID	Blank	Bid	Double	Offer
PR1-1	0	8	0	0
PR1-2	0	7	1	0
PR1-3	1	2	1	4
PR1-4	0	3	2	3
PR2-1	0	2	1	5
PR2-2	0	4	3	1
PR2-3	0	7	0	1
PR2-4	0	4	4	0
Total	1	37	12	14
Kendall's coefficient of concordance: 0.578		P-value: 0.0014		

As can be seen in Table VI, a similar pattern of consistent agreement is revealed by the sellers' voting behavior. Three sellers – PR1-3, PR1-4 and PR2-1 - cast votes for the offer auction only. Accordingly, the estimated coefficient of concordance is 0.629 and highly significant.

Table VI. **Plurality rule: Individual voting behavior, sellers**

Seller ID	Blank	Bid	Double	Offer
PR1-1	0	6	1	1
PR1-2	0	2	0	6
PR1-3	0	0	0	8
PR1-4	0	0	0	8
PR2-1	0	0	0	8
PR2-2	0	4	2	2
PR2-3	0	2	1	5
PR2-4	0	1	3	4
Total	0	15	7	42
Kendall's coefficient of concordance: 0.629		P-value: 0.0004		

A summary of approval votes is given in Table VII. The total number of votes cast by buyers and sellers in each case exceeds 64 due to double and triple voting. On average, the double auction constitutes the sellers' preferred auction type, while the bid auction obtains the greatest vote share amongst buyers.

Table VII. **Approval-voting behavior, by trader type**

Session	Buyers			Sellers		
	Bid auction	Double auction	Offer auction	Bid auction	Double auction	Offer auction
	# (%)	# (%)	# (%)	# (%)	# (%)	# (%)
AV1	24 (50.00)	11 (22.92)	13 (27.08)	9 (16.36)	22 (40.00)	24 (43.64)
AV2	10 (25.00)	12 (30.00)	18 (45.00)	19 (47.50)	18 (45.00)	3 (7.50)
Total	34 (38.63)	23 (26.14)	31 (35.22)	28 (29.47)	40 (42.11)	27 (28.42)

The individual voting behavior of approval voting buyers is summarized in Table VIII. Five of the eight buyers cast vote ballots that approve of more than just one trading institution. Approximately 33% of the buyers' votes are cast for two or all three trading institutions. The point estimate of the coefficient of concordance in this case is 0.217, implying a weak degree of agreement. However, the p-value of 0.0819 suggests that this degree of conformity is only weakly statistically significant.

Table VIII. **Approval voting: Individual voting behavior, buyers**

Buyer ID	Blank	Bid	Double	Offer	Bid + Double	Bid + Offer	Double + Offer
AV1-1	0	1	1	3	1	2	0
AV1-2	0	8	0	0	0	0	0
AV1-3	0	1	3	0	3	0	1
AV1-4	2[*]	1	0	0	0	5	0
AV2-1	0	0	3	5	0	0	0
AV2-2	1	0	2	5	0	0	0
AV2-3	0	0	1	2	2	2	1
AV2-4	0	2	0	2	3	1	0
Total	3	13	10	17	9	10	2
Kendall's coefficient of concordance: 0.217				P-value: 0.0819			

[*] These vote ballots approved of all three auctions.

The summary of individual vote ballots cast by sellers in the approval-voting treatment is shown in Table VIII. Here, seven of the eight sellers choose to approve of more than just one auction in at least one election. Moreover, exactly 50% of the votes are cast for two, or all three, auction types. A noticeable majority of the double votes approve of the double auction. Nevertheless, in this case the estimated coefficient of concordance is rather low at 0.153, whereas the associated probability value is as high as 0.2937. As a result, there is no significant consensus as regards the sellers' individual voting behavior.

Table VIII. **Approval voting: Individual voting behavior, sellers**

Seller ID	Blank	Bid	Double	Offer	Bid + Double	Bid + Offer	Double + Offer
AV1-1	1[*]	0	1	1	0	0	5
AV1-2	0	0	2	0	0	1	5
AV1-3	0	1	0	0	2	4	1
AV1-4	0	0	2	3	0	0	3
AV2-1	1	4	0	1	2	0	0
AV2-2	1	2	3	2	0	0	0
AV2-3	0	0	3	0	5	0	0
AV2-4	0	3	2	0	3	0	0
Total	3	10	13	7	12	5	14

Kendall's coefficient of concordance: 0.153   P-value: 0.2937

[*] This vote ballot approved of all three auctions.

Result 2:

In the plurality-rule case, buyers (sellers) first and foremost vote for the bid (offer) auction. Further-more, the voting behavior of the individual buyers and seller shows a high degree of concordance. In the approval-voting sessions the voting behavior is distinctly heterogeneous and not significantly con-cordant. Also, a majority of both buyers and sellers cast votes that approve of more than just one insti-tutional candidate. In total, 52 (41%) of the approval voting ballots are cast for two auction types, 37 (73%) of which choose the double auction as well as either the bid or the offer auction.
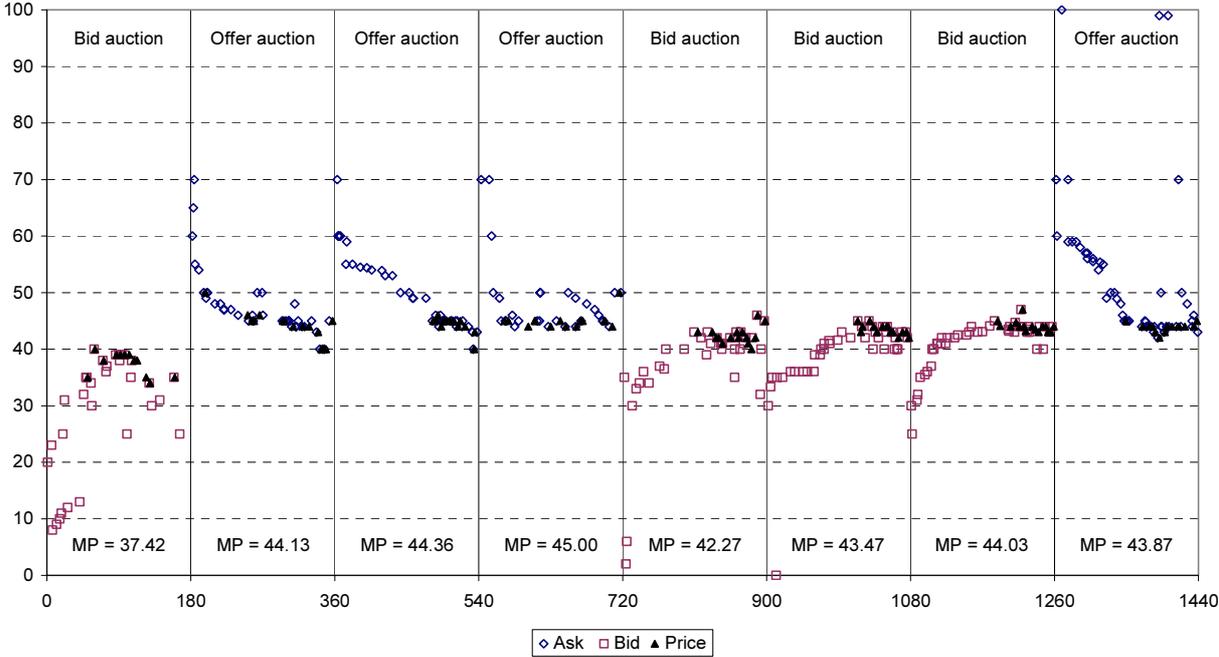
3.3. Auction prices

The following discussion is divided into two parts. First, chronological sequences of asks, bids and confirmed contract prices are presented graphically, by session. Second, is an econometric analysis of the prices pooled from the four sessions, the focal purpose of which is to evaluate the separate effects of changes in auction types on the price-formation process.

Figure 6 displays the time series of asks, bids and prices during the plurality rule session PR1. The offers to buy and sell as well as confirmed prices are measured in experimental dollars and plotted against time in seconds. Solid vertical lines delineate the eight trading rounds, each of which lasts 180 seconds. The employed auction types are listed at top of the figure. At the bottom of the figure the calculated mean price (MP) is shown for each trading round. Recall that prices by experimental design need to be above 30 (below 70) dollars for trading to be profitable for sellers (buyers), whereas asks and bids are confined by the utilized software to the interval (0,100) experimental dollars.

Bid-auction rules govern the first round of trading in this session, and the initial bids are around 10 experimental dollars. The bids then increase over time, and confirmed prices in the vicinity of 40 experimental dollars starts to be registered during the middle phase of the trading period.

The offer auction won the second election during session PR1 and was consequently implemented during the second trading round. The change of trading rules seemingly implies a reversal of the preceding trading process whereby asks are posted way above the prices agreed to during the first round. In particular, competition amongst the sellers results in successively lower asks, some of which are accepted towards the end of the trading round. Furthermore, the change in trading rules induces markedly higher prices, which is mirrored in the mean price increase from 37.42 to 44.13 experimental dollars. Conversely, prices fall when the bid auction replaces offer auction rules in the fifth round.

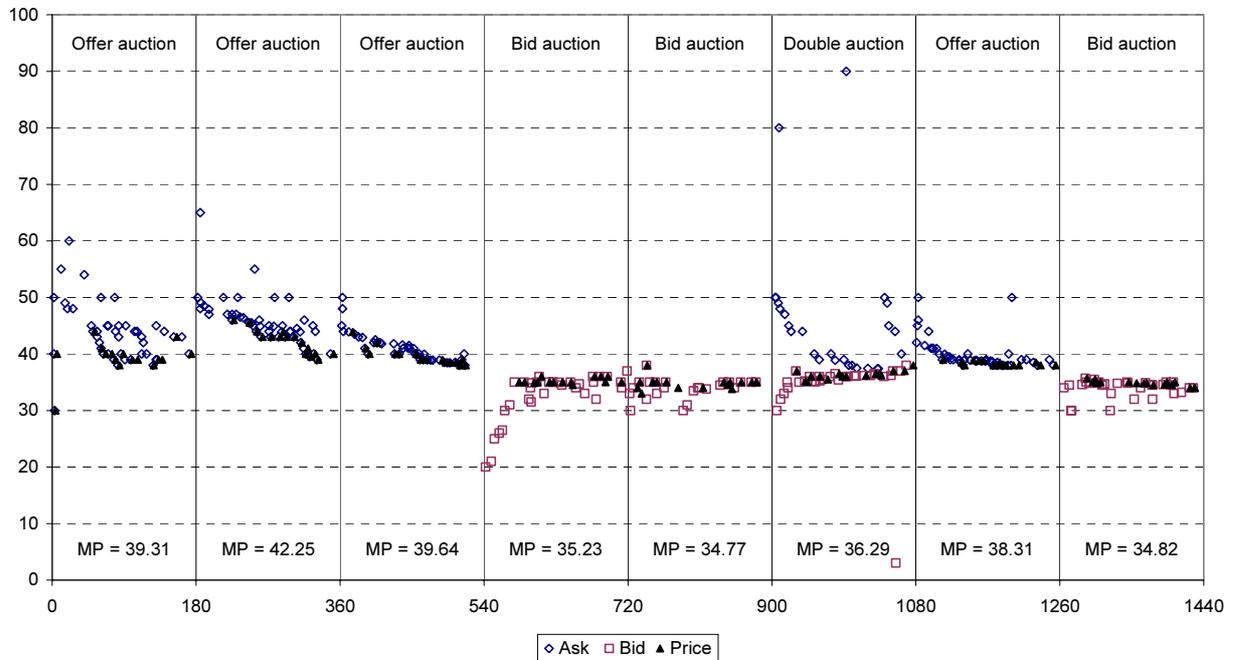*Figure 6*. **Asks, bids and prices, session PR1**

Analogous time series from the second plurality rule session PR2 are depicted in Figure 7. A general impression is that, again, buyers (sellers) try during bid (offer) auction trading to signal low (high) prices, but intra-type competition amongst buyers (sellers) seems to increase (decrease) bids (asks).

The bid auction is implemented in the fourth trading round, hence the price level declines relative to the preceding offer auction prices. The change to double auction and offer auction rules in the

19

subsequent rounds yields higher prices. However, bid-auction trading in the last round leads to another decrease in the mean price.

Figure 7. **Asks, bids and prices, session PR2**

Figures 8 and 9 display time series of asks, bids and prices recorded during the approval-voting sessions. The main characteristic of session AV1 is relatively stable prices across trading rounds. During the initial three rounds of offer auction trading, sellers try to trade at high prices but eventually settle for prices around 60 experimental dollars. Asks and bids announced during subsequent rounds do not deviate markedly from this level, and range between 70 and 50 experimental dollars.

Figure 9 reveals a more erratic trading pattern during session AV2. Prices fluctuate distinctly during the first bid auction rounds, but appear to stabilize at approximately 50 experimental dollars, the midpoint of the feasible price range. There is a discernable difference in the behavior of buyers and sellers throughout this laboratory session. When allowed to initiate prices, buyers persist in submitting bids noticeably below this level. In contrast, sellers' asks in general deviate less from the established price level, and do not vary to the same extent as the observed bids.
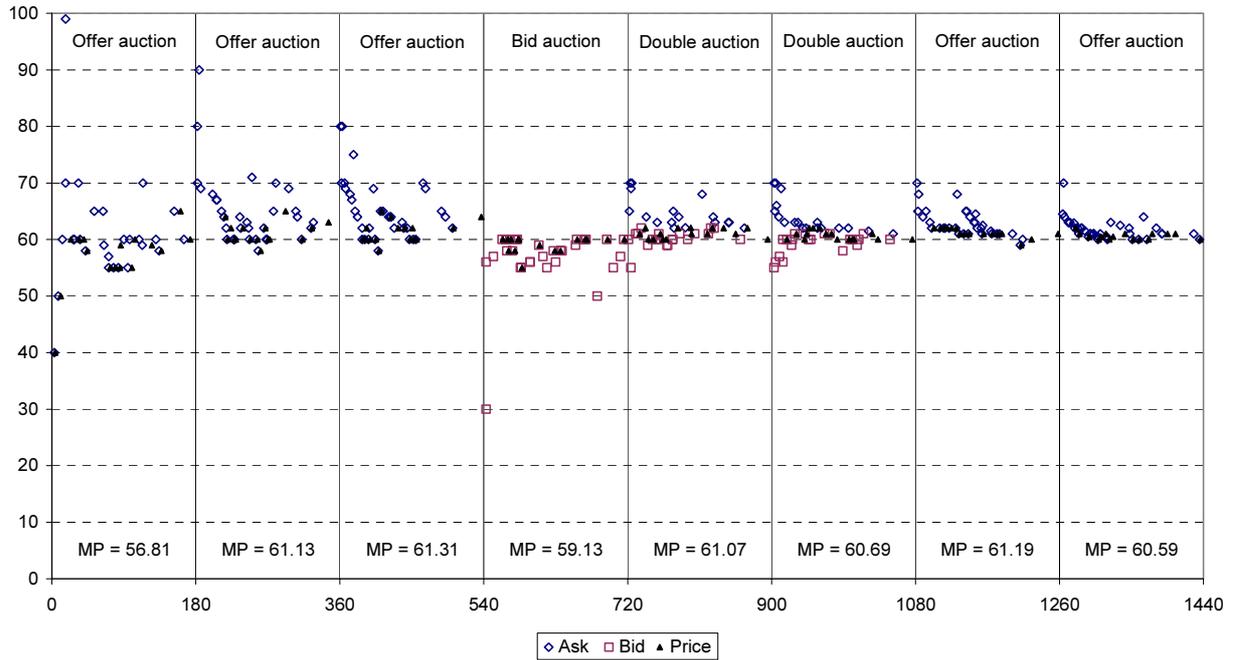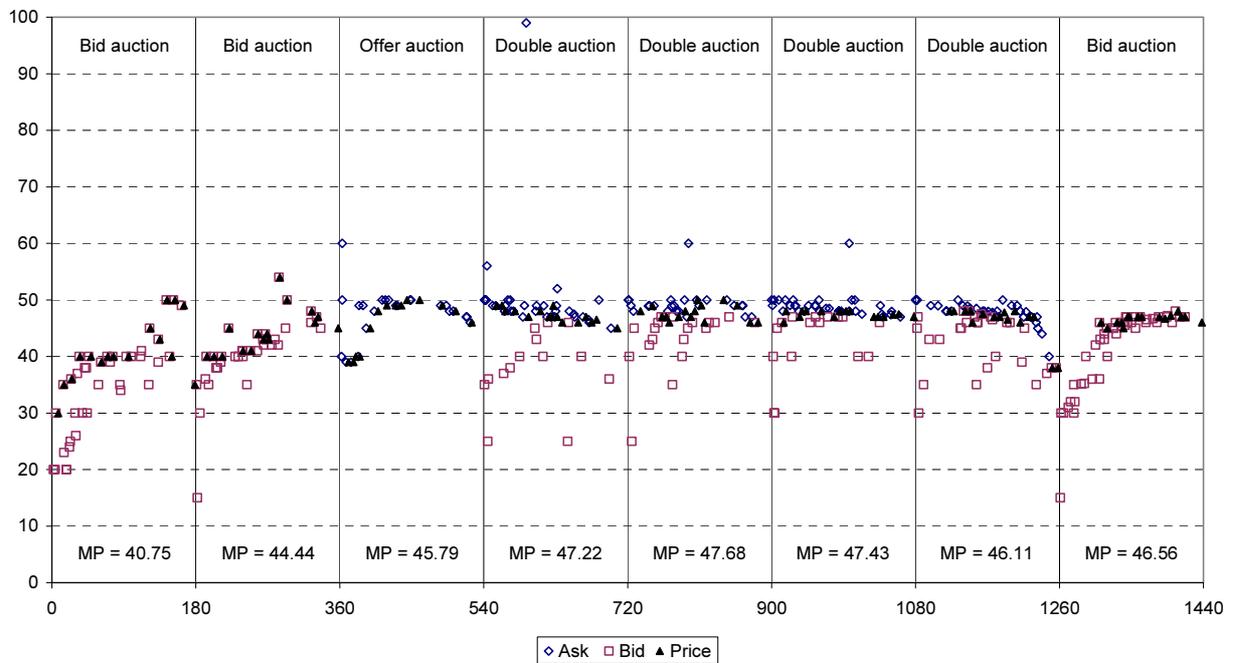
Figure 8. Asks, bids and prices, session AV1

Figure 9. Asks, bids and prices, session AV2

On the whole, the graphical depiction of confirmed prices indicates that auction rules exert a visible degree of influence on the level of prices. Moreover, the contracts formed during the initial trading rounds seem to anchor the price formation process during subsequent rounds by means of establishing an "acceptable" price level. However, the preceding figures indicate that this level varies noticeably across the four laboratory sessions. There is also evidence of time effects in that mean prices in the first trading rounds appear to be consistently below prices agreed to during ensuing trading rounds.

The objective of the following econometric analysis of auction prices is to disentangle the effect of sessions and trading round sequence from the impact of alternations in trading rules. The following fixed-effects panel data model will be used to evaluate these separate effects on individual contract prices. It is estimated with a first-order autocorrelated error structure to correct for interdependencies between price observations within sessions.

$$(5)\ P_{i,t(i)} = \alpha_i + \sum_{j=2}^{8} \beta_j D_j^{Trading\ round} + \beta_{Bid\ auction} D_{i,t(i)}^{Bid\ auction} + \beta_{Offer\ auction} D_{i,t(i)}^{Offer\ auction} + \varepsilon_{i,t(i)}$$

$$(6)\ \varepsilon_{i,t(i)} = \rho \varepsilon_{i,t(i)-1} + \eta_{i,t(i)}$$

$$(7)\ \varepsilon_{i,t(i)} \sim iid\left(0, \sigma_\varepsilon^2\right)$$

$$(8)\ \eta_{i,t(i)} \sim iid\left(0, \sigma_\eta^2\right)$$

Each variable and disturbance term is indexed relative to session $i \in \{AV1, PR1, AV2, PR2\}$ and observation number $t(i)$. The latter is session dependent because the number of prices varies across sessions. In particular, $\{t(AV1), t(PR1), t(AV2), t(PR2)\} = \{128, 117, 126, 127\}$[6]. Hence, the dependent variable $P_{i,\ t(i)}$ is the $t(i)$-th contract price in session i. In equation (5) α_i is a session specific constant term, and $D_j^{Trading\ round}$ is a binary variable that takes the value 1 during trading round j, $j \in \{2, 3, .. , 8\}$. The binary variables $D^{Bid\ auction}$ and $D^{Offer\ auction}$ equal 1 whenever trading is governed by bid-auction and offer-auction rules, respectively.

Table IX lists the regression results. The estimates of the session-specific constants at the top of the table confirm the visual impression of marked price differences across laboratory sessions. The first R^2

---

[6] The maximum number of price observations within any trading round is 16. Thus, at most, 128 prices may be formed during a laboratory session.

statistic at the bottom of the table shows that the model as fitted explains 83% of the variability in prices, but session effects alone explain 80% of the price fluctuation[7]. Also, the data support statistically significant time effects. Relative to the first trading round, prices are generally higher in six of the seven subsequent trading periods, but there is a discernible price decrease from the fifth trading period onwards.

After controlling for session and time effects, the regression estimates show that bid (offer) trading rules induces lower (higher) prices relative to the double auction. The point estimate in the bid (offer) auction case is -1.53 (1.89) experimental dollars. These institutional effects are statistically significant.

Table IX. **Estimated parameters for the model**

$$P_{i,t(i)} = \alpha_i + \sum_{j=2}^{8} \beta_j D_j^{Trading\ round} + \beta_{Bid\ auction} D_{i,t(i)}^{Bid\ auction} + \beta_{Offer\ auction} D_{i,t(i)}^{Offer\ auction} + \varepsilon_{i,t(i)}$$

1. Session effects

Parameter	α_{AV1}	α_{PR1}	α_{AV2}	α_{PR2}
Estimate	57.83	41.34	44.60	35.60
P-value	0.0000	0.0000	0.0000	0.0000

2. Trading round (time) effects

Parameter	β_2	β_3	β_4	β_5	β_6	β_7	β_8
Estimate	2.74	0.80	2.12	2.37	2.22	1.87	1.70
P-value	0.0000	0.2596	0.0030	0.0028	0.0101	0.0070	0.0130

3. Auction type effects

Parameter	$\beta_{Bid\ auction}$	$\beta_{Offer\ auction}$
Estimate	-1.53	1.89
P-value	0.0118	0.0148

Number of observations:		494	Estimated autocorrelation of e:	0.519
Mean value of P (experimental dollars):		46.80	Standard deviation of P:	8.98
R^2:		0.83	R^2 (session effects only):	0.80

Result 3:

Auction prices vary markedly between sessions and slightly over the course of sessions. When controlling for these effects, the regression results reveal that bid (offer) auction prices are lower

---

[7] The marked price level differentials across sessions are consistent with the variance in buyer and seller mean payoffs depicted in Table I.

(higher) than double auction prices. The magnitude of these differences is approximately equal as well as highly statistically significant.

4. Discussion

The plurality-rule election results corroborate Duverger's law, which predicts that plurality rule tends to reduce a three-candidate race to just two effective candidates. Phrased in economic terms, Duvergerian effects may be interpreted as barriers to entry against a third party (Myerson, 1995). The laboratory data strongly suggest that plurality-rule voters choose by ballot to shut out the double auction. Highly polarized laboratory electorates drive these electoral results. A strict majority of buyers' (sellers') votes are cast for the bid (offer) auction. Hence, the voting behavior induced by plurality rule reveals that both trader types manifestly prefer to trade on an auction that restricts the ability to initiate prices to their own side of the market.

In contrast, close three-way races characterize the institutional competition that takes place under approval voting. The number of effective auctions is consistently in the vicinity of three, thereby rendering all auctions viable electoral candidates. Therefore, the main implication of approval voting is the improved electoral standing of the double auction. This change is partly explained by a majority of voters taking advantage of the ability to express both first and second choices: 41% of the approval-voting ballots is cast for two institutional alternatives, 73% of which approves of the double auction.

The reported experiment is heuristic in the sense that economic theory does not generate precise predictions regarding the institutional preferences of buyers and sellers. Instead, a range of conjectures appears plausible: *A priori*, buyers (sellers) may strictly prefer the offer (bid) auction because competitive pressures affecting the other side of the market may tend to generate advantageous price levels. A contrary second conjecture is equally likely if buyers (sellers) believe that bid (offer) auction rules will allow them to collude in dictating beneficial terms of trade in the form of low (high) prices. Certainly, indifference will be a preferred option provided voters do not perceive that prices are likely to differ markedly across auction types, the implication of which would be a large number of blank votes. The last supposition is clearly refuted by the laboratory evidence, whereas the plurality-rule ballots are consistent with the second conjecture. In contrast, approval voting induces individual voting behavior that to a larger extent reflects both competitive pressure and tacit collusion speculations, but primarily mirror distinctly heterogeneous preferences.

Both plurality-rule and approval-voting elections take place in an incomplete information setting, in the sense that the payoff implications of choosing any auction type is neither exogenous nor common knowledge. Also, within any one session the participants' opportunity to assess the empirical properties of the three alternative auctions is limited, primarily because the complete set of auctions is not necessarily implemented.

However, the price data from the trading stage of the experiment facilitates an *ex post* assessment of the empirical properties of the alternative trading institutions. This appraisal is based upon a fairly balanced sample consisting of prices formed during eleven bid-auction, seven double-auction and fourteen offer-auction trading rounds[8]. After controlling for session and time effects, the evidence shows that bid-auction prices are significantly lower than double-auction prices, which again tend to be significantly lower than offer-auction prices. *Ceteris paribus*, this ordering of prices rationalizes buyers' (sellers') preferences for the bid (offer auction) as revealed during the plurality rule sessions. In addition, it implies that the double auction amounts to a rational second choice for both trader types. Moreover, the majority of buyers' and sellers' double votes in the approval voting sessions approve of the double auction.

In each trading round the number of asks and/or bids outweighs the amount of confirmed contract prices. The graphical depictions of unaccepted price offers during trading rounds governed by bid (offer) auction rules suggest that competitive pressures are operating amongst buyers (sellers) in the form of increasing (decreasing) bids (asks). Similar effects were anticipated by Smith (1964) to favor the trader type prohibited from making price quotes: Offer-auction rules could yield competition amongst sellers for trading opportunities and thus result in relatively low prices, whereas in the bid auction the competitive pressure would affect the buyers and thereby imply increasing bids to buy as well as relatively high prices. Using six laboratory sessions and a symmetric market environment with an equal number of buyers and sellers, Smith found support for his *a priori* hypothesis that bid-auction prices tend to be greater than double-auction prices, which again tend to be greater than offer-auction prices.

---

[8] The adopted design for the trading stage of the experiment - horizontal demand and supply schedules - has been labeled a box design, and contrasts with the conventional choice in experimental economics of ordered demand (supply) schedules that decrease (increase) in price. Price formation within a box design over the course of subsequent trading rounds avoids being disciplined by a (narrow) competitive price (range). Consequently, the box design is particularly suited to laboratory analyses of how price formation may vary with alternative trading rules (see, for instance, Smith and Williams, 1990).

The ranking of auction prices ascertained in this paper amounts to a reversal of Smith's findings. One reading of the present price ordering is that competitive effects, as reflected in chronological sequences of unaccepted asks and/or bids, are offset by aggressive price signaling: The level at which buyers start increasing bids tends to be well below the "acceptable" price level, and vice versa with regard to sellers' asks. Hence, tacit collusion amongst buyers and sellers appears to dominate the competitive pressures that are simultaneously affecting their bargaining behavior. The difference between these results and Smith's conclusion may, in part, stem from dissimilar numbers of buyers and sellers. Smith employed either 20 or 28 traders as compared to eight in each of the sessions reported above, and perhaps tacit collusion is harder to sustain and competitive pressures become more paramount as the number of economic agents increases[9].

5. Conclusion

This paper has considered institutional competition within a collective decision-making framework in which traders' votes in laboratory referenda are aggregated in order to determine common trading rules. Specifically, the study has analyzed traders' choices between bid, double and offer auctions over the course of eight elections. In each election, the electorate consisted of four buyers and four sellers, and the purpose of the elections was to choose one of the auctions to govern a subsequent trading round. Two different vote-counting schemes were implemented: Plurality rule and approval voting. The former enabled each trader to vote for at most one auction, whereas the latter allowed for voting on none, one, two or all three auctions.

The key laboratory results can be summarized as follows. First, voting rules matter in the sense that plurality rule induces a Duverger effect by which the bid and offer auction emerge as the only viable auctions. Approval voting instead yields three effective auctions with each auction winning approximately one third of the elections as well as the aggregate vote. Second, in the plurality-rule sessions the buyers (sellers) vote predominantly for the bid (offer) auction. Approval-voting behavior is comparatively more heterogeneous. Also, a majority of voters in these sessions and nearly half of the approval-voting ballots approve of two institutional alternatives. Third, bid-auction prices are significantly lower than double-auction prices, which are similarly lower than offer-auction prices. In

---

[9] Moreover, Smith's experimental design induced descending (ascending) demand (supply) schedules in contrast to the inelastic market demand and supply employed in the experiment reported here. The core implication of this difference in experimental design is merely the width of the competitive equilibrium price range, which is smaller in Smith's experimental sessions.

sum, price formation varies across the three auction types, whereas the implementation of auctions is affected by the two voting mechanisms.

References

Bronfman, C., K. McCabe, D. Porter, S. Rassenti and V.L. Smith (1996): An experimental examination of the Walrasian *tâtonnement* mechanism, *RAND Journal of Economics* **27**, 681-699.

Brams, S. and J. Nagel (1991): Approval Voting in Practice, *Public Choice* **71**, 1-17.

Cox, G.W. (1997): *Making votes count. Strategic coordination in the world's electoral systems*, Cambridge University Press.

Davis, D.D. and C.A. Holt (1993): *Experimental economics*, Princeton University Press.

Duverger, M. (1967): *Political parties: Their organization and activity in the modern state*, Methauen and Company, London.

Forsythe, R., T. Rietz, R. Myerson and R. Weber (1996): An Experimental Study of Voting Rules and Polls in Three-Candidate Elections, *International Journal of Game Theory* **25**, 355-383.

Friedman, D. (1993): "The Double Auction Market Institution: A Survey", in D. Friedman and J. Rust (eds.): *The double auction market*, Addison-Wesley, Reading, 3-25.

Friedman, D. and S. Sunder (1994): *Experimental Methods*, Cambridge University Press.

Greene, W. (2000): *Econometric Analysis*, Prentice Hall International, Inc.

Hollander, M. and D.A. Wolfe (1999): *Nonparametric Statistical Methods*, John Wiley & Sons Inc., New York.

Holt, C.A. (1995): "Industrial Organization: A Survey of Laboratory Research", in J. Kagel and A. Roth (eds.), *Handbook of Experimental Economics*, Princeton University Press, 349-443.

Ketcham, J., V.L. Smith and A.W. Williams (1984): A Comparison of Posted-Offer and Double-Auction Pricing Institutions, *Review of Economic Studies* **51**, 595-614.

Levin, J. and B. Nalebuff (1995): An Introduction to Vote-Counting Schemes, *Journal of Economic Perspectives* **9**, 3-26.

Mueller, D.C. (1989): *Public choice II*, Cambridge University Press.

Myerson, R. (1995): Analysis of Democratic Institutions: Structure, Conduct and Performance, *Journal of Economic Perspectives* **9**, 77-89.

Plott, C.R. (1988): "An updated review of industrial organization: Applications of experimental methods", in Schmalensee and Willig (eds.): *Handbook of Industrial Organization 2*, Elsevier Science Publishing, 1109-1176.

Plott, C.R. and V.L. Smith (1978): An Experimental Examination of Two Exchange Institutions, *Review of Economic Studies* **45**, 113-153.

Rapoport, A., D. Felsenthal and Z. Maoz (1991): "Sincere versus Strategic Voting Behavior in Small Groups", in T. Palfrey (ed.), *Laboratory Research in Political Economy*, The University of Michigan Press, 201-235.

Smith, V.L. (1964): Effect of Market Organization on Competitive Equilibrium, *Quarterly Journal of Economics* **78**, 181-201.

Smith, V.L. and A.W. Williams (1990): "The Boundaries of Competitive Price Theory: Convergence, Expectations, and Transactions Costs", in L. Green and J. Kagel (eds.), *Advances in Behavioral Economics, Vol. 2*, Norwood, New Jersey, 31-53.

Walker, J.M. and A.W. Williams (1988): Market Behavior in Bid, Offer, and Double Auctions. A Reexamination, *Journal of Economic Behavior and Organization* **9**, 301-314.

Weber, R.J. (1995): Approval voting, *Journal of Economic Perspectives* **9**, 39-49.

Experimental instructions

A.1. General

You are about to participate in a voting and trading experiment where you will have an opportunity to earn money. The experiment is estimated to last approximately 2 hours and 30 minutes. The Norwegian Research Council has provided funding for this experiment. The structure of the experiment is as follows:

First, you participate in an election in which you cast a vote. The objective of this voting stage is to choose a trading institution. The voting rules and the alternative trading institutions are described below.

Second, you trade on the chosen trading institution. Four of the participants in this experiment will act as buyers during this trading stage, whereas four participants are going to be sellers. Details of the trading procedures are outlined below.

This basic structure will be repeated eight times: You are going to take part in eight elections and eight subsequent trading stages.

The amount of money that you make during the trading stages depends upon the market prices. The money that you earn is tax-free and will be paid to you in private immediately after the experiment. This experimental session will be conducted in the following manner:

1. <u>Read these instructions carefully</u>. Answer the test questions in writing. Try to finish reading within 10 minutes from now. If you have any questions, please be so kind as to raise your hand and the experimenter will assist you. *You are not allowed to speak to any of the other participants during this experiment.*

2. <u>Voting test</u>: When everyone has finished reading the instructions you will practice your role as a voter in a test election.

3. <u>Trading test</u>: Then you are going to be introduced to the computer software that will be used during the trading stages. You will practice your role as a trader on each of the three alternative trading institutions. No money is earned during this part of the experiment.

4. The experimental elections and trading begin.

Specific instructions for plurality-rule sessions PR1 and PR2:

A.2. Voting: Alternatives and voting rules

In each election there will be three alternative trading institutions to choose amongst (details on these trading institutions are given in section A.3. below). Listed alphabetically, the alternatives are as follows:

Ask auction

Ask and bid auction

Bid auction

In an election you can vote for one of these alternatives ("Ask auction" <u>or</u> "Ask and bid auction" <u>or</u> "Bid auction"). You may also abstain, that is, cast a blank vote. Which alternative you vote for will not be revealed to the other voters. The votes are going to be counted in public and the complete election results will be listed on the blackboard.

The chosen trading institution is the one that is chosen by the largest number of voters. In the event of ties (2 or 3 trading institutions get an equal number of votes), the winner is determined by the throw of a fair die (each alternative has an equal probability of winning).

<u>Example 1</u>: Suppose 8 persons (represented by the numbers 1 - 8) vote in the following way (the sign √ denotes a vote. Absence of such a sign indicates a blank vote):

Alternatives	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Number of votes*
Ask auction	√					√	√		3
Ask and bid auction		√	√						2
Bid auction				√				√	2

In this example the "Ask auction" wins the election with 3 votes. Person 5 cast a blank vote.

<u>Example 2</u>: Now consider this voting outcome:

Alternatives	1	2	3	4	5	6	7	8	Number of votes
Ask auction			√		√			√	3
Ask and bid auction		√				√			2
Bid auction	√			√			√		3

In Example 2 both the "Bid auction" and the "Ask auction" gets 3 votes each. The election is then decided by the throw of a die. This means that either the "Ask auction" or the "Bid auction" wins the election with probability 0.5.

<u>Question 1</u>:

Consider the hypothetical election results listed in the following table. Count the number of votes.

Alternatives	1	2	3	4	5	6	7	8	Number of votes
Ask auction			√	√					
Ask and bid auction	√	√							
Bid auction					√		√		

Which trading institution is chosen?

Specific instructions for approval-voting sessions AV1 and AV2:

A.2. Voting: Alternatives and voting rules

In each election there will be three alternative trading institutions to choose amongst (details on these trading institutions are given in section A.3. below). Listed alphabetically, the alternatives are as follows:

Ask auction

Ask and bid auction

Bid auction

In an election you can vote for one, two or all three of these alternatives ("Ask auction" and/or "Ask and bid auction" and/or "Bid auction"). You may also abstain, that is, cast a blank vote. Which alternative(s) you vote for will not be revealed to the other voters. The votes are going to be counted in public and the complete election results will be listed on the blackboard.

The chosen trading institution is the one that gets the largest number of votes. In the event of ties (2 or 3 trading institutions get an equal number of votes), the winner is determined by the throw of a fair die (each alternative has an equal probability of winning).

Example 1:

Suppose 8 persons (represented by the numbers 1 - 8) vote in the following way (the sign √ denotes a vote. Absence of such a sign indicates a blank vote):

Alternatives	1	2	3	4	5	6	7	8	Number of votes
Ask auction	√		√			√	√	√	5
Ask and bid auction	√	√	√						3
Bid auction			√	√		√			3

In this example person 1 votes for both the "Ask auction" and the "Ask and bid auction". Person 2 votes for the "Ask and bid auction" whereas person 3 votes for all three trading institutions. In terms of the final result, voting for all three trading institutions is equivalent to abstaining from voting, which is what person 5 in this example does.

Counting all the votes, you see that the "Ask auction" wins the election with 5 votes in total.

Example 2:

Now consider this voting outcome:

Alternatives	1	2	3	4	5	6	7	8	Number of votes
Ask auction	√					√	√		3
Ask and bid auction		√	√				√	√	4
Bid auction	√			√	√			√	4

In this example both the "Ask and bid auction" and the "Bid auction" gets 4 votes each. The election is then decided by the throw of a die. This means that either the "Ask and bid auction" or the "Bid auction" wins the election with probability 0.5.

Question 1:

Consider the hypothetical election results listed in the following table. Count the number of votes.

Alternatives	1	2	3	4	5	6	7	8	Number of votes
Ask auction			√	√	√			√	
Ask and bid auction	√	√			√		√		
Bid auction	√		√		√		√		

Which trading institution is chosen?

Specific instructions for buyers (all sessions):

A.3. Trading

A.3.1. Trader role

In each of the 8 trading stages of this experiment you are going to be a <u>buyer</u> of a fictitious good on a computerized market. Each trading stage lasts <u>180 seconds</u>. Apart from you there are 3 other buyers and 4 sellers on this market.

Your "value" from buying units of the good in this experiment is shown numerically on your computer screen. You earn money by buying units at prices below your value. You can buy one unit at a time.

Example 3:

Your value associated with buying maximum 4 units of the good may look like this on your computer screen (but will assume different values during the experiment):

Value	Price	Quantity	Profit
550		1	
550		1	
550		1	
550		1	

Specifically, if you buy 1 unit of the good for a price equal to 200, your profit in this example becomes (550 - 200) = 350 and will be depicted on your computer screen in this manner:

Value	Price	Quantity	Profit
550	200	1	350
550		1	
550		1	
550		1	

If you buy 3 units of the good for prices equal to 300, 100 and 250, your profit can be calculated as follows: (550 - 300) + (550 - 100) + (550 - 250) = 1000. Note that buying at prices above 550 would be unprofitable. This is a graphical illustration of these three transactions:

Value	Price	Quantity	Profit
550	300	1	250
550	100	1	450
550	250	1	300
550		1	

Question 2:

Given the values shown in Example 3: What is your profit if you buy the first unit for a price equal to 300, the second unit for 150 and the third unit and the fourth unit at a price equal to 200?

A.3.2. Trading rules

How trading prices are determined depends on the trading institution. Here the trading rules that characterize each of the three alternative trading institutions are explained:

In the "Ask auction", the sellers can formulate offers to sell. An offer to sell is called an ask and specifies the price a seller wants for one unit of the good. As a buyer you can buy a unit by accepting an ask from a seller.

In the "Bid auction", the buyers can formulate offers to buy. An offer to buy is called a bid and specifies the price at which a buyer wants to buy a unit. As a buyer you get to buy a unit of the good if a seller accepts your bid.

> In the "Ask and bid auction", the sellers can specify asks and the buyers can specify bids. Thus, you can buy a unit of the good in two ways: Either a seller accepts a bid from you, or you accept an ask from a seller.

During the trading stages all asks, bids and prices (that is, accepted asks and/or bids) will be nominated in experimental dollars. At the end of the experiment the aggregated profit is converted to Norwegian kroner and paid to you in cash by the experimenter. In this experiment the conversion rate is 1:1, meaning that one experimental dollar equals one Norwegian krone[10].

Question 3:

Who (buyers and/or sellers) suggest/propose and who accept/determine the level of prices in the

- Ask auction?

- Ask and bid auction?

- Bid auction?

Final remarks: This has been a preliminary introduction to the trading institutions only. Afterwards you will practice how to trade at your own pace by means of a computerized learning scheme. Note that in the computer program, "trading period" means trading stage. Also, "total earnings" will be shown on your computer screen, but will be zero: Instead the experimenter keeps track of your aggregate earnings.

Please raise your hand if you have any questions. Otherwise please wait until the experiment continues.

---

[10] The instructions for the sessions at the University of Nottingham contained this information about conversion rates: "At the end of the experiment the aggregated profit is converted to pounds and paid to you in cash by the experimenter. In this experiment the conversion rate is 1:15, meaning that 100 experimental dollars equals £ 6.67."

Specific instructions for sellers (all sessions):

A.3. Trading

A.3.1. Trader role

In each of the 8 trading stages of this experiment you are going to be a <u>seller</u> of a fictitious good on a computerized market. Each trading stage lasts <u>180 seconds</u>. Apart from you there are 3 other sellers and 4 buyers on this market.

Your "cost" of selling this good is shown numerically on your computer screen. You earn money by selling units at prices above your cost. You can sell one unit at a time.

<u>Example 3</u>:

Your cost associated with selling maximum 4 units of the good may look like this on your computer screen (but will assume different values during the experiment):

Price	Cost	Quantity	Profit
	550	1	
	550	1	
	550	1	
	550	1	

Specifically, if you sell 1 unit of the good for a price equal to 750, your profit in this example becomes (750 - 550) = 200 and will be depicted on your computer screen in this manner:

Price	Cost	Quantity	Profit
750	550	1	200
	550	1	
	550	1	
	550	1	

If you sell 3 units of the good for prices equal to 850, 600 and 800, your profit can be calculated as follows: (850 - 550) + (600 - 550) + (800 - 550) = 700. Note that selling for prices below 550 would be unprofitable. This is a graphical illustration of these three transactions:

Price	Cost	Quantity	Profit
850	550	1	300
600	550	1	150
800	550	1	250
	550	1	

Question 2:

Given the costs shown in Example 3: What is your profit if you sell the first unit for a price equal to 750, the second unit for 700 and the third unit and the fourth unit at a price equal to 900?

A.3.2. Trading rules

How trading prices are determined depends on the trading institution. Here the trading rules that characterize each of the three alternative trading institutions are explained:

In the "Ask auction", the sellers can formulate offers to sell. An offer to sell is called an ask and specifies the price a seller wants for one unit of the good. As a seller you get to sell a unit if a buyer accepts your ask.

In the "Bid auction", the buyers can formulate offers to buy. An offer to buy is called a bid and specifies the price at which a buyer wants to buy a unit. As a seller you can sell a unit of the good by accepting a bid from a buyer.

In the "Ask and bid auction", the sellers can specify asks and the buyers can specify bids. Thus, you can sell a unit of the good in two ways: Either a buyer accepts an ask from you, or you accept a bid from a buyer.

During the trading stages all asks, bids and prices (that is, accepted asks and/or bids) will be nominated in experimental dollars. At the end of the experiment the aggregated profit is converted to Norwegian kroner and paid to you in cash by the experimenter. In this experiment the conversion rate is 1: 1, meaning that one experimental dollar equals one Norwegian krone.

Question 3:

Who (buyers and/or sellers) suggest/propose and who accept/determine the level of prices in the
- Ask auction?

- Ask and bid auction?

- Bid auction?

Final remarks: This has been a preliminary introduction to the trading institutions only. Afterwards you will practice how to trade at your own pace by means of a computerized learning scheme. Note that in the computer program, "trading period" means trading stage. Also, "total earnings" will be shown on your computer screen, but will be zero: Instead the experimenter keeps track of your aggregate earnings.

Please raise your hand if you have any questions. Otherwise please wait until the experiment continues.