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Endogenous Market Institutions: Experimental Evidence

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A wide variety of market institutions exist in the field and on the Internet. Examples are English auctions and two-sided marketplaces like the double auction where both buyers and sellers initiate prices. This paper investigates how the emergence of (different) market institutions is shaped by buyers' and sellers' institutional preferences. The experimental evidence reveals that both buyers and sellers in the main prefer market institutions that restrict the ability to make price offers to their side of the market. However, when buyers and sellers are allowed to express both first and second choices, the double auction emerges as the most viable market institution.

Key words: Market institutions, institutional preferences, voting rules, experimental economics.

JEL classification: D70, D44, C92.

Market institutions can be thought of as rules that govern trading. The double auction is a case in point. Double auction trading allows both buyers and sellers to suggest prices, and transactions occur if either buyers or sellers accept an offer from the other side of the market. A wide variety of market institutions exist in the field and on the Internet. Most stock exchanges and electronic marketplaces like EnronOnline resemble the double auction. However, one-sided versions of the double auction are prevalent as well. Reverse auctions exist within which sellers compete to sell products or services to one or more buyers, so the bid prices proceed downwards instead of upwards. FreeMarkets is but one e-marketplace providing online reverse auctions. Conversely, variants of the English auction – where buyers only are allowed to bid and transactions occur when a seller accepts a bid

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– are often used to organize real estate trading. Also, English auction trading rules characterize several web-based auctions like Onsale and eBay.

How come so many types of market institutions emerge in the field and on the Internet? One explanation is that liquidity considerations yield increasing returns to market size; "order flow generates order flow". Thus, a market institution that becomes viable in a specific market will become entrenched. An alternative conjecture is that the emergence of market institutions is very sensitive to environmental details, *e.g.*, the kind of good traded as well as the (revealed) institutional preferences of the relevant traders (Friedman, 1993).

Recently a small number of laboratory studies have focused on how market institutions are shaped and emerge endogenously as a result of traders' preferences and revealed choices[1]. This literature consists of mainly exploratory as opposed to theory-driven laboratory experiments. The purpose of exploratory experimentation is a search for empirical regularities and phenomena in the absence of well-formed and relevant theory (Steinle, 1997). Relevant examples of this approach vis-à-vis endogenous market institutions are Kirchsteiger *et al.* (2001) and Ivanova-Stenzel and Salmon (2002). The former study reports experiment in which buyers (sellers) choose whom to inform about offers to buy (sell). Acceptance of an offer leads to a transaction, and every trader initially informed about the offer observes the confirmed prices as well. Thus, complete dissemination of offers and prices produces a market institution equal to the double auction. The evidence shows a marked revealed preference for informing the other side of the market about offers while concealing this information from competitors. Thus, the endogenous market institution resembles a "secret offer double auction". Ivanoa-Stenzel and Salmon examine buyers' preferences between alternative auction institutions, and find that the English auction is preferred to the sealed-bid auction.

This paper adds to the existent experimental evidence on endogenous market institutions. The objective of the present study is to analyze the linkage between traders' institutional preferences, decision rules and what types of market institutions that emerge as viable. Specifically, subjects have to choose amongst the double, bid and offer auction. The bid auction is a variant of the English auction, and restricts the ability to initiate contracts to the buyer side of the market. Conversely, the offer auction is a type of reverse auction in which sellers only may communicate offers to sell. Confirmed prices are common knowledge, and each type of market institution is sequential in the sense that traders negotiate prices continuously during real-time sequences.

The subjects' institutional preferences are revealed by means of laboratory referendums, in which the subjects elect one of the three alternative market institutions and engage in trading. Each experimental session consists of 8 consecutive election and trading rounds. The payoffs earned by subjects are not directly determined by their voting behavior, but ultimately depend upon the prices agreed to during trading rounds.

Two different voting rules are used to aggregate the subjects' institutional prefer-

1. The convention in experimental economics have been 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).

ences. 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. 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. In sum, plurality voting 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 facilitates a ranking of candidates on the basis of more complete individual preferences.

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 are 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. Institutional preferences 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.

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

2. 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 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.

3. Auction prices

A final intention of this study is to gauge whether the level of prices varies across market institutions, provided at least two types of auctions are chosen in the laboratory elections. If so, the adopted null hypothesis is that no significant differences across auction types obtain. The rationale 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. 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 main finding in this paper is twofold. First, the evidence shows that varying voting rules matter and influence which auctions are selected as trading institutions. When subjects are restricted to cast one vote only (plurality rule), buyers prefer the bid auction whereas sellers vote for the offer auction. Thus, agents opt for the trading institution that restricts the ability to suggest prices to their own side of the market. However, a majority of voters choose to express second choices also when approval voting rules apply, the implication of which is that the double auction emerges as a viable trading institution as well. Equivalently, the effective number of auctions is higher under approval voting. Second, prices vary with auction type. Bid prices are lower than double auction prices, which are lower than offer auction prices. Hence, this is consistent with buyers voting for the bid auction and sellers' preference for the offer auction.

The remainder of this paper is organized in four sections. The first two describe the experimental design and the results. The subsequent section discusses the findings and the last section concludes.

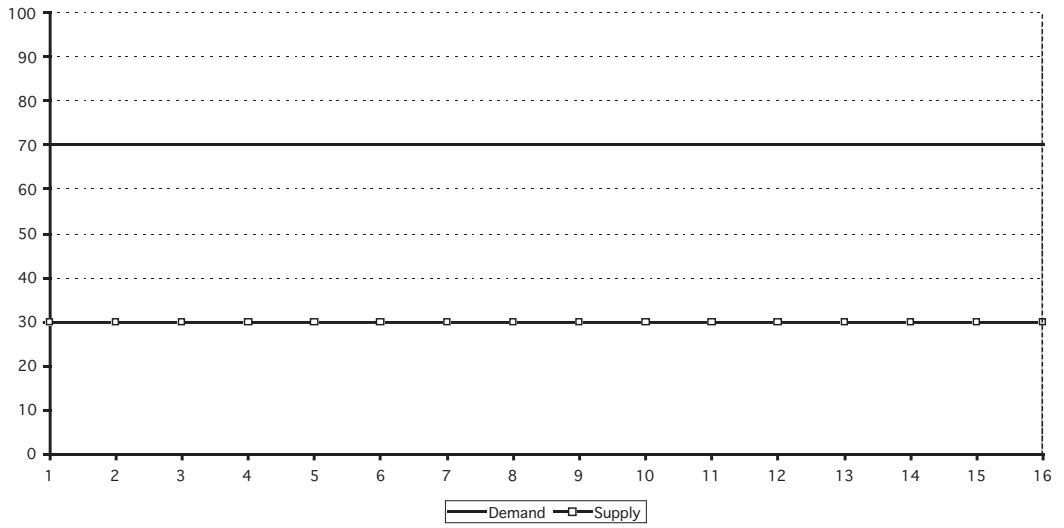
Experimental design

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

Figure 1.
Market demand and supply



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.

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[2]. 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.

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

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

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.

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[3]. 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).

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.

The Norwegian (English) session mean payoffs include individual show-up fees equal to 10 (7) U.S. dollars[4]. For comparison, efficient trading conducted at the mid-point of the feasible price range implies an expected payoff of 84 (69) U.S. dollars to each trader in the Norwegian (English) sessions. The implemented nominal discrepancy in expected payoffs reflects the difference in Norwegian and British GNP per capita levels (Statistics Norway, 2001).

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

3. 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.
4. 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.

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

participated in a test election with hypothetical alternatives labeled "X", "Y" and "Z"[5]. 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.

Experimental results

Institutional preferences 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 II. 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

Table II.
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)

5. The instructions are reproduced in Appendix A.

Table III.
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

initiate price quotes to their own side of the market.

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, *e.g.*, Hollander and Wolfe, 1999).

Table III 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

Table IV.
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

Table V.
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)

agreement can safely be rejected. Hence, plurality-rule buyers appear to cast votes in a fairly consistent manner.

As can be seen in Table IV, 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.

Result 1:
Buyers (sellers) first and foremost vote for the bid (offer) auction. The voting behavior of the individual buyers and seller shows a high degree of concordance.

A summary of approval votes is given in Table V. 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.

The individual voting behavior of approval voting buyers is summarized in Table VI. 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

Table VI.
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.

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.

The summary of individual vote ballots cast by sellers in the approval-voting treatment is shown in Table VII. 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.

Result 2:
Approval voting behavior is distinctly heterogeneous and not significantly concordant. However, a majority of both buyers and sellers cast votes that approve of more than just one institutional 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.

Effective number of auctions
Table VIII 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[6]. 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

Table VII.
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.

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

Table VIII.
Election results

Voting rule	Bid auction		Double auction		Offer auction		Effective no.
	# wins	% of vote	# wins	% of vote	# wins	% of vote	of auctions
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

sessions each auction receives roughly an equal share of the vote. Accordingly, the pooled effective number of auctions is marginally below three.

The EN values listed above indicate that approval voting yields an increased number of effective auctions relative to the plurality rule benchmark.

Result 3:
Plurality rule induces a Duverger effect in the sense that just two of the three alternatives – the bid and offer auctions – win 15 of the 16 laboratory elections. 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[7].

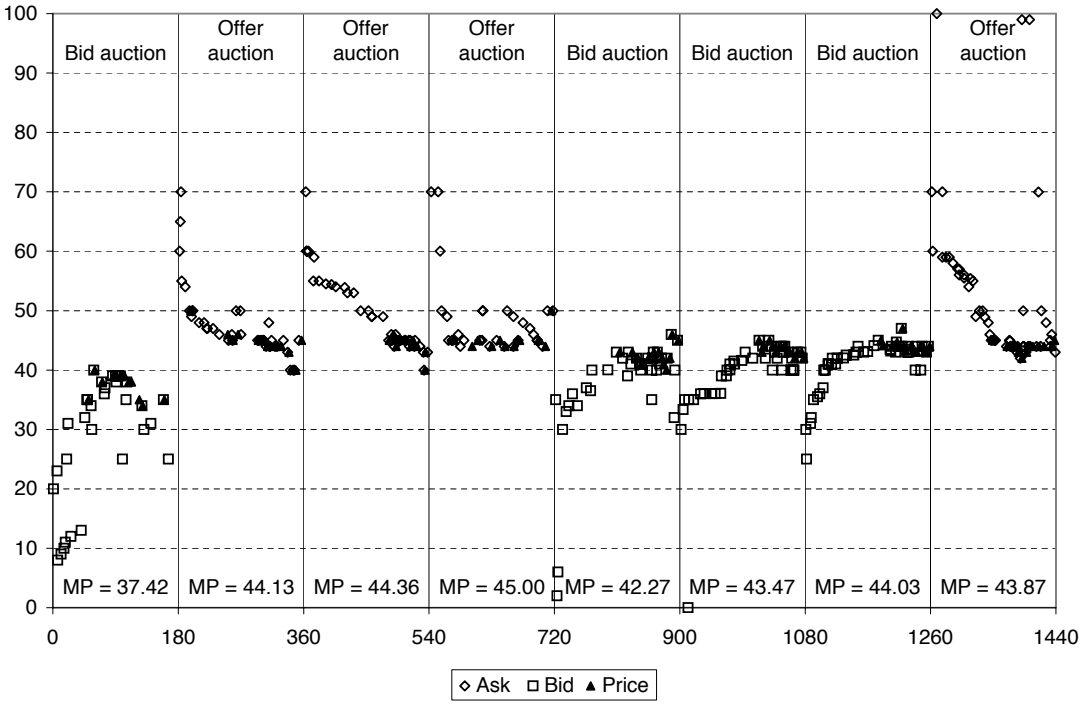
Auction prices
The following discussion is divided into two parts. First, chronological sequences of asks, bids and confirmed contract prices are presented graphically, by session. Second, an econometric analysis is employed to weed out the effect of market institution on price formation.

Figure 2 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. Note that each trading period 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

7. Confer the econometric analysis contained in Appendix B.

Figure 2.
Asks, bids and prices, session PR1



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.

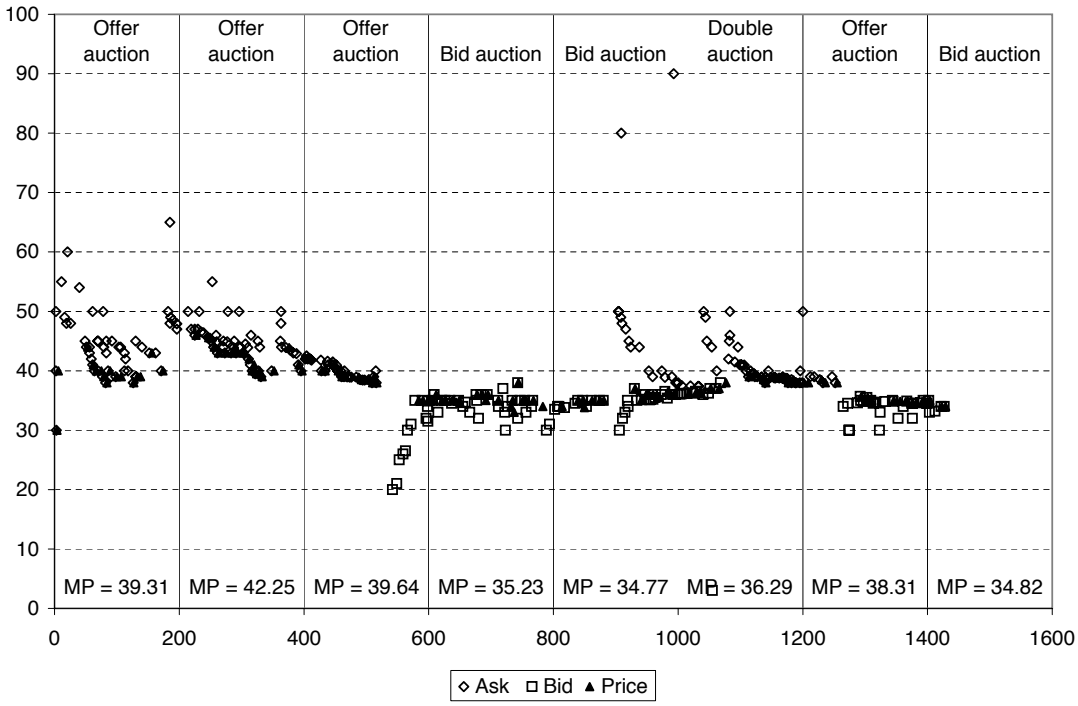
Analogous time series from the second plurality rule session PR2 are depicted in Figure 3. A general impression is that, again, buyers (sellers) try during bid (offer) auction trading to signal low (high) prices, but intra-type competition amongst buyers (sellers) seems to increase (decrease) bids (asks).

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

Figures 4 and 5 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 5 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

Figure 3.
Asks, bids and prices, session PR2



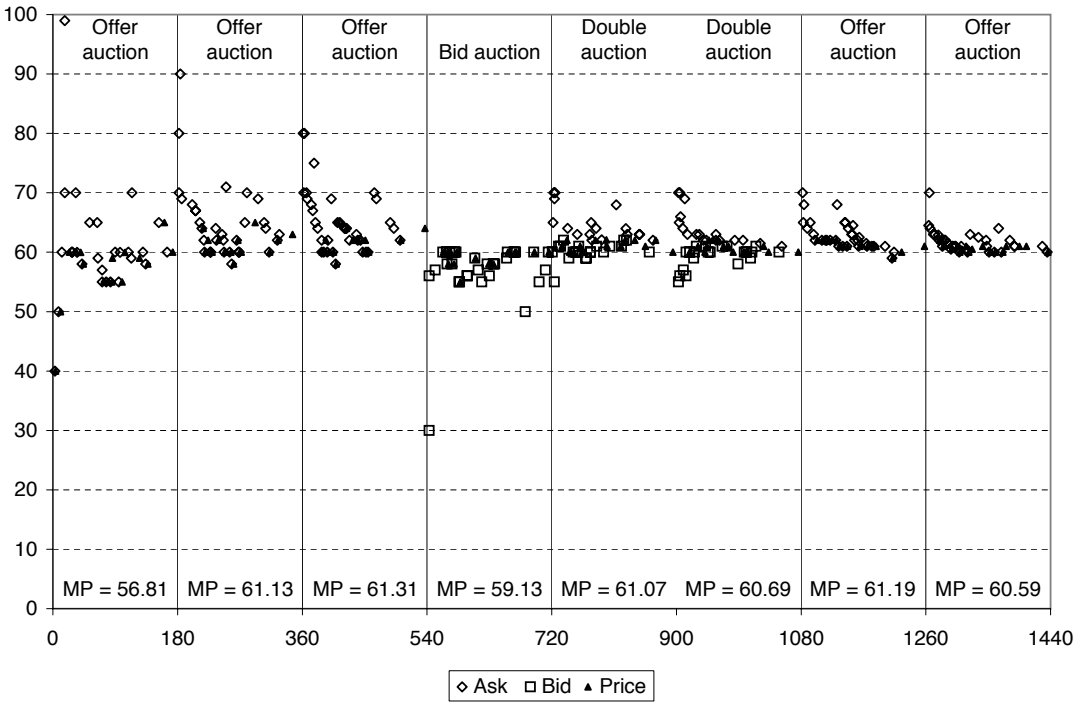
experimental dollars, the midpoint of the feasible price range. There is a discernable difference in the behavior of buyers and sellers throughout this laboratory session. When allowed to initiate prices, buyers persist in submitting bids noticeably below this level. In contrast, sellers' asks in general deviate less from the established price level, and do not vary to the same extent as the observed bids.

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.

After controlling for session and time effects, the data show that bid (offer) trading rules induces lower (higher) prices relative to the double auction[8]. The point estimate in the bid (offer) auction case is -1.53 (1.89) experimental dollars. These institutional effects are statistically significant.

8. Confer the econometric analysis contained in Appendix C.

Figure 4.
Asks, bids and prices, session AV1



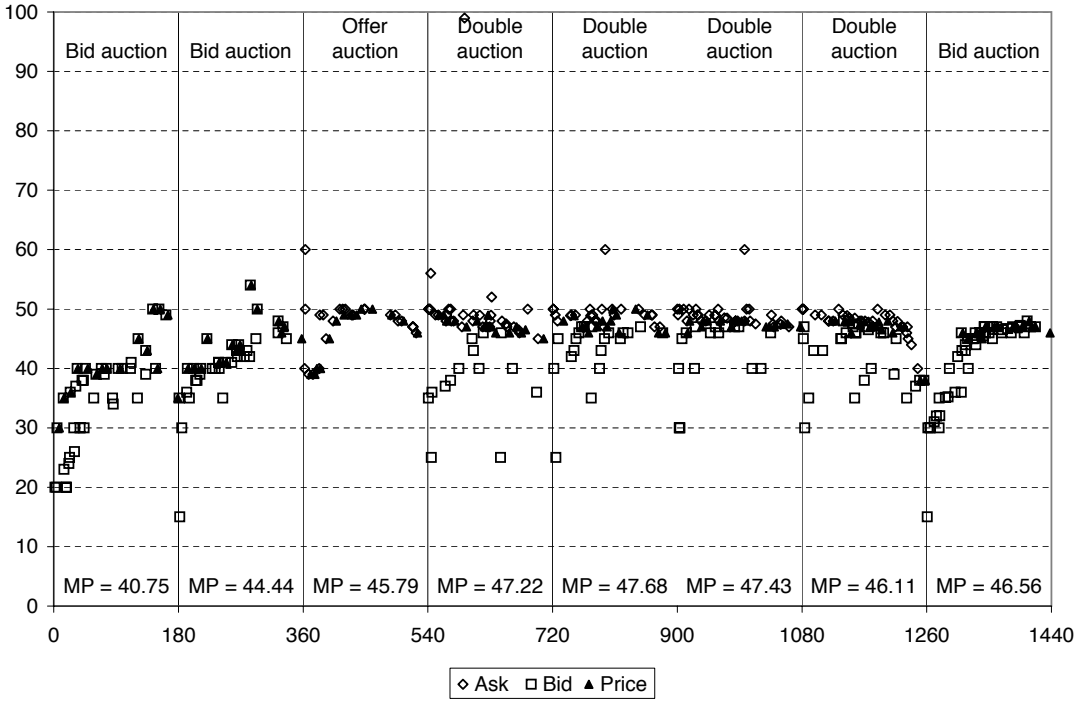
Result 4:
Auction prices vary markedly between sessions and slightly over the course of sessions. When controlling for these effects, the data reveal that bid (offer) auction prices are lower (higher) than double auction prices. The magnitude of these differences is approximately equal as well as highly statistically significant.

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 is 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

Figure 5.
Asks, bids and prices, session AV2



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 are 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[9]. 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.

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

9. 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).

become more paramount as the number of economic agents increases[10].

Conclusion

There is a wide variety of market institutions in the field. A multitude of such institutions may be characterized in terms of the ability to initiate price quotes. Variants of English (reverse) auctions enable buyers (sellers) only to suggest prices, whereas the double auction combines these alternatives. The emergence of such market institutions may result from history-specific interactions between decentralized actions by economic agents and/or deliberate legislative design. For instance, Friedman (1993) has conjectured that the specifics of a market institution may be sensitive to environmental details, and may be conjectured to reflect the institutional preferences of a set of relevant traders and/or policy makers.

The starting point of this paper is that the emergence of market institutions is affected by the institutional preferences of traders, as well as by the decision process or voting rule traders use – in a hypothetical "constitutional" setting – to set up and agree upon trading rules. The experimental data corroborate the conjecture that type of voting rule – *i.e.*, how preferences are aggregated – markedly influence the choice of market institution. Specifically, voting rules matter in the sense that plurality rule induces a Duverger effect by which the bid (buyer) and offer (seller) auction emerge as the only viable market institutions. Thus, when buyers and sellers express first choices only, one-sided market institutions emerge that restrict the ability to suggest prices to one side of the market. Approval voting instead yields three effective auctions with each auction winning approximately one third of the elections as well as the aggregate vote. Counting first and second choices consequently implies a more varied landscape of market institutions in which the double auction figures alongside the one-sided market institutions.

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10. 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.

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Appendix A: 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. Read these instructions carefully. 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. Voting test: When everyone has finished reading the instructions you will practice your role as a voter in a test election.

3. Trading test: 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" or "Ask and bid auction" or "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).

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	√					√	√		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.

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		√				√			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.

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 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 buyer of a fictitious good on a computerized market. Each trading stage lasts 180 seconds. 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[11].

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.

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 seller of a fictitious good on a computerized market. Each trading stage lasts 180 seconds. Apart from you there are 3 other sellers and 4 buyers on this market.

11. 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 equal £ 6.67.

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.

Example 3:
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.

Appendix B: Econometric analysis of the effective number of auctions

The following random-effects panel data model is used to evaluate whether voting rules affect the effective number of auctions in a statistically significant manner:

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

where subscript i denotes session (i∈{AV1, PR1, AV2, PR2}), and t signifies election number within any one session (t∈{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) $\varepsilon_{i,t} \sim iiN(0,\sigma_\varepsilon^2)$

(3) $u_i \sim iiN(0,\sigma_\varepsilon^2)$

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

Table IX 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 IX.
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 a ($\beta_{Voting\ rule}$) is the value for α two-tailed (one-tailed) test of the hypothesis that the parameter equals zero.

Appendix C: Econometric analysis of auction prices

The objective of the following econometric analysis of auction prices is to investigate whether price levels vary with auction types as well as 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[12].

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

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

$$(7)\quad \varepsilon_{i,t(i)} \sim iiN(0,\sigma_\varepsilon^2)$$

$$(8)\quad \eta_{i,t(i)} \sim iiN(0,\sigma_\eta^2)$$

Each variable and disturbance term is indexed relative to session i∈{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}[13]. 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∈{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 X 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 statistic at the bottom of the table shows that the model as fitted explains 83% of the variability in prices[14]. 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 induce 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.

12. Formally, a Durbin-Watson test implies the rejection of zero autocorrelation. The Durbin-Watson statistic for panel data d_p = 0.96, whereas the 5% significance points of the upper (lower) bound of d_p i = 6 and t = 100 equals 1.82 (1.91) (Bhargava *et al.*, 1982).
13. The maximum number of price observations within any trading round is 16. Thus, at most, 128 prices may be formed during a laboratory session.
14. The marked price level differentials across sessions are consistent with the variance in buyer and seller mean payoffs depicted in Table I.

Table X.
Estimated parameters for the model $P_{i,t(i)} = \alpha_i + \sum_{j=2}^{8} \beta_j D_j^{Trading\ round} + \beta_{Bid\ auction} D_{i,t(i)}^{Offer\ auction} + \varepsilon_{i,t(i)}$

1. Session effects				
Parameter	AV1	PR1	AV2	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	2	3	4	5	6	7	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	Bid auction	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		