# UNCERTAIN DECISIONS

## Bridging Theory and Experiments

*edited by*

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# 14 BUYER AND SELLER EFFECT DISENTANGLED

## *an experiment on the microstructure of demand*

Claudio Borelli, Alessandro Innocenti, Luigi Luini*

## 14.1 INTRODUCTION

Buyer and seller behavior were disentangled by reselling goods in a double auction market.

Certain markets (e.g. stock and commodity markets) have two prices: a selling price and buying price. Much literature on finance is concerned with interpreting the economic meaning of the difference between these prices, usually called bid-ask spread. Is this price differential caused (or motivated) by different opinions, different information, or different risk attitudes?[1]

A number of experimental studies on market behavior have analysed the phenomenon of buying prices substantially below (i. e. more than can be accounted for by income effect) selling prices. Willingness to pay (WTP) and willingness to accept (WTA) compensation are the two measures of the value a person places on something. In the absence of transaction costs these two measures should differ only by an income effect, which in the laboratory case is negligible.

The disparity between buying and selling prices was investigated in an experiment by Knetsch & Sinden (1984)[2]. In a response to Knetsch & Sinden (1984), Coursey, Hovis & Schulze (1987) tested the hypothesis that a market environment provides subjects with enough feedback and experience so to eliminate such anomalies as the buying and selling price disparity. The market environment in their experiment is a second price auction, so that it is a dominant strategy for utility maximisers to state their true reservation prices[3].

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*The authors thank to P. Lomagistro for invaluable help in writing the program for the experiment.

[1] For a review of the literature on finance, see O'Hara (1995). The experimental literature also shows how the trading institutions affect financial market performance (Friedman 1993b).

[2] They review that result from hypothetical choice experiments and report an experiment showing that this disparity between buying and selling prices persists for real transactions. Knetsch & Sinden (1984) gave half their subjects lottery tickets and the other half $3. The first group of subjects allowed to sell their tickets for $3 and the second group was permitted to buy tickets for $3. A large disparity was observed: 82% of those with tickets kept them, but only 38% of the other group decided to buy a ticket.

[3] Actually their results are quite controversial for methological reasons: see Kagel & Levin (1988).

Kahneman, Knetsch & Thaler (1990) provided some evidence that choice anomalies may persist even in market environments. In their experiment, half the subjects were endowed with a small consumer good. In these experiments subjects who wished to buy or sell a good (with their own money) were free to do so, and the authors report that substantially fewer trades were transacted than would be expected in the absence of the endowment effect.

Another experiment, concerned with preference reversals and buying and selling price disparities in a market setting, is reported by Knetz & Smith (1987) who tested whether markets act as if agents were utility maximizers even if the agents do not behave as such. They observed several repeated markets in which subjects were first asked to state hypothetical preferences and buying or selling prices for a P bet and a $ bet[4] with expected values of $3.85, and were then allowed to trade. Trading was conducted in two separate double auction markets, first a market for P bets, then for $ bets[5]. Although Knetz & Smith observed numerous and persistent price disparities[6] in the hypothetical responses, they argue that very few of the prices at which lottery tickets were exchanged were inconsistent with utility theory, in the sense that they do not lie outside the interval of possible payoff of the lottery tickets. In fact, most transactions occurred sufficiently close to the expected value to be consistent with plausible risk preference or aversion.

In order to obtain some insight into this subject, the experiment had two main aim that were different from the usual test of convergence toward competitive equilibrium of most experimental literature on double auction. The first was to differentiate between the behavior of subjects when they act as "buyers" and when they act as "sellers", through the device of rebuying and reselling a given good. The second was to study empirically the price formation process and how it influences subjects' behavior. Although several theories of the price formation process have been proposed, they start from theoretical assumptions and derive consequently empirical implications. On the contrary, this work adopts a microstructural approach to the problem by studying the empirical regularities pointed out by the experiment without any explicit supporting theory.

Bilateral trading theory has not yet reached any rigorous conclusion. Myerson & Satterthwaite (1983) examined the case of one buyer and one seller bargaining with privately known valuations, and found that there was no Bayesian equilibrium which guaranteed ex-post equilibrium. Makowsky & Mezzetti (1993) demonstrated

[4] A 'P bet' is a bet with the higher probability of winning, while a '$ bet' is a bet with the higher payoff. The expected payoff is the same for both bets, but the latter bet is riskier.

[5] In each market each buyer was given an endowment of $ 5.50, and was allowed to buy no more than a single lottery. Each seller was given an endowment of one lottery (and was also paid $1.65). After both markets had been conducted, buyers and sellers were again asked to state hypothetical preferences and reservation prices, and all initial endowments were replenished. The whole process was repeated several times, with each subject remaining always a buyer or a seller.

[6] These authors also observed a "hard core" of reversals of 35 to 38%. They conclude questioning the relevance of the preference reversal phenomenon in the joint context of repetitive responses and market trading. In a recent series of experiments on preference reversals, also Cox & Grether (1996) inquired whether the reversals could be observed in market settings. The authors elicited preferences by application of the Becker ,De Groot & Marshak procedure; moreover they used a second price auction to obtain pricing data and an English clock auction to obtain the choice data. Their results confirm that preference reversals are eliminated only if both repetition and incentives are build into a market setting. In this sense, reversals appear to be the product of lack of learning (feedback) and motivation.



that an equilibrium solution exists in the case of one seller and two or more buyers; Menicucci (1998) extended this result to the case of n buyers.[7] To our knowledge, no formal model exists for the case of several buyers and several sellers.

This paper has four parts. The first is devoted to an account of the theoretical approach on which the experiment design is based. The second part describes the laboratory procedure. The third part gives an analysis of the data. The concluding section contains some final remarks and observations. An appendix includes all the figures mentioned in the paper.

## 14.2 A MICROSTRUCTURAL APPROACH

We chose, a double computerized auction experiment, a set of subjects exchange goods with value schedules telling the players how much they will obtain for each unit of the good at the end of the experiment. Experimental data obtained with the computerised markets were used to analyze the process of price formation. Because such data is quickly and easily processed and is independent of face-to-face interaction between subjects.

This also explains why theoretical models to explain experimental data have flourished recently. A summary of this literature is given in Cason & Friedman (1993), who use data from many experiments to investigate the validity of their own model. Their findings, however, do not clear by support any of the models

| Hypothesis | I | II | III |
|---|---|---|---|
| Equilibrium Price | Buyer price | Seller price | Intermediate |
| Price Change Autocorrelation | Positive | Negative | Zero |
| Transaction Partners | Speculative | Competitive | |
| Transaction Timing | Uniform distribution | Non-uniform distribution | |
| Bid/Ask Improvements | By the same seller/buyer | By different sellers/buyers | |
| Bid/Ask Spread | Decreasing | Increasing | Constant |
| Other limited rationality effects | Important | Not Important | |

Table 14.1: Summary of Implications to be Tested

[7] Kagel & Vogt (1993) have experimentally demonstrated that "the most significant failing of the theory is that efficiency fails to increase significantly as the number of traders increase ...

proposed. They conclude that future experiments must examine other factors that are presumably important in a complex environment such as a double continuous action market. These factors include the timing of transactions and the source of market efficiency losses. This suggestion can only be taken by empirical analysis without explicit reference to any of the theoretical models formulated to date. Our idea is that such models do not take into account the complexity of behavior in the setting we consider. Although general competitive equilibrium theory is a powerful tool for investigating price setting (see Hahn 1987), it is to say the least vague for discussing the process by which clearing prices are attained. We therefore take the view that it is preferable to avoid explicit reference to the theoretical models proposed in literature and to use microstructural analysis to obtain some empirical evidence. We, therefore, examine the process of price formation by empirical analysis along the lines proposed by Cason & Friedman (1993) and Friedman (1993a). Their approach permits us to describe this process in a very concrete way and to study it not only from the point of view of equilibrium and efficiency but also to see how market phenomena are affected by variables other than utility maximisation, for example "disequilibrium" transactions, the sequence in which they occur, the process by which participants "learn" and the interdependence between them.

In their paper, Cason & Friedman test three theoretical models of behavior in a continuous double auction, namely Wilson's model (1987), Friedman's model (1993b) and Gode & Sunder's zero intelligence algorithm (1993).[8] We do not consider these models directly but we adopt some of the empirical proxies employed by Cason & Friedman to test them. We also add some other facts to be tested (Table1). Apart from this addition, the main difference from other studies on double auction is that we focus the analysis on the possibility of rebuying and reselling goods given to the subjects during the experiment[9].

## 14.3. LABORATORY PROCEDURES

The participants were students of the Faculty of Economics of Siena University[10]. Each student took part in an initial learning phase in which the rules of the

attributed to buyers bidding substantially more than predicted in auctions with small numbers of traders" (p. 302).

[8] Easley & Ledyard (1993) and Gjerstad & Dickhaut (1995) provide other models that take some empirical regularities of double auction data into account.

[9] As will be evident from discussion of the data, we also considered the hypothesis that convergence to competitive equilibrium in double auctions is influenced by the parameters of the supply and demand curves (for a previous reference on oral double auction see Holt, Langan, and Villamil 1986 and Banks, Ledyard & Porter 1989) not in the sense that some subjects have market power (as in Holt, Langan & Villamil 1986) but that the possibility of rebuying and reselling is important to determine equilibrium.

[10] Our work began in 1994 when some pilot experiments were performed. The first version of the experimental design was more complex than the present one. The participants had the problem of making buying and selling decisions about two different goods. They did not know the utility of the goods with certainty, but at different times they obtained information about it and had to make a price statements of indifference between acting as buyer or seller of the goods. This statement, which was made before and after the auction, was the basis for studying behavior. A cursory glance at the first data sheets showed, some subjects were not well trained for the experiment and did not clearly understand the relation between the price statement and selling and buying. More generally, we observed a myopic behavior



experiment were introduced. Later the students were called back for another training phase and then eight students were selected for the real experiment. The latter took about two hours and thirty minutes to completed. [11]

Participants were motivated in the following way. Every subject received 10,000 lira for taking part at the initial learning phase. Then, at the end of the experiment, the profits earned by the participants were ordered. Those in the top third of the scale (i.e. those who earned the highest profits) obtained an additional 50,000 lira. Those ranked in the middle third gained an additional 40,000 lira, and those at the lower third obtained an additional 30,000 lira. The latter can be assumed to have paid an opportunity cost for participating in the experiment.

The experiment was divided into three phases. In each phase, subjects could buy or sell but they were labeled "buyers" or "sellers" depending on their initial endowments. Buyers were distinct from sellers in the first two phases of the experiment by virtue of different demand or supply schedules. This difference was to assess the effect of the possibility of reselling and rebuying goods on behavior. In instance, in phase A and B a competitive equilibrium might be defined on the basis of the initial endowments but this equilibrium changed if the possibility of reselling and rebuying was taken in account. Buyers in phase A (sellers in phase B) had a demand (offer) schedule different from the sellers (buyers) and we considered the distance from competitive equilibrium as a proxy to evaluate the difference between "seller-traders" and "buyer-speculators". In phase C this difference disappeared because two markets were open simultaneously. Our experimental design was also characterized by the fact that equilibrium price changed across trading periods, permitting us to study price formation process in a more analytical way.

The parameters of the experiment were as follows:

### *Phase A*

- Market 1 is open for two periods of five minutes each.
- Total endowment: 40 items and 22,000 lira divided among 8 subjects.
- Initial allocation: Four subjects are sellers, each with 10 items and no money.
  Four subjects are buyers, each with 5,500 lira and no items.
- Reservation prices: See Figure 1.

caused by the complexity of calculating equilibrium prices and monitoring price variations. Such difficulties became more evident when two markets were open simultaneously but they were also clear with a single market when subjects specialized in bidding or in asking without exploiting all the possibilities for speculation allowed by double auction. Finally, we also had some trouble in defining the temporal structure of the experiment. Since we tried to get an idea of how time influences behavior, we divided each of the phases of the experiment into five periods and this further increased the amount of data to analyze. In order to simplify the data analysis and to obtain more relevant data, we simplified the experimental procedure as described below. Our experience also confirms that participants require a training period in order to be able to cope with the tasks. In the final session of the experiment we used only experienced subjects who where familiar with the computerized procedures. This selection process prevented that keyboard skills from becaming a nuisance variable.

[11] The experiment was performed at the computer laboratory of the Faculty of Economics, University of Siena. We used a computerized continuous double auction market based on the MUDA (Multiple Unit Double Action) program developed at Caltech. The institutional features of this program and all details are described in Plott & Gray (1990).

N.B. The four buyers have unit redemption values (demand curve) 50 lire higher than sellers.

*Phase B*

- Market 2 is open for two periods of five minutes each.
- The four buyers of Phase A become the sellers and the four sellers become buyers.
- Total endowment: 48 items and 27,600 lira divided among 8 subjects.
- Initial allocation: Four subjects are sellers, each with 12 items and no money
  Four subjects are buyers, each with 6,900 lira and no items.
- Reservation prices: See Figure 2.

N.B. The four sellers have unit inventory use costs (offer curve) 50 lire lower than buyers.

*Phase C*

- Market 1 and 2 are open simultaneously for ten minutes.
- All subjects have the same endowments received initially in phases A and B, but there are no longer differences in redemption value or inventory cost.
- Reservation prices: See Figure 3.

N.B. There are no differences between the demand and offer curves of sellers and buyers in either markets.

## 14.4 DESCRIPTIVE DATA ANALYSIS

The following analysis is divided into four subsections on price distribution and transaction price changes, transaction partners and timing, bid and ask behavior, limited rationality effects. A summary of the empirical findings closes the section.

*Price distribution and transaction price changes*

The first result to comment on is the average price. Table 2 shows some parameters calculated after eliminating transactions that appeared to be the result of outrageous errors. The size and effect of these errors, that are common in computerized double auctions (see Holt 1995, p. 369), will be analyzed below.

The average price was nearer to buyer price than to seller price in phase A and B. This finding is confirmed by a glance at the evolution of the transactions (Figures 4-9 in the Appendix). It shows that subjects rapidly learned the meaning of buyer price, after an initial period in which seller price seemed to attract more transactions. This convergence was higher, and consequently price distribution variance lower, in phase B than in phase A. Two different processes of learning seemed to be acting. The first was learning of the whole experimental design such that in phase B transaction prices approached equilibrium prices -first seller then buyer price- faster than in phase A. The second was learning of the correct value of the buyer price in any single phase. Even in this case, phase B showed a more rapid convergence that is testified not only by the lower variance but also by the fact that the distribution



converged more constantly through time, contrary to what happened for example in the first minutes of the second period of phase A.

Phase C showed apparently contradictory results. It is useful to remember that in phase C the divergence between buyer and seller price disappeared and therefore our initial hypothesis concerning the difference between seller and buyer behavior is confirmed if consumer price is again dominant in phase C. In market 1 the average price was more than 10 lira below the average price of phase A confirming our initial hypothesis, but in market 2 the average price decreased slightly with respect to phase B.

The rationale of this evidence runs as follows. In phase C two markets were open şimultaneously. The problem of dealing with this more complex setting is shown by the fact that the transactions were not distributed uniformly between the two markets (24 transactions in market 2 vs. 11 transactions in market 1) and subjects specialized in one of the two. This behavior, will be discussed again below, and may explain the partially contradictory results we obtained in terms of average prices. Another observation supports this point: in both markets the deadline effect (as represented by the final two/three transactions) showed a convergence of prices in the required direction, up in market 2 and down in market 1. This confirms that the sequential nature of double auction implies that subjects usually make price concessions at the end of each period in order to reach efficient equilibrium.

The second point to comment on concerns the correlation coefficient between price change and lagged price change. In all phases, this coefficient was negative and near to 0.5, that is, the value implied by Gode & Sunder's model based on zero intelligence traders. This result was only partially contradicted by the autocorrelation coefficient of phase B, which was negative but higher than 0.5 (0.18). However, the plot of price change against lagged price change for this phase (Figure 10) shows that this difference is caused by some extreme values

| | Phase A | Phase B | Phase C Market 1 | Phase C Market 2 |
|---|---|---|---|---|
| Seller price | 1100 | 1150 | 1100 | 1150 |
| Buyer price | 1130 | 1130 | 1100 | 1150 |
| no. of transactions | 39 | 46 | 11 | 24 |
| Average price | 1120.25 | 1131.67 | 1109.91 | 1130.04 |
| Variance of price distribution | 652.09 | 531.51 | 308.69 | 1460.13 |
| Correlation coefficient price-lagged price | 0.25 | 0.30 | -0.20 | 0.24 |
| Correlation coefficient price change lagged price change | -0.39 | -0.18 | -0.52 | -0.44 |

Table 14.2 Price Distribution and Transaction Price Changes

concentrated near the null price change. This finding confirms a point argued by Friedman & Cason (1993, p.268), namely that the increase in the autocorrelation coefficient may be attributed to the more experienced subjects or, alternatively, to learning, as discussed before.

### *Transaction partners and timing*

Concerning what we defined as the "buyer effect", Table 3 presents an index of the importance of speculative activity during the experiment.

A rough indicator of the activity of reselling and rebuying is the number of goods sold by the subjects initially endowed with goods, whom we defined as "buyers", and by the number of goods purchased by the subjects initially endowed with money, the "sellers". Both values were significant in phases A and B, although the "buyers" were more active in both phases. This speculative activity seemed to be the

**Phase A**

| | | Subject who sells: Seller | Buyer | Total |
|---|---|---|---|---|
| Subject who buys | Buyer | 14 | 14 | 28 |
| | Seller | 5 | 6 | 11 |
| | Total | 19 | 20 | 39 |

**Phase B**

| | | Subject who sells: Seller | Buyer | Total |
|---|---|---|---|---|
| Subject who buys | Buyer | 18 | 13 | 31 |
| | Seller | 6 | 9 | 15 |
| | Total | 24 | 22 | 46 |

**Phase C** Market 1

| | | Subject who sells: Seller | Buyer | Total |
|---|---|---|---|---|
| Subject who buys | Buyer | 8 | 1 | 9 |
| | Seller | 1 | 1 | 2 |
| | Total | 9 | 2 | 11 |

**Phase C** Market 2

| | | Subject who sells: Seller | Buyer | Total |
|---|---|---|---|---|
| Subject who buys | Buyer | 14 | 3 | 17 |
| | Seller | 3 | 4 | 7 |
| | Total | 17 | 7 | 24 |

Table 14.3 Transaction Partners



main reason for the fact that the transaction price and the buyer price converged. In phase C, the buyer effect was lower, though buying still prevailed over selling. Basically, comparison of the first two phases with phase C suggests that speculative activity influenced transaction price.

With regard to the timing of transactions, most experiments on auctions show an absence of uniformity. For instance, double auction seems to be characterized by a delay before the first transaction and a concentration of exchanges toward the end of each period. To check this point, we divided each period into subperiods of thirty seconds for phase A and phase B and one minute for phase C. We then calculated the number of transactions made in each subperiod as a percentage of the total number of transactions in the period. The average values are reported in Figure 11 and the values divided into subperiods in Figure 12.

The average values showed the presence of two cycles in the transactions. The first cycle had its upper point in the second and third subperiods, and the second in the last subperiod. This observation was confirmed by the divided data, except in the second period of phase B where the deadline effect was weaker and the transactions were concentrated in the first subperiod.

Our data did not reveal any initial delay before the first transaction. In both periods of the two initial phases the delay was less than thirty seconds – 20 and 27 in phase A, 19 and 21 in phase B – and only in the first market of phase C was the initial delay longer than two minutes.

Evidence concerning the deadline effect was even less ambiguous. The last transactions of each period were very near the deadline, namely 1 and 25 seconds in phase A, 1 and 5 seconds in phase B, 14 and 32 seconds in phase C.

### *Bid and ask behavior*

One variable concerns subjects who made successive improvements on a bid or an ask before a transaction. Friedman & Cason (1993) adopts a strict test of this variable. First they test whether the improvements leading to a transaction are made by the same buyer (or seller) without any interference from other traders. Then they test all other cases. With computerized double auction, however, bidding and asking are so rapid that a trader cannot submit successive bids or asks without interference from other traders. We therefore decided to use different parameters for the two tests. In any phase, we considered all subperiods preceding acceptance by a seller (buyer) and we calculated how many successive improvements on a bid (ask) were made by the trader who accepted. We then calculated the percentage of subperiods in which the seller (or buyer) made 25%, 50% and 75% per cent of the successive improvements. The results are reported in Table 4.

The distribution of improvements was concentrated in the high percentage classes which is in line with the hypothesis that improvements by the same trader are more frequent. This was most evident in the first two phases, when the average percentage of improvements made by the same trader was greater than 60%. The decrease in phase C may be due to the fact that transaction prices were settled after much more haggling. Indeed, the average number of offers preceding a transaction was 5.33 in phase C, versus 3.81 in phase A and 3.69 in phase B. This finding partially contradicts Cason & Friedman's evidence that improvements by different traders are more common than improvement by the same trader.

The other variable to be tested is the ask/bid spread. Figures 13-16 show the different patterns of evolution of this value across the phases after eliminating "outrageous errors". In phase B variance was lower and convergence faster than in phase A and this suggests a learning effect. It is difficult to recognize any similarity between the phases, though the ask-bid spread of phase C deserves a comment. The few transactions made in both markets in this phase (especially market 1) was combined with the opposite trends of the ask-bid spread. In market 1, the spread reached its highest value near the deadline; in market 2, it decreased except for a slight increase in the very last seconds of the phase. This pattern of evolution can be attributed to the splitting of traders between market 1 and market 2, which made bargaining less competitive. Despite this effect, there was a deadline effect in both markets.

*Institutional desing's effects*

The results discussed above show that efficiency in the sense of convergence of transaction prices to the fully revealing rational expectations equilibrium was partially attained. Altough our aim was not to provide further evidence of the efficiency of double auction which is widely documented in previous literature, our results confirm that auction theory has received important insights from experimental evidence. The *tatonnement* process, the "gedanken" experiment of walrasian auctioneer described by Hahn (1987) as the "fictitious" agent, must be intended as a theoretical lacuna with a "lack of any clear theory of how trade would proceed". Performed experiments on auctions have widely documented the importance of different institutional rules governing this process: in particular bidding incentive are extremely relevant (Smith, 1987). Our research is only a step along the line of "investigating the properties of two-sided auctions in term of games with incomplete information" (Kagel, 1995 p. 571).

This notwithstanding, limited rationality and computational limits seems to play an important role in explaining our results. We have already pointed out some experimental findings representing a departure from the full rationality assumption.

The first was the difficulty of dealing with two markets at the samr time. Simple

| | Phase A | Phase B | Phase C | Total | Percent. |
|---|---|---|---|---|---|
| 0 - 25% | 3 | 7 | 4 | 14 | 16.3% |
| 26% - 50% | 12 | 12 | 16 | 40 | 46.5% |
| 51% - 75% | 1 | 2 | 0 | 3 | 3.5% |
| 76% - 100% | 11 | 14 | 4 | 29 | 33.7% |
| Total no. of subperiods | 27 | 35 | 24 | 86 | 100.0% |
| Average percentage | 62.9% | 62.2% | 48.3% | 58.6 % | |

Table 14.4 Successive Improvements on Bids (Asks) by the Same Seller



proof of this was the decreasing of the number of transactions in phase C. Another departure was that subjects chose to focus attention on either bidding or asking. This behavior, which made the trading less efficient, seemed to be caused by the complexity of calculation that induce the choice of a focal good for some subjects at the start of the phase and of a focal activity for almost all subjects during the phase.

Data analysis revealed other patterns of behavior. The first was a consequence of the experimental procedure. At the beginning of each phase, the subjects sought flexibility, holding more cash than optimal inventory policy would advise. This fact can be partially explained by the process of bargaining adopted by the computer network. The program uses the rules of a normal double auction (bids and offers are public and bids (offers) have to be higher (lower) than the best ones on the floor) but it does not include a "rank queue" according to which bids (offers) different from the outstanding ones are stored by the program. Since bilateral contact is not allowed, this implies that, as time passes, the public price established by the market is a constraint to the possibility of generating a larger number of transactions. The final result is that flexibility seeking becomes flexibility trap behavior. However, this effect became less and less important in the final part of each period.

A last point concerns outrageous errors in a computerized auction. It is indeed possible that a subject faced with multiple choices may have moments of inattention or make a choice different from the one he meant by a slip of the hand. It is useful to analyze whether these errors influenced trading or were irrelevant. During the experiment, only three transactions could be considered as outrageous errors. The first was in the second period of phase A, the second very near the end of the second period of phase B, the third was in phase C of market 2. The latter transaction may be considered a simple error, because its price (1,000 lira) cannot be defined as outrageous but simply out of the 1100-1200 price range. Table 5 shows asks, bids and transactions made thirty seconds before and after these errors.

Apart from the error in phase B, that was made at the end of the period and does not permit any generalization, the mistakes in the other two cases did not seem to influence trading and asking/bidding. In phase A, the level of asks and bids did not change after the error and the successive transaction was at a price (1,150 lira) that was the average of the previous trades (1,200 for selling and 1,120 for buying). In phase C, transaction prices returned to the level prevalent before the error (1,100 lira) but there was a mimic effect in bidding activity (bid of subject 1 at 1,002). These observations suggest that outrageous errors did not influence market activity.

| Time | Subject | Activity | Subject | Price | N. of goods |
|---|---|---|---|---|---|
| **Phase A** Second Period | | | | | |
| 00:03:57 | 06 | BUY FROM | 00 | 1120 | 1 |
| 00:03:51 | 01 | BID | | 1050 | 1 |
| 00:03:46 | 04 | ASK | | 1300 | 1 |
| 00:03:46 | 03 | BID | | 1200 | 1 |
| 00:03:40 | 07 | SELL TO | 03 | 1200 | 1 |
| 00:03:38 | 00 | ASK | | 1160 | 4 |
| 00:03:33 | 05 | BID | | 0 | 3 |
| 00:03:34 | 01 | ASK | | 1150 | 2 |
| **00:03:28** | **02** | **SELL TO** | **05** | **0** | **1** |
| **00:03:25** | **02** | **SELL TO** | **05** | **0** | **1** |
| **00:03:24** | **02** | **SELL TO** | **05** | **0** | **1** |
| 00:03:23 | 00 | ASK | | 1150 | 4 |
| 00:03:23 | 06 | BID | | 1100 | 1 |
| 00:03:21 | 02 | BUY FROM | 00 | 1150 | 1 |
| 00:03:12 | 07 | BUY FROM | 00 | 1150 | 1 |
| 00:03:06 | 05 | BUY FROM | 00 | 1150 | 1 |
| 00:03:01 | 01 | ASK | | 1148 | 1 |
| **Phase B** | | | | | |
| 00:00:34 | 06 | ASK | | 1130 | 1 |
| 00:00:34 | 01 | BID | | 1085 | 1 |
| 00:00:25 | 05 | ASK | | 1120 | 2 |
| 00:00:22 | 00 | BID | | 1090 | 1 |
| 00:00:17 | 01 | BID | | 1095 | 1 |
| 00:00:14 | 04 | ASK | | 1110 | 1 |
| 00:00:09 | 03 | BUY FROM | 04 | 1110 | 1 |
| 00:00:08 | 07 | ASK | | 100 | 1 |
| **00:00:05** | **00** | **BUY FROM** | **07** | **100** | **1** |
| CLOSE MRK | | | | | |
| **Phase C** | | | | | |
| 00:06:11 | 06 | ASK | | 1180 | 1 |
| 00:06:09 | 02 | ASK | | 1190 | 1 |
| 00:06:08 | 03 | SELL TO | 05 | 1100 | 1 |
| 00:06:04 | 06 | ASK | | 1180 | 1 |
| 00:05:59 | 04 | ASK | | 1189 | 2 |
| 00:05:58 | 01 | ASK | | 1170 | 2 |
| 00:05:53 | 06 | ASK | | 1169 | 2 |
| 00:05:49 | 02 | BID | | 1000 | 1 |
| **00:05:44** | **05** | **SELL TO** | **02** | **1000** | **1** |
| 00:05:42 | 02 | ASK | | 1190 | 1 |
| 00:05:41 | 01 | BID | | 1002 | 2 |
| 00:05:36 | 00 | ASK | | 1160 | 1 |
| 00:05:32 | 04 | ASK | | 1189 | 1 |
| 00:05:30 | 03 | SELL TO | 05 | 1100 | 1 |
| 00:05:30 | 06 | BID | | 1050 | 1 |
| 00:05:23 | 00 | BID | | 1100 | 2 |
| 00:05:18 | 07 | SELL TO | 00 | 1100 | 1 |
| 00:05:18 | 07 | SELL TO | 00 | 1100 | 1 |

Table 14.5 The effect of outrageous errors



## 14.5 FINAL REMARKS

This experiment shows that buyer and seller behavior influence price formation in the market in different ways. The difference between "buyer" and "seller" behavior was partially explained by speculative activity which is responsible for much of the departure from competitive prices. Average prices were nearer to the buyer price than to the seller price in both cases. Although phase C did not confirm this result because it was difficult for most subjects to trade in both markets at the same time, we can argue that in the case of a single market the microstructure of demand clearly depended on this difference. On the other hand, outrageous errors hardly modified bidding/asking activity and transaction prices.

From the point of view of the process (rather than the final price) we found that transaction price changes were negatively correlated with a coefficient that grew in value with the experience of the subjects, and the seller's adaptative behavior was more pronounced towards the buyer's price than vice versa.

With regard to bidding and asking activities, we found that improvements on a bid (ask) by the same seller (buyer) were more common than improvements by different traders and that the ask-bid spread showed a learning effect across the phases, even if no common trend emerged.

To analyse the congruence between actual transaction prices and potential prices (asks and bids) we considered the timing of transactions and discovered that it was relevant for trading activity because there was a deadline effect in each phase and cyclic patterns of transactions.

# Appendix : Figures

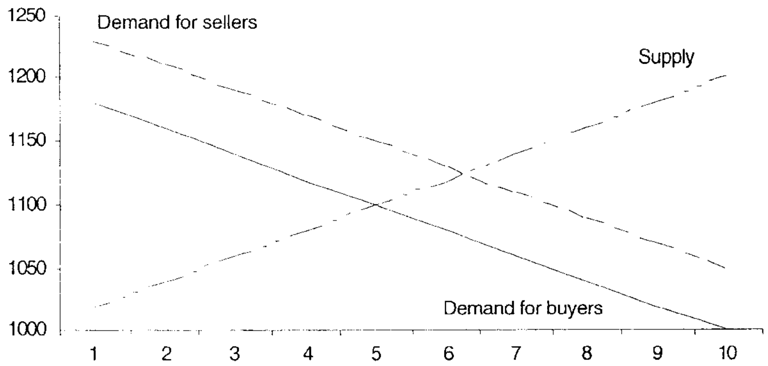


Figure14.1: Parameters for Phase A

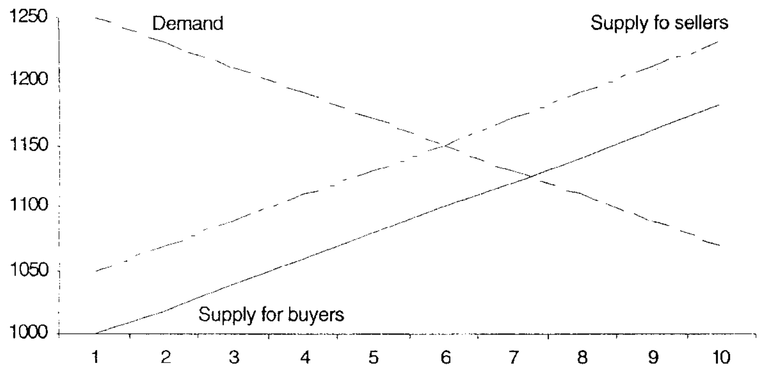


Figure14.2: Parameters for Phase B



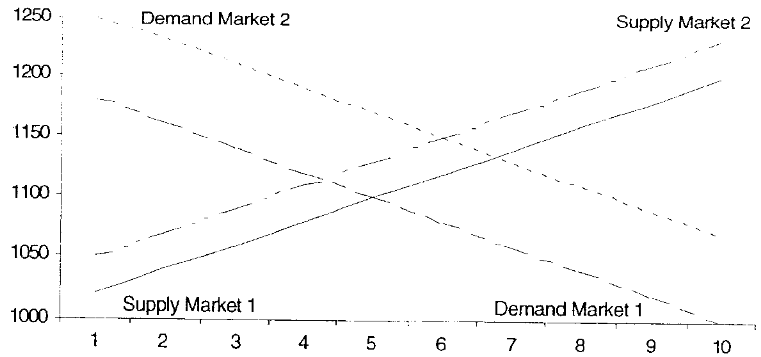


Figure14.3: Parameters for Phase C

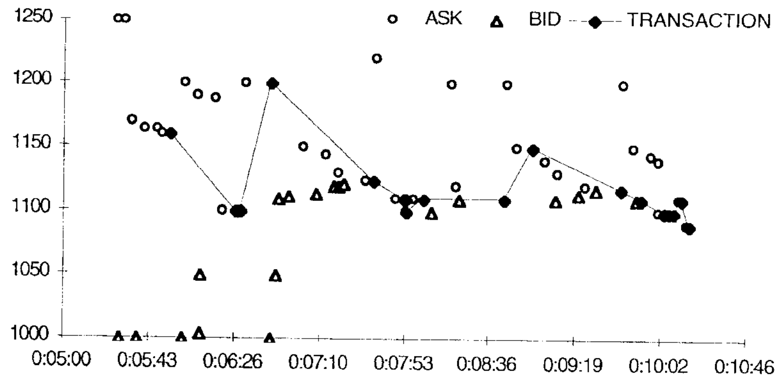


Figure 14.4: Phase A First Period – Plot of Bids, Asks and Transactions Prices

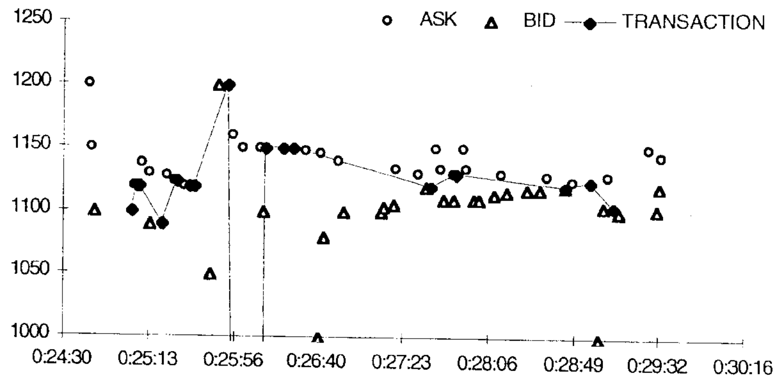


Figure 14.5: Phase A Second Period – Plot of Bids, Asks and Transactions Prices

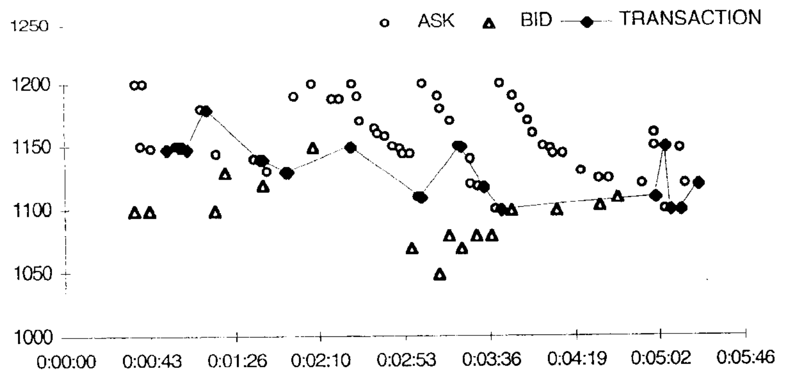


Figure 14.6: Phase B First Period – Plot of Bids, Asks and Transactions Prices

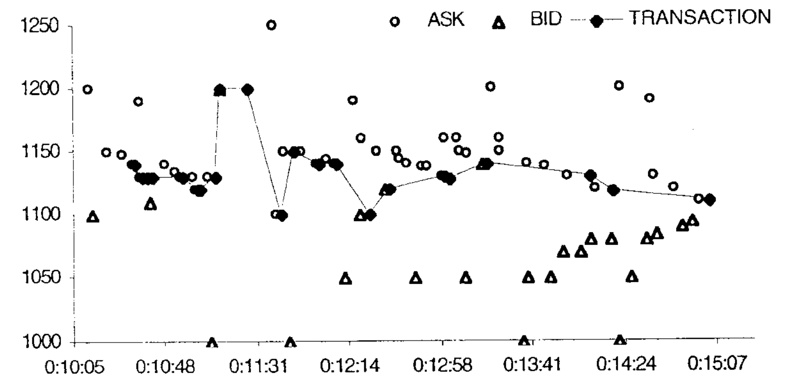


Figure14.7: Phase B Second Period - Plot of Bids, Asks and Transactions Prices

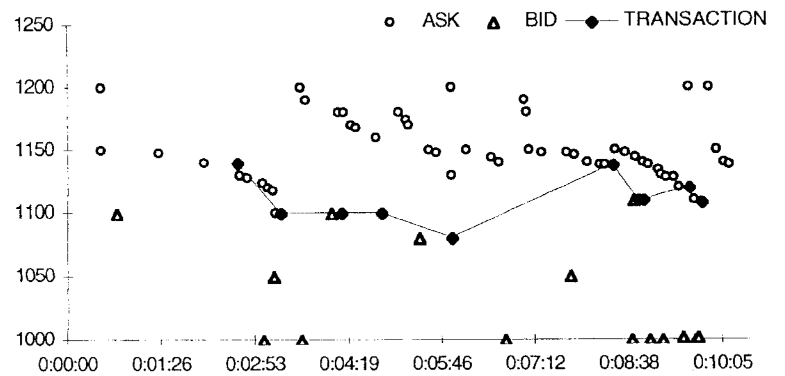


Figure14.8: Phase C Market 1 - Plot of Bids, Asks and Transactions Prices



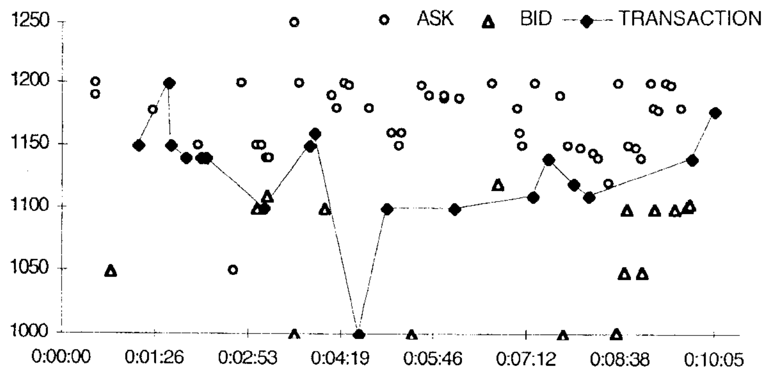


Figure14.9: Phase C Market 2 - Plot of Bids, Asks and Transactions Prices

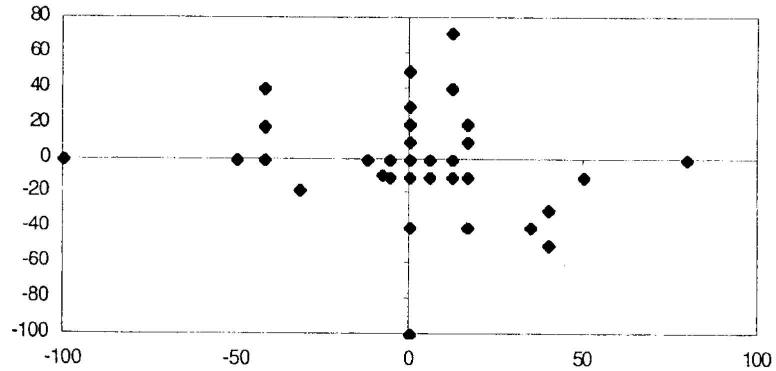


Figure 14.10: Phase B – Plot of Price Change (X axis) against Lagged Price Change (Y axis)

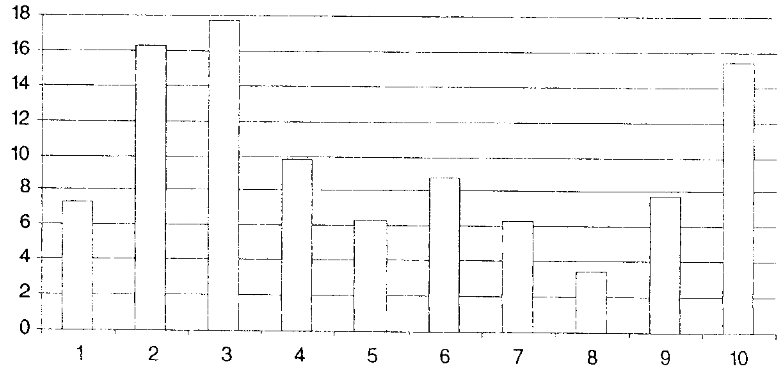


Figure14.11: Timing of Transactions, Average Values – Subperiods (X axis); no. of Transactions in Percentage of the Total of the Period (Y axis)

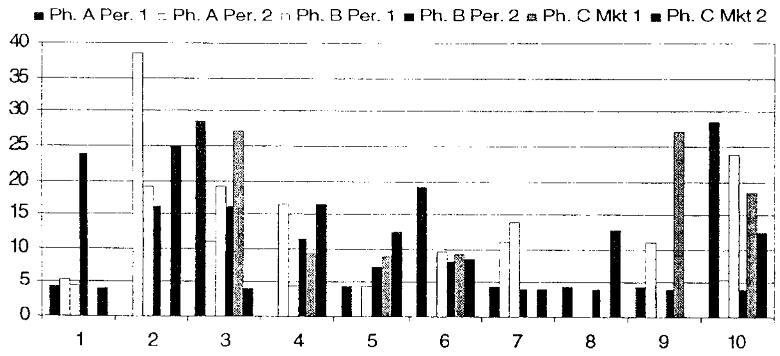


Figure 14.12: Timing of Transactions - Subperiods (X axis); no. of Transactions in Percentage of the Total of the Period (Y axis)

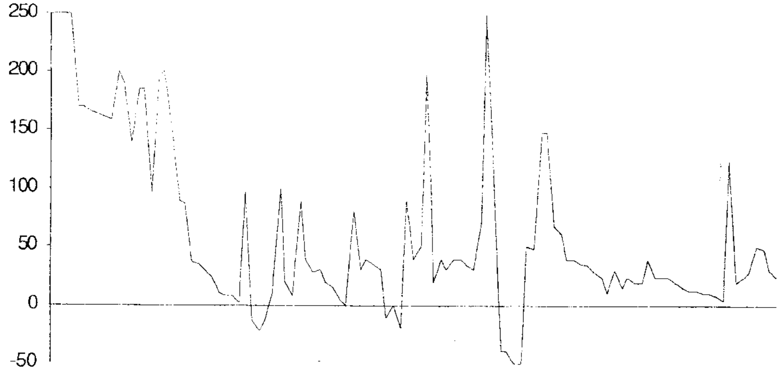


Figure 14.13: Phase A - Ask-Bid Spread

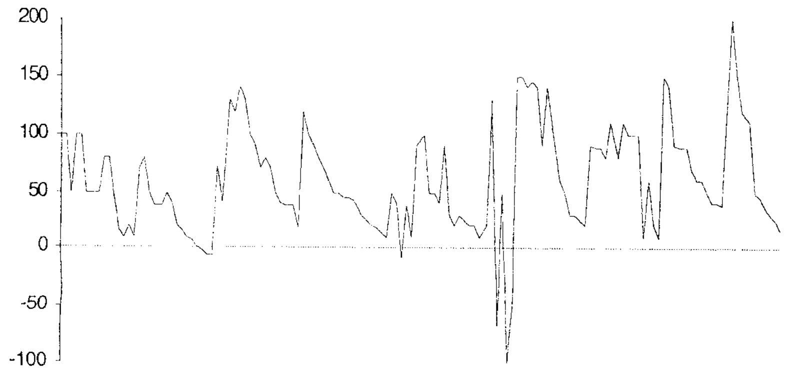


Figure 14.14: Phase B - Ask-Bid Spread



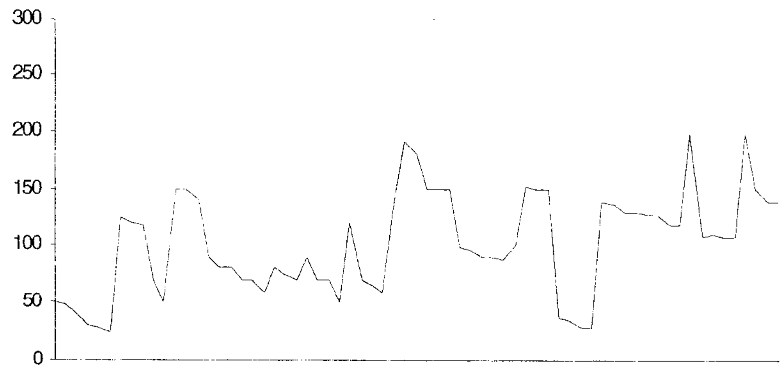


Figure 14.15: Phase C Market 1 - Ask-Bid Spread

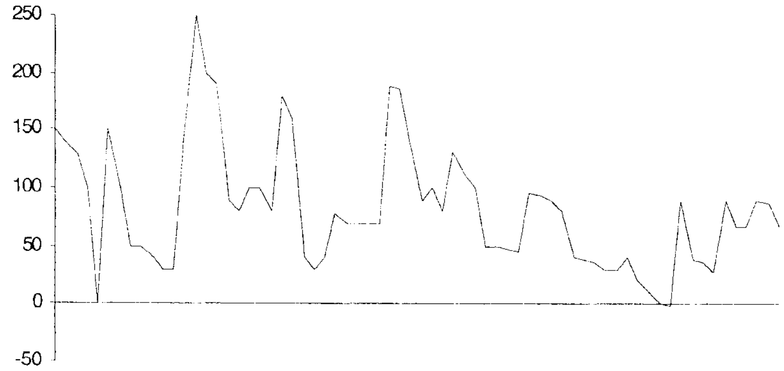


Figure 14.16: Phase C Market 2 - Ask-Bid Spread