Insider trading, imitative behaviour and price formulation in a stimulated double-auction stock market

Additional Information:

- Economics Research Paper, no. 00-01

Department of Economics

Economic Research Paper No. 00/01

Insider Trading, Imitative Behaviour and Price Formation in a Simulated Double-Auction Stock Market

Olivier Brandouy, Pascal Barneto
(Université de Limoges, France)
and
Lawrence A. Leger
(Loughborough University)

January 2000

Loughborough University

Centre for International, Financial and Economics Research
Department of Economics
Loughborough University
Loughborough
Leics., LE11 3TU
UK

Tel: + 44 (0)1509 222734
Fax: + 44 (0) 1509 223910
Email: E.J.Pentecost@lboro.ac.uk

Insider Trading, Imitative Behaviour and Price Formation in a Simulated Double-Auction Stock Market

Abstract

This paper presents the results of a series of experiments in a simulated double-auction stock market. Price formation was observed under various manipulations of asymmetric information and communication, including conditions intended to promote imitative behaviour and rumour. Inefficient prices were observed when the presence of insiders was completely disguised – that is, prices reflected the expectations of non-insiders. When the presence (but not the identity) of insiders was revealed there was a sharp increase in imitative behaviour that appeared to be one-sided – observed prices became efficient with respect to bad news but not with respect to good news. When subjects were allowed to communicate uncertain information to create a climate of rumour (they could lie, tell the truth and/or spread rumours but were forbidden to prove the veracity of any communication) there was a decrease in both efficiency and price volatility – that is, informational noise appeared to mask the signals of insiders. Price formation under these conditions was similar to the homogeneous expectations baseline, but there was also some evidence of speculative pricing.

Insider Trading, Imitative Behaviour and Price Formation

in a

Simulated Double-Auction Stock Market

1. Introduction

The effects of asymmetric information, rumours and what Black (1986) has referred to as 'noise trading' have provoked an increasing degree of academic interest over the past few years, but the behavioural mechanisms of information dissemination and price discovery are still poorly understood. The existence of asymmetric information in asset markets allows the possibility of adverse selection (the exploitation of private information when trading with uninformed agents, for example by offering for sale only inferior quality assets). This in turn motivates not only the search for information by market traders but also the communication of misleading information and other strategic behaviour. For the uninformed, a situation of general uncertainty may also lead to imitation (and ultimately to 'herd' behaviour): as Grossman (1976) has observed, when confidence in fundamentals disappears, naive imitative behaviour may actually be the best option. While there has been a considerable literature on the effect of the structural characteristics of markets on informational efficiency there appears to have been very little systematic research either into the effects of misleading information and rumour or into the conditions under which imitative behaviour is likely to occur. The experimental approach is ideally suited to investigations of this kind since it is possible to control both the structure of the market and the signals through which information is disseminated.

This paper presents the results of a series of experiments in a simulated double-auction stock market. Price formation was observed under various manipulations of asymmetric information and communication, including conditions intended to promote imitative behaviour and rumour. Inefficient prices were observed when the presence of insiders was completely disguised – that is, prices reflected the expectations of non-insiders. When the presence (but not the identity) of insiders was revealed there was a sharp increase in imitative behaviour that appeared to be one-sided – observed prices became efficient with respect to bad news but not with respect to good news. When subjects were allowed to communicate uncertain information to create a climate of rumour (they could lie, tell the truth and/or spread rumours but were forbidden to prove the veracity of any communication) there was a decrease in both efficiency and price volatility – that is, informational noise appeared to mask the signals of insiders. Price formation under these conditions was similar to the homogeneous expectations baseline, but there was also evidence of imitative behaviour and a small amount of speculative price formation.

There is a fairly large theoretical and empirical literature on the effects of asymmetric information on market efficiency. Much of the debate focuses on the institutional conditions under which the behaviour of insiders will transmit revealing signals that lead to efficient price discovery, but less seems to have been written about the strategic behaviour of market participants and behavioural mechanisms of price formation.

When information is asymmetric but perfect, experimental evidence suggests that market prices are fully efficient (Plott and Sunder, 1982; Sunder, 1992). When information is imperfect, it appears that dissemination in experimental markets is partial. Leland (1992), has suggested that insider trading leads to greater informational efficiency, lower market liquidity, more volatile prices and ambiguous overall welfare effects. Copeland and Friedman (1991) examine price formation in experimental asset markets, finding evidence of partial revelation of private information that supports a semi-strong form of market efficiency. Ackert *et al.* (1997) present evidence for Bayesian pricing with partial (and somewhat slow) dissemination of information in experimental, oral, double-auction markets. The degree of non-Bayesian pricing (generally occurring as price under-reaction) seemed to increase with the uncertainty of private information. Ackert and Church (1998) find that information dissemination and insider profits in experimental markets are affected by the traders' previous experience, and suggest that efficiency increases with both the number of insiders and the experience of traders. The substantive effect of insider trading on market prices in the real world has been the subject of some debate. The case histories of illegal insider trading presented by Cornell and Sirri (1992), Meulbroek (1992) and Chakravarty and McConnell (1997) (involving relatively large trading volumes) appear to provide strong evidence that insider trading is significantly correlated with stock-price run-ups. However, these studies have recently been subjected to methodological criticism by Chakravarty and McConnell (1999) who argue that these studies did not compare the effects of insider trading to the effects of normal (non-insider) trading and that no such conclusion can be sustained when the appropriate comparisons are made.

These studies raise the question as to whether relatively large volumes of insider trading are necessary in order to communicate information through price signals. There is a conceptual distinction between small (but revealing) price signals that are subsequently exaggerated by large volumes of imitative uninformed trading (fads and herd behaviour) and large price changes that are directly initiated by large volumes of insider trades.

Holding constant the institutional characteristics of markets (such as market transparency) and the diligence of search behaviour, we might expect the quality of a signal generated by inside trading to be influenced by the market power of insiders. This empirical question seems to have received little attention[1].

Similarly, holding constant the number of insiders and their market power, we may expect the quality of a price signal to be influenced by the institutional features of the market. This has been the subject of a considerable amount of research, largely stimulated by the theoretical models of Kyle (1985) and Glosten and Milgrom (1985). In particular, researchers have asked whether market liquidity, transaction costs, informational efficiency, price discovery and the welfare of market participants are influenced by the structural characteristics of trading arrangements (particularly with respect to disclosure of information and market transparency). Madhavan (1992) distinguishes between quote-driven and order-driven markets, arguing for more efficient price discovery in the quote-driven system. Pagano and Roell (1996) use a theoretical model in which the effect of insider trading on market liquidity is examined in markets that are classified by degree of transparency (the extent to which market makers are able to observe the size and direction of the current order flow). They conclude that market makers are able to reduce the bid-ask spread (increase market liquidity) in more transparent markets (such as the call auction of Kyle, 1985), with consequent benefits to uninformed traders. Schnitzlein (1996), also based on Kyle (1985), presents results from experimental market trading comparing call auctions (buy and sell orders collected over an interval, batched, then executed at a single price) and continuous auctions (buy and sell orders executed on arrival). Schnitzlein finds not only that call auctions are no less efficient than continuous auctions but that they are more liquid and lead to lower adverse selection costs for uninformed traders. Lamoureux and Schnitzlein (1997) present experimental results suggesting that market makers price more aggressively when bilateral trades between liquidity traders are allowed, with a consequent decrease in dealer profits. Garfinkel and Nimalendram (1998) conclude that the NYSE is less anonymous than NASDAQ, encouraging price discovery, reducing the problem of adverse selection and reducing transaction costs. Bloomfield and O'Hara (1999) manipulate information disclosure

[1] Franciosi *et al.* (1996) and Guth *et al.*, (1997) have reported experiments on the so-called 'endowment effect' that predicts undertrading (willingness to accept greater than willingness to pay). They have found, *inter alia*, that the portfolio choices of individuals are affected by the composition of their initial endowed portfolios. However, we have been unable to find any papers that directly test whether markets with rich insiders display greater price efficiency than markets with poor insiders.

in experimental markets and find that disclosure increases efficiency (more rapid convergence to true value) but may increase bid-ask spreads at market opening and allow market makers to benefit at the expense of both uninformed traders and liquidity traders. The results of Bloomfield and O'Hara are apparently contradicted by those of Flood *et al*. (1999), whose experimental design is based on the theoretical model of Glosten and Milgrom (1985). Flood *et al*. find that pre-trade spreads are wider, and initial volume lower, in opaque experimental markets, but that price discovery is accelerated in opaque markets by aggressive pricing by market makers seeking information once trading begins.

The general consensus of this research seems to be that greater disclosure of information improves price discovery but that secondary effects on welfare, transaction costs and liquidity depend quite sharply on specific trading arrangements in the particular markets. As Glosten (1999) has observed, the apparent contradictions between Bloomfield and O'Hara (1999) and Flood *et al*., (1999) can be at least partly explained by differences in experimental treatments and controls[2], providing insights into the sensitivity of price formation to specific experimental trading arrangements[3].

The behavioural mechanisms of communication and price formation seem to be less well documented. Of particular interest are (i) strategic behaviour by traders trying to exploit privileged information and/or to create opportunities through rumour or bluff, and (ii) imitative behaviour by uninformed traders.

Communication mechanisms have been the focus of a small literature[4] on experimental games, but only a very few papers seem to have been written about strategic insider behaviour (such as providing misleading information in an attempt to enhance gains from adverse selection). Glosten (1989) describes a model in which a specialist with a monopoly of information is able to price-discriminate between trades in order to make strategic profits. Neuberger and Hansch (1996), in a study of dealer behaviour on the London Stock Exchange, conclude that dealers seek to avoid quoting prices that reveal information

---

[2] For example, Flood *et al.* employed experienced professional traders who used very positive strategies for discovering information in opaque markets.

[3] The sensitivity of results to experimental manipulation (sometimes unintended) has been long established in experimental psychology. Researchers in experimental economics have begun to be similarly aware: for example, Tuttle *et al.* (1997) show that efficiency in experimental double-auction markets is influenced by the order in which information items are presented.

[4] This is a literature in which information is either held in common or must be disclosed in order for trade to occur. Thus there is no scope for adverse selection. (For a brief review of this literature see Forsythe *et al*., 1999).

and instead trade on their own account, accepting losses on some trades in order to make abnormal profits on others. In the only experimental paper we have been able to find, Forsythe *et al.* (1999) report results from a very tightly-controlled experiment incorporating two conditions on communication. To investigate adverse selection, insider sellers were either allowed to make unrestricted claims about the value of the asset to be traded ('cheap talk') or were required to give a range of estimated values which contained the true value ('anti-fraud'). Experimental parameters were manipulated so as to ensure the existence of gains from trade. The predicted Nash equilibrium involving credible communication of sellers' information and full market efficiency was not achieved, although both types of communication led to an increase in efficiency compared to a 'no-communication' control (in which adverse selection was evident). There was a transfer of wealth from buyers to sellers under the 'cheap talk' condition – buyers evidently believed exaggerated claims under the 'cheap talk' condition because they tended to pay too much for the asset[5]. The paper by Flood *et al.* (1999) is an excellent example of tight control and precise hypothesis-testing, but this is achieved by surrendering the richness of a continuous and dynamic market environment. In the experiments reported below we have investigated, *inter alia*, the responses of subjects who were allowed freedom to use strategic behaviour in continuous trading with relatively few controls on communication.

The literature on imitative behaviour examines how individual actions aggregate into 'herd' behaviour that is not obviously consistent with underlying economic fundamentals[6] – for example, models of fads (Shiller, 1984), speculative dynamics (Cutler *et al*., 1990, 1991) and informational cascades (Bikhchandani *et al*., 1992, 1998). Other interesting theoretical developments have focused specifically on the contagious nature of imitative behaviour. Thus, Topol (1991) describes stock market traders with incomplete information who assume that different prices posted by other traders represent information different from their own. These traders therefore condition their bid/ask offers on the average of the bid/ask offers of traders with whom they are in direct contact, as well as on their own (incomplete) information about fundamental values, with contagion-led speculative bubbles emerging in more-or-less mechanical consequence. The model of Banerjee (1993) is similar to that of Topol but incorporates optimisation behaviour by individual investors. For Banerjee, each investor uses

[5] This result is not readily explained – multi-period strategies were irrelevant and all subjects had experience as both buyer and seller and were prevented from engaging in side-deals.

[6] See Spotton and Rowley (1998) for a review of both orthodox and unorthodox approaches to the treatment of market volatility.

an optimal Bayesian rule to decide whether to invest in a project with uncertain profitability, and only learns of the existence of the project from another agent who has already accepted the opportunity to invest. This means that the probability of receiving the uncertain information increases with the number of other people who have invested – a ‘rumour’ process. The model of herd behaviour used by Scharfstein and Stein (1990) is in some ways similar but uses a very different set of behavioural assumptions. These authors assume that managers seek to increase their worth on the labour market by deliberately mimicking the investment behaviour of other managers. If successful, they are perceived as ‘smart’ but if unsuccessful they are able to share the ‘blame’ with a large number of others. Such imitative behaviour leads to socially inefficient outcomes that are nonetheless individually rational. In empirical work that gives some support to the notion of contagion, Camerer and Weigelt (1991) report that experimental market traders occasionally over-react to uninformative trades during the early part of trading sessions, creating information mirages and mini-bubbles when no insiders are present. The general conclusion of the theoretical literature on communication and imitative behaviour is that speculative bubbles and crashes may be provoked by the contagious spread of uncertain (and possibly highly inaccurate) information between uninformed traders. However, very little empirical evidence has been so far presented to support this conclusion.

Our experiment adds to the literature reviewed above by reporting results from continuous double-auction markets characterised by asymmetric information and several different conditions on communication. We examine price formation when: i) the presence of insiders is either known or unknown; ii) insiders have varying degrees of market power; and iii) free communication is allowed (intended to stimulate rumour and imitative behaviour).

2. Experimental Design

The general design of the experiment is presented in Table 1. In an attempt to retain experimental control while simultaneously allowing a reasonable degree of contextual richness and realism we used regime changes to achieve successive experimental manipulations with a single group of subjects (traders). Each session differed with respect to a single aspect of information dissemination. Sessions were long enough (about 30 to 70 minutes) to allow dynamic price formation processes (such as feedback trading, strategic trading by insiders, portfolio re-composition) while possible learning effects were mitigated by providing training prior to the baseline session.

Table 1. Experimental Design

	Duration (seconds)	Insiders exist	Specification	Role of session
Session 1	2750	No	• Identical endowments • Homogeneous expectations (identical information) • Communication between traders not permitted	Baseline
Session 2	1783	Yes	• Inside traders exist, unknown to uninformed traders • Identical endowments • Communication between traders not permitted	Test
Session 3	1792	Yes	• All traders know that unidentified insiders exist • Identical endowments • Communication between traders not permitted	Test
Session 4	1950	Yes	• All traders know that unidentified insiders exist • Insiders given larger endowments than non-insiders • Communication between traders not permitted	Test
Session 5	4200	Yes	• All traders know that unidentified insiders exist • Identical endowments • Communication between traders encouraged	Test

An undesirable feature of this approach was the surrender of control over the manipulation of ‘rumour’. We aimed at creating a climate in which rumour would flourish by allowing subjects to communicate with almost total freedom – they were forbidden only to prove the veracity of their communications (that is, they were not allowed to show messages they had received from the experimenters). This meant that we could not guarantee the emergence of rumour, or dictate its type, but neither were we constrained by a sterile, static environment[7].

Hypotheses

Session 1 provided a homogeneous expectations baseline against which to measure the effect of the secret introduction of asymmetric information in session 2. In session 3, announcing the existence of anonymous insiders was intended to produce a step-wise increase in the transparency of the market[8]. Session 3 also provided a natural baseline against which to measure the effects of the endowment manipulation of session 4 and the rumour manipulation of session 5. The following hypotheses are represented by these manipulations:

1. Price formation is efficient in a simulated asset market with homogeneous information.
2. Price formation is strong-form inefficient when the existence of asymmetric information is disguised and traders are naïve.
3. The simple announcement that insiders exist leads to an increase in market efficiency (because of an effective increase in market transparency).
4. Market efficiency increases when insiders have market power (because of an effective increase in market transparency).
5. The incidence of speculative bubbles and crashes increases in a climate of rumour (An effective decrease in market transparency when the presence of insiders is suspected).

Procedures

The experiments were conducted in a simulated electronic stock market, using computer software obtained from the Economic Science Laboratory at the University of Arizona, requiring a DOS-based local network. The market was a double-auction order-driven stock market that was not subject to any fiscal, financial or institutional regulation. Trading was continuous and all orders and trades were recorded centrally. The market was simplified in the sense that i) only one stock was traded, ii) traders were not allowed to borrow or lend their

[7] This is a trade-off inherent in all experimental work and there is a place for both extremes.
[8] The manipulation also helped to prevent unwanted learning effects since it meant that all traders were simultaneously alerted to the informational content of price signals.

endowed capital, iii) information was presented simultaneously to all traders (although different traders could receive different information) and iv) there were no formal transaction costs. Informal transaction costs were present in the sense that it required vigilance and effort on the part of traders to follow and interpret the information available through the order book. Illustrations of the trading screen and the Order Book are given in Appendix 1, together with the summary instruction sheet.

Traders (the experimental subjects) were given an initial endowment of shares and cash (‘experimental’ dollars) and could trade until either bankruptcy or the end of the session. To ensure subject motivation and continued participation throughout the entire series of experiments the endowment was re-set to the original amount at the beginning of each session. In fact, no bankruptcies were observed.

The exact duration of each session was not known to the subjects in advance, because it was necessary to encourage active trading at all times and to avoid flurries of last-minute trading. As the results indicate, this goal was achieved. The basic features of each session were standardised (the same laboratory, the same traders, the same experimental procedures) to give a constant and controlled experimental environment.

In each session an initial price of $4 was established by reference to preceding hypothetical trading periods. Information conveying good or bad news was presented at random times during trading. This information was revealed by a system of coded messages projected onto a screen and signalled by a clearly audible bell. Each message consisted of an alpha-numeric code (such as A453 or B877) which could be quickly interpreted by reference to a code-sheet (private to each trader) linking the observed code to a very simple probability distribution of values. The prefixes A and B always signified good and bad news respectively, while the numeric suffix identified a particular probability distribution on the code-sheet. Traders were therefore immediately able to judge the quality of the information and could quickly adjust their orders in general. The only exception was for ‘current’ offers (defined as the highest bid and the lowest ask) which could not be withdrawn. For example, the coded message A741 indicated that the stock price should rise (from a pre-existing value of about $3.70). The possible share values associated with this message are shown in Table 2, as $3.80, $3.95 or $4.10, with probability .5, .25 and .25 respectively.

Table 2. Example of Code and Corresponding Information

Coded Message	Information (Probability Distribution)		
	25%	50%	25%
A741	3.80	3.95	4.10

This procedure allowed asymmetric information to be introduced in controlled and discreet fashion and had two particular advantages. First, it was unnecessary for traders to perform complicated calculations in order to arrive at possible stock values, thereby avoiding unnecessary transaction costs. Second, it was possible to introduce different private information to different traders by altering the contents of the code-sheet reference tables provided to particular individuals. Values revealed to insiders were always higher for good news and lower for bad news than those revealed to other traders and insiders were always aware that the true value of the share would be drawn from their private information.

New information was delivered to the market at random time intervals, varying between 1 and 15 minutes. The average number of messages per session was 12, but with some variation between sessions. The messages did not appreciably interrupt the continuous flow of trading.

Traders were able to choose portfolio management strategies that depended on both coded information and the behaviour of other traders (they could observe the complete order book on the computer screen at all times during each session, and could therefore see all prices and quantities proposed for trading). They were able to propose their own orders (ask or bid) and accept the orders of others either wholly or in part. Orders to sell (ask) could be implemented either by proposing a price lower than the current lowest asking price or by accepting another trader's bid. Similarly, orders to buy could be implemented either by increasing the current highest bid or by accepting the current ask. Thus, the lowest asking price and the highest bid price constituted the current bid-ask spread of the market while market depth was shown by the quantities of shares displayed in the complete order book. Traders could occupy more than one bid or ask position simultaneously and could either raise their bid or lower their asking price. They were also able to see their position in the order book by an asterisk, visible only to themselves, and to keep track of the composition and value their own portfolios.

To examine price efficiency and imitative behaviour we carried out tests for co-integration between observed prices and expected prices (with either public or insider information). The means of the probability distributions for the information series were taken from a computer-generated random walk so that the current information message estimated the rational expected price (conditional on either insider or non-insider information, as appropriate).

Experimental Subjects

12 student volunteers (MSc students[9] of Banking, Economics and Finance) participated in the experiment as traders in the simulated market. An initial training session of 90 minutes was given prior to the experimental sessions to ensure that each participant was thoroughly familiar with the computerised quotation system, the mechanisms of trading and the dissemination of information.

Each subject was paid a fixed participation fee of £10, plus a variable amount that depended on the results of their simulated trading over the five experimental sessions. While the amounts earned were relatively small, all of the subjects became enthusiastically caught up in the competitive market spirit of the experiment. Profits and losses from each session were accumulated over the entire experiment, but endowments were re-established at the beginning of each session. In this way, rewards were made linked to total experimental performance. In order to even out the opportunities for profit across all participants (to prevent any post-experiment acrimony) each participant was designated as an insider on one occasion during the experiment.

The endowment given to each trader at the beginning of each session consisted of an amount of shares (a risky asset) and cash (which earned a risk-free rate of return). The size of the endowment was varied only in session 4. At the end of each session the values of portfolios were calculated by using the end-of session share price and a 10% rate of return on cash. The end-of-session share price was drawn at random from the probability distribution of possible insider share values defined by the last information message of the session – that is, the probability distribution seen by insiders always included the correct share value and insiders were aware of this. Since traders could not predict the exact time at which a session would terminate, any information message had the possibility of being the last.

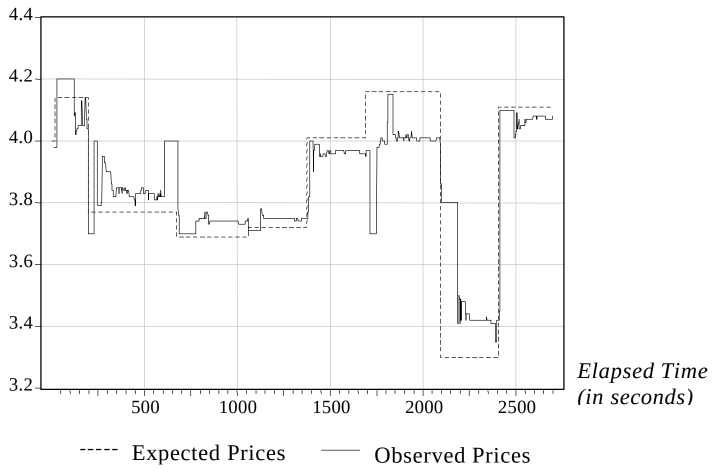
[9] Such 'student-traders' have been widely used in experimental economics and seem likely to to generate qualitative results similar to those provided by professional traders (Dejong *et al.*, 1988) although see also footnote 2 above.

3. Experimental Results

Session 1: Base-line (Homogeneous Endowments and Information)

In this session all traders received the same information and endowments. Nothing about the conduct of this (or any other) session gave any indication about the experimental manipulations of subsequent sessions. The session was used to establish a homogeneous expectations base-line against which to compare other results. The session was also made long enough to ensure that subjects were fully trained, thereby adding to the extensive prior instruction and practice. Results are presented graphically in Figure 1, where it is evident that new information is quite quickly reflected in market prices.

Figure 1. Evolution of Prices in Session 1



Efficiency requires information to be immediately incorporated into observed prices. If both the observed and expected prices are non-stationary I(1) processes, this implies that the two series should have a stationary I(0) co-integrating relationship. To test for this we assigned an expected price and an observed price to each second of the session. There is a problem with this procedure – although the information series was itself generated as a random walk, the implied expected prices necessarily remained constant for relatively long intervals (see Figure 1). This appears to violate the assumption that the expected price series is stochastic, but without a clearly superior alternative we report the co-integration results.

We tested for unit roots in the price series using sequential augmented Dickey-Fuller tests (ADF) in the manner of Jobert (1992). The results are displayed in Table 3.

Table 3: Results of Sequential ADF tests on Session 1 Price Series

Session 1	Expected Prices	Observed Prices
Value of ADF	-2.334173	-2.8475
Rejection Threshold	10%: -2.8631	5%: -2.8631
Jobert Diagnosis of Process	I(1)	I(1)

Evidently the observed and expected prices both follow a non-stationary I(1) process. Efficiency requires the observed prices to follow the expected prices very closely (information is immediately incorporated into observed prices) implying that the observed and expected price series should have a stationary I(0) co-integrating relationship. The results of a Johansen testing procedure are presented in Table 4.

Table 4. Results of Johansen Tests on Session 1 Observed and Expected Price Series

	Likelihood Ratio	Critical Value 5%	Critical Value 1%	Decision on Hypothesis
$H_0^1: r = 0$	18.2928	12.53	16.31	Rejected*
$H_0^2: r \le 1$	0.02128	3.84	6.51	Accepted

The order of co-integration is denoted by *r*. H_0^1: the series are not co-integrated. H_0^2: there exists at most one co-integrating relationship.* Hypothesis rejected at 1% level. Critical values from Osterwald-Lenum (1992).

Hypothesis H_0^1 is rejected at the 1% level while hypothesis H_0^2 cannot be rejected. It is therefore likely that observed and expected prices are co-integrated and that the market can be regarded as reasonably efficient. Normalising on OP_t gave the estimate $OP_t - 1.00282EP_t$ (standard error 0.00832).

Despite the evidence of co-integration, it appears from Figure 1 that there tends to be an under-reaction to new information, suggesting that perfect efficiency may not have been entirely achieved. To examine this further we define the deviation of observed (OP_1^t) from expected (EP_1^t) prices as the 'spread' (S_1^t):

(1) $$S_1^t = OP_1^t - EP_1^t .$$

The subscript denotes session 1, while the superscript denotes elapsed time during the experimental session. The evolution of S_1^t is shown in Figure 2, with descriptive statistics given in Table 5. A non-zero value of S_1^t evidently measures a component of price that is not explained by current information in a risk-neutral market. While this may reflect a degree of informational inefficiency it could also be due to learning effects or risk-aversion. Since S_1^t does not differ significantly from zero we conclude that the results from session 1 cannot be used to reject a hypothesis of market efficiency, and can therefore be used as a base-line against which to compare the results of other sessions.

Figure 2. Spread S_1^t for Session 1

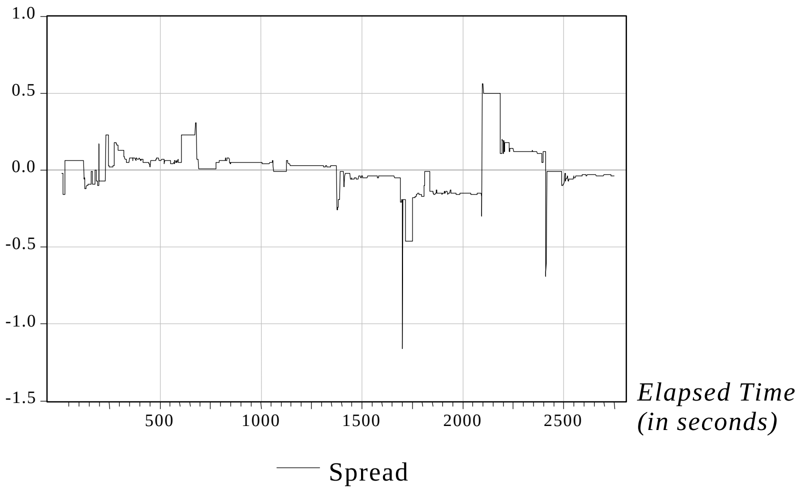


Table 5. Statistics of Spread S_1^t

Statistic	**Value**
Mean	0.01333
Median	0.20
Maxim.	0.56
Min.	-1.16
Std. Dev.	0.147242

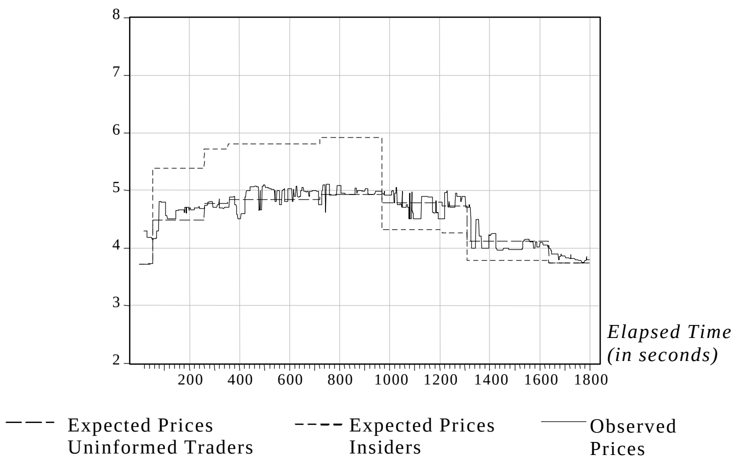
Session 2. Unannounced Presence of Insiders, Homogeneous Endowments

In Session 2 an attempt was made to influence market prices by introducing asymmetric information and insider trading, with initial endowments being equal for all traders. Insiders received privileged information about true market values and their presence in the market was not disclosed to other traders. Since the experimental subjects were naïve with regard to asymmetric information and insider trading we did not anticipate any appreciable change in price formation (hypothesis 2).

Privileged information was introduced by giving insider traders a different code-sheet. Insiders were told both of their privileged position as insiders and that their information was true (a random drawing from the insider code-sheet was used to determine end-of-session share prices). Insiders were therefore in a position to benefit from each new piece of information by exploiting the erroneous share valuations of uninformed traders.

Figure 3 shows the behaviour of observed prices in session 2, OP_2^t. These are compared to i) the rationally expected prices for uninformed traders, EP_2^t, and ii) the rationally expected prices conditional on insider information, IP_2^t.

Figure 3. Evolution of Prices in Session 2



Comparing Figure 3 with Figure 1, it appears that the presence of insiders did not much affect the evolution of market prices – that is, efficiency with respect to insider information was not achieved[10].

[10] The two insiders were also able to exploit their private information for gain, making larger profits than the other traders in this session.

The observed price series actually contains information that might have been detected by skilled uninformed traders. We define the 'spreads' for uninformed and informed traders by SN_2^t and SI_2^t respectively:

(3) $$SN_2^t = OP_2^t - EP_2^t$$

(4) $$SI_2^t = OP_2^t - IP_2^t.$$

As indicated in Table 6 below, SN_2^t is significantly larger than S_1^t (the base-line session), indicating a significantly greater deviation of observed prices from their predicted path when insiders are present. The very large discrepancy between SN_2^t and SI_2^t reflects the non-transmission of insider information.

Table 6. Comparison of Mean values for SN_2^t and SI_2^t with S_1^t

	Mean	Std dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_2^t	-0.0517	0.1687	1783	13.317*	$H_0 : S_1^t$ and SN_2^t have identical means
SI_2^t	0.2885	0.6411	1783	-17.821*	$H_0 : S_1^t$ and SI_2^t have identical means

* Hypothesis rejected at the 1% significance level.

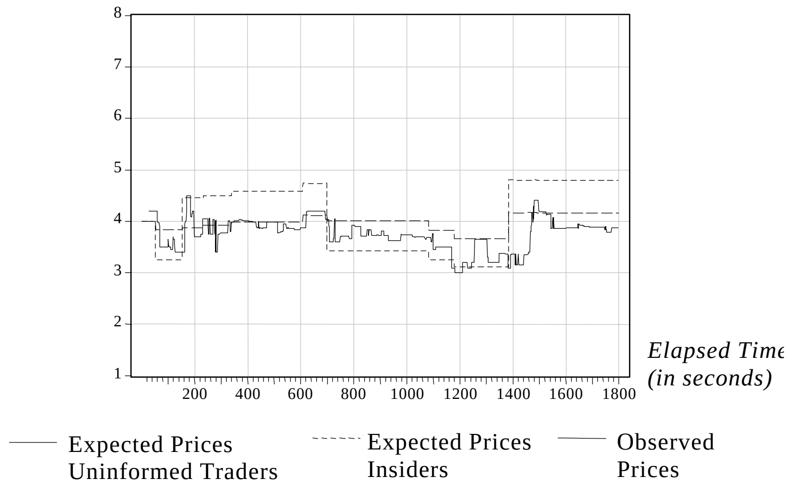
In summary, it appears that the unannounced introduction of traders with privileged information to a previously efficient market led to a small increase in price volatility whose significance was apparently not understood by uninformed traders.

Session 3. Insiders known to Exist, Homogeneous Endowments

In session 3 the existence of anonymous insiders was made known to all participants. All traders were made to understand that the insiders possessed privileged information that they could use to trade advantageously. This manipulation was intended to the informational transparency of the market simply by reducing the naivete of the participants. Under hypothesis 3, we anticipated a general increase in the efficiency of observed prices.

The evolution of prices in session 3 is depicted in Figure 4. An interesting feature of this Figure 4 is the tendency for observed prices to move towards the expected price for insiders following bad news but to move towards the expected price for uninformed traders following good news. Hypothesis 3 appears to be only partly confirmed.

Figure 4. Evolution of Prices in Session 3



Session 3 also produced very large spreads (SN_3^t and SI_3^t) compared to the base-line session, as shown in Table 7 below. The mean value of SN_3^t is 17 times greater than that of the base-line spread, S_1^t, (and 4½ times as large as the corresponding spread for session 2, SN_2^t) with a substantially larger standard deviation.

Table 7. Comparison of Mean values for SN_3^t and SI_3^t with S_1^t, Session 3

	Mean	Std Dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_3^t	0.23	0.2577	1792	-32,319*	$H_0 : S_1^t$ and SN_3^t have identical means
SI_3^t	0.3096	0.5802	1792	-21,176*	$H_0 : S_1^t$ and SI_3^t have identical means

H_0 rejected at 1% significance level.

The sensitisation of traders to the existence of insiders appeared to induce two types of behaviour. First, traders apparently began to imitate the behaviour of others, using both price and quantity information from the on-screen order book. Such behaviour is consistent with the findings of other researchers (Bloomfield and Libby 1996, Cao *et al.*, 1998). Second, reactions to ‘bad news’ were amplified, while reactions to ‘good news’ were damped. This counter-intuitive result seems to reflect risk-averse portfolio behaviour (avoidance of loss has greater priority than exploitation of uncertain gain – selling equities in a falling market both restricts further equity losses and increases the share of the riskless asset in the portfolio). It is also possible that the insiders may have felt liquidity constrained to the extent that the insider price signals were weaker in a rising market – that is, they may have better able to sell shares on receipt of bad news than to buy shares on receipt of good news.

There are two sub-periods in session 3 which provide evidence of imitative behaviour: *Interval 35-180* and *Interval 700-1500* (intervals measured in seconds of elapsed time). During both of these intervals insider information indicated a greater potential decline in asset values than did the information of non-insiders. The price paths for these two intervals are shown in Figures 5 and 6 while the corresponding spreads are given in Tables 8 and 9. It is evident that the spread for non-insiders, SN_3^t, is substantially greater than the spread for the baseline session, S_1^t.

Figure 5. Evolution of Prices during Interval 38-180, Session 3

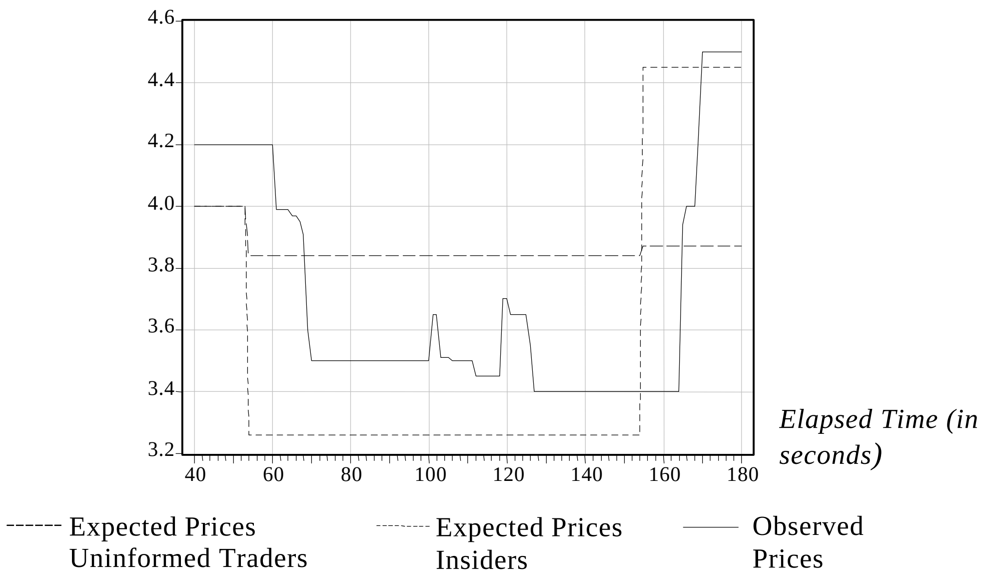


Figure 6. Evolution of Prices during the Interval 700-1500, Session 3

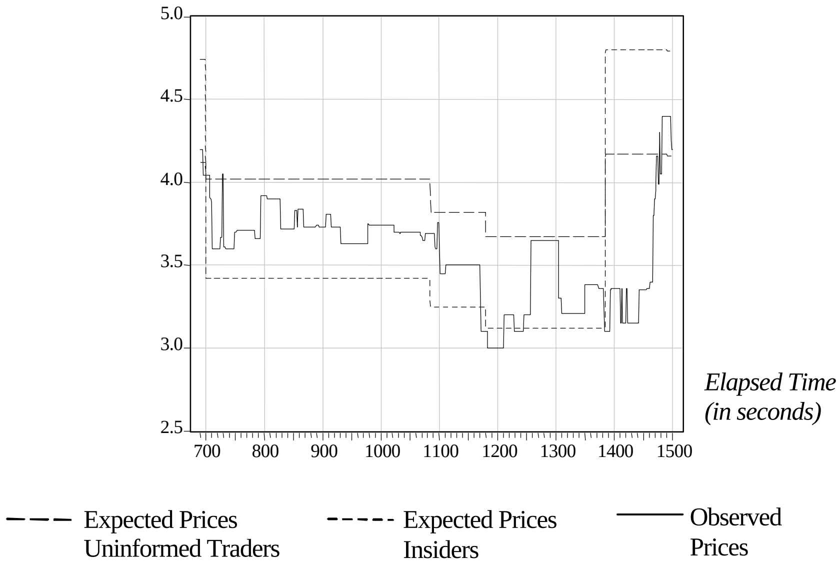


Table 8. Comparison of SN_3^t, SI_3^t and S_1^t, Session 3, Interval 38-180

	Mean	Std Dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_3^t	0.1467	0.3447	143	-4.6054*	$H_0 : S_1^t$ and SN_3^t have identical means
SI_3^t	-0.1575	0.4117	143	4.9448*	$H_0 : S_1^t$ and SI_3^t have identical means

H_0 rejected at 1% significance level.

Table 9. Comparison of SN_3^t, SI_3^t and S_1^t, Session 3, Interval 700-1500

	Mean	Std Dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_3^t	0.3648	0.2510	801	-37.761*	$H_0 : S_1^t$ and SN_3^t have identical means
SI_3^t	-0.040	0.5823	801	2.6005*	$H_0 : S_1^t$ and SI_3^t have identical means

H_0 rejected at 1% significance level.

It is possible that in *Interval 700-1500* uninformed traders had less confidence in information provided by the order book than in *Interval 35-180* – this could have been caused by the subsequent failure of insider orders to provoke a sustained price increase during *Interval 180-700.* That is, non-insiders may have come to distrust the quality of information conveyed by abnormal orders, perhaps because the volume of abnormal orders was too small. As already noted, an expectation that imitative behaviour would increase with the market power of insiders was the driving rationale behind the manipulation in session 4.

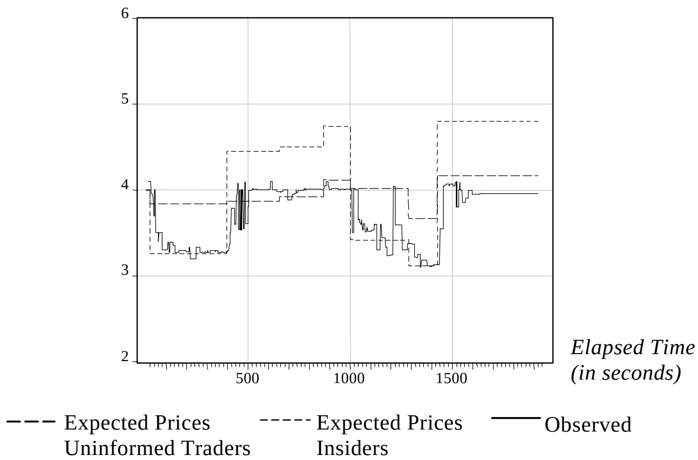
In summary, a degree of imitative behaviour emerged when uninformed traders used information available through the Order Book, although this was restricted to down-market conditions (periods of bad news). A comparison between sessions 2 and 3 shows that this imitative behaviour only occurred after the experimental subjects were sensitised to the presence of insiders – as naïve traders they ignored the available signals.

Session 4. Insiders known to Exist, Insiders with Market Power.

Session 4 was identical to session 3 except that the endowments of insiders were increased by 300% relative to those of uninformed traders. The aim was to investigate further the conditions under which imitative behaviour might occur – in this case by making it possible for insider trades to be more clearly signalled. Under hypothesis 4 we anticipated a general increase in the efficiency of market prices, over and above any efficiency gains obtained through the manipulation in session 3.

Figure 7 shows a marked tendency for the observed price to approach the expected price for insiders following bad news but to approach the expected price for uninformed traders following good news. The continued failure of the market to transmit insider information in up-market conditions was even more marked in session 4 than in session 3 and was unexpected.

Figure 7. Evolution of Prices for Session 4



Spread SN_4^t is once again large compared to the base-line spread S_1^t**,** as shown in Table 10 – that is, observed prices diverge from the expected prices of uninformed traders by substantially more than in the base-line session.

Table 10. Comparison of Mean Values for SN_4^t and SI_4^t with S_1^t, Session 4

	Mean	Std Dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_4^t	0.2616	0.2706	1911	13.140*	$H_0 : S_1^t$ and SN_4^t have identical means
SI_4^t	0.367	0.4523	1911	18.279*	$H_0 : S_1^t$ and SI_4^t have identical means

* H_0 rejected at 1% significance level.

SN_4^t is actually closer to SI_4^t than it is to S_1^t. This is largely driven price formation during two sub-periods – *Interval 1-600* and *Interval 1000-1500*. The spreads for these intervals are shown in Tables 11 and 12 while the evolution of prices is shown in Figures 8 and 9 respectively.

Table 11: Comparison of SN_4^t and SI_4^t with S_1^t, Interval 1-600, Session 4

	Mean	Std Dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_4^t	0.3168	0.3019	595	-12.329*	$H_0 : S_1^t$ and SN_4^t have identical means
SI_4^t	0.1531	0.3908	595	-0.4413	$H_0 : S_1^t$ and SI_4^t have identical means

* H_0 rejected at 1% significance level.

Table 12: Comparison of SN_4^t and SI_4^t with S_1^t, Interval 1000-1500, Session 4

	Mean	Std Dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_4^t	0.4593	0.2339	501	-41.2151*	$H_0 : S_1^t$ and SN_4^t have identical means
SI_4^t	0.0649	0.4642	501	-2.4640*	$H_0 : S_1^t$ and SI_4^t have identical means

* H_0 rejected at 1% significance level.

Figure 8. Evolution of Prices during Interval 1-600, Session 4

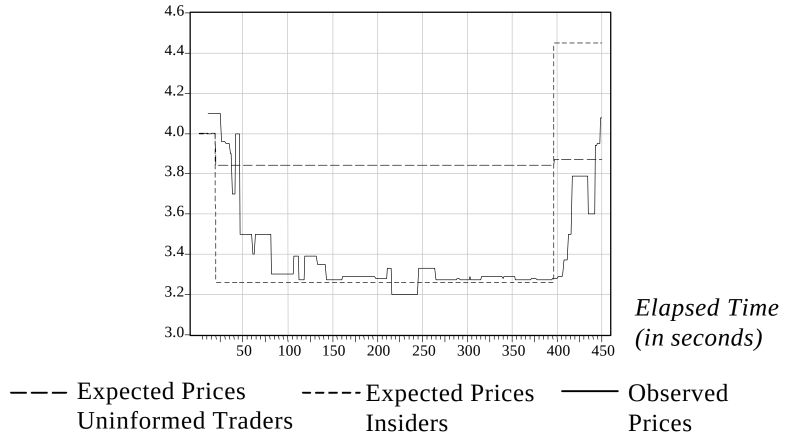
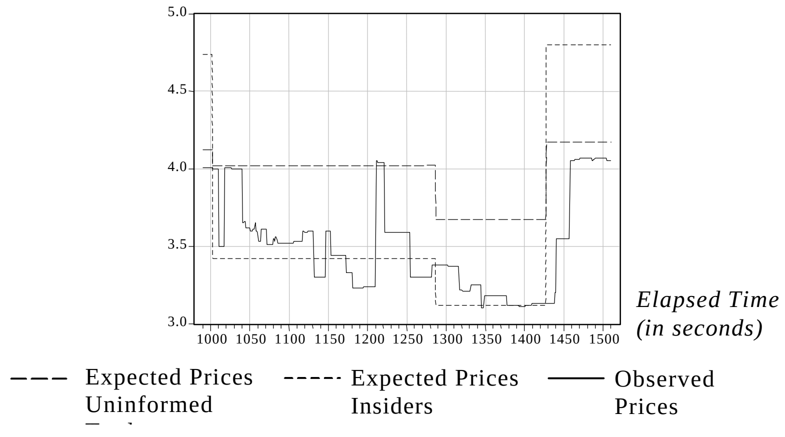


Figure 9. Evolution of Prices during interval 1000-1500, Session 4



Interval 1-600 shows the more marked effect. During this interval, covering 10 minutes of trading, observed prices were driven entirely by the information available only to 2 insiders (out of 12 traders). We conclude that imitative behaviour was present for *Interval 1-600*.

Such behaviour is also evident in *Interval 1000-1500*, although it is slightly less marked. Uninformed traders were evidently less sure of detecting insider information during this interval than they were during interval 1-600. This is suggested by the sudden but temporary return of observed prices to the expected path for uninformed traders at times 1020 and 1220.

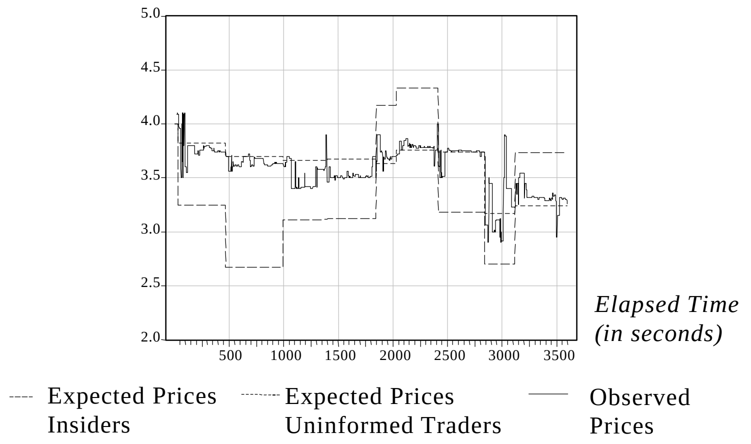
In summary, the results of both sessions 3 and 4 suggest that the revealed presence of insider information led to imitative behaviour on the part of uninformed agents. It is also apparent that this behaviour was asymmetric, in the sense that insider 'bad news' was transmitted to the market while insider 'good news' was not. Somewhat surprisingly, the relative increase in the market power of insiders from session 3 to session 4 appeared to exacerbate this asymmetry. Such behaviour is consistent with risk-aversion, although we have no other evidence to support this explanation.

Session 5. Free Communication, Identical Endowments and Insiders known to exist.

The parameters for this session were identical to those of session 3, except that traders were allowed to communicate freely and to spread rumours. The only restriction was that no trader was allowed to show any written evidence to prove that he/she was or was not an insider (traders could not show their code-sheets.) The intention was to create a climate in which speculative bubbles and imitative behaviour would be stimulated. Under hypothesis 5 we anticipated a decrease in informational efficiency and an increase in price volatility.

The results provide evidence in support of the beneficial effect of market transparency on price efficiency. As Figure 10 shows, observed prices behaved very much in accordance with those of the base-line session (symmetric information and homogeneous endowments).

Figure 10. Evolution of the prices for Session 5



Communication between traders was very active during this session, creating considerable informational noise that apparently prevented the signalling of insider information. It is also noticeable that speculative bubbles and crashes were not an marked feature of this session although there were three short intervals during which prices were volatile and peaked at values in excess of the highest rational expectation. This did not happen at any point during Sessions 2, 3 and 4 and these peaks are suggestive of the kind of speculative pricing that might be expected under conditions of uncertainty and rumour. No strong evidence of imitative behaviour can be seen, however.

The spread for uninformed traders in session 5, SN_5^t, was very close to that of the base-line session, S_1^t, whereas SI_5^t was significantly different. That is, prices were no more volatile than in the base-line session.

Table 19. Comparison of SN_5^t and SI_5^t with S_1^t, Session 5

	Mean	Std dev.	N	Z	Hypothesis
S_1^t	0.01333	0.1472	2750		
SN_5^t	0.1575	0.4736	4178	-1.2413	$H_0 : S_1^t$ and SN_4^t have identical means
SI_5^t	-0.0079	0.888	4178	10.14779*	$H_0 : S_1^t$ and SI_4^t have identical means

* H_0 rejected at 1% significance level.

We were unable to record the verbal communications between traders and hence are unable to ascertain that a climate of rumour actually emerged. To this extent we were unable to directly test the hypothesis that the incidence of speculative bubbles and crashes increases in such a climate. It was clear from the communication we observed, however, that a considerable amount of informational ‘noise’ was created and it seems very likely that this masked the order-book operations of the insiders. This raises questions about how to spread rumours effectively and in a controlled fashion in a simulated trading experiment. Further work on the experimental design, incorporating tighter experimental controls, will be needed before conclusions can be drawn about the effect of rumours in experimental markets.

4. Conclusion

Imitative behaviour may be responsible for a significant proportion of the volatility of prices observable in real-world asset markets. This experimental study was designed to explore the conditions that provoke such imitative behaviour. The experiment used a double-auction electronic simulated stock market with twelve participants and asymmetric information.

When the asymmetric information was not revealed it had little effect on observed prices other than a slight increase in volatility – uninformed traders apparently used public information to determine their ask and bid orders. Insiders were able to exploit their positions to earn greater than average profits by trading discreetly. In contrast, imitative behaviour by uninformed traders emerged in as soon as the existence of insiders was revealed. We suspect that uninformed agents used quantity information from the observable electronic order book to guide their trading behaviour – an abnormal bid or ask price is more likely to persist in the market if accompanied by high volume. This is a subject for further research.

The experiment was also intended to investigate the possibility that speculative bubbles in auction markets are created by imitative behaviour. Surprisingly, the imitative behaviour that we observed was linked to ‘bad news’ (an announced fall in the fundamental value of shares) but not to ‘good news’, so that no speculative bubbles were actually simulated in sessions 3 and 4. This result may be partly explained by risk-averse trading strategies, although there may have been other unintended experimental constraints of which we are as yet unaware.

Finally, we unable to generate strongly abnormal price movements by encouraging communication between traders and the spread of rumours, although there was weak evidence of speculative pricing in Session 5 that was not observable in sessions 2, 3 and 4. It appeared that the trading of insiders was generally obscured by uninformed trading. In any event, insiders had no incentive to reveal themselves to the market by direct communication and they were apparently not revealed through the electronic order book. Uninformed traders may have preferred to use their own information and accept trading profits that were somewhat limited. In effect, the cost of scouring the order book for revealed insider information in the search for hypothetical profits may simply have been too great – traders may have preferred less costly information of lower quality.

Further experiments are necessary if these issues are to be explored further. Of particular interest is further investigation of the role of rumour and of the processes that generate risk-averse behaviour. This may necessitate tighter experimental control (possibly with ‘stooge’ participants) to make the rumours better defined and implanted.

References

Ackert L.F., B.K. Church and M. Shehata, 1997, "Market Behaviour in the Presence of Costly, Imperfect Information: Experimental Evidence", *Journal of Economic Behaviour and Organisation*, 33, 61-74.

Ackert, L.F. and B.K. Church, 1978, "Information Dissemination and the Distribution of Wealth: Evidence from Experimental Asset Markets", *Journal of Economic Behaviour and Organisation*, 37, 357-371.

Banerjee, A., 1993, "The Economics of Rumours", *Review of Economics Studies*, 60, 309-327.

Black F, (1986), "Noise", *Journal of Finance*, 41, 3, 529-543.

Bikhchandani, S., D. Hirshleifer and I. Welch, 1992, "A Theory of Fads, Fashion, Custom and Cultural-Change as Informational Cascades", *Journal of Political Economy*, 100, 992-1026.

Bikhchandani, S., D. Hirshleifer and I. Welch, 1992, "Learning from the Behavior of Others: Conformity, Fads and Informational Cascades", Journal of Economic Perspectives, 12, 151-170.

Bloomfield, R. and R. Libby, 1996, "Market Reactions to Differentially Available Information in the Laboratory", *Journal of Accounting Research*, 34, 183-206.

Bloomfield, R. and M. O'Hara, 1999, "Market Transparency: Who Wins and Who Loses?", *Review of Financial Studies*, 12, 5-35.

Camerer, C. and K. Weigelt, 1991, "Information Mirages in Experimental Asset Markets", *Journal of Business*, 64, 463-493.

Cao, C., E. Ghysels and F. Hatheways, 1998, "Price Discovery without Trading: Evidence from the NASDAQ Pre-Opening", *Congress on Microstructure and High Frequency Data*, Paris, December.

Chakravarty, S. and J.J. McConnell, 1997, "An Analysis of Prices, Bid/Ask Spreads and Bid/Ask Depths Surrounding Ivan Boesky's Illegal Trading in Carnation Stock", *Financial Management*, 26, 18-34.

Chakravarty, S. and J.J. McConnell, 1999, "Does Insider Trading Really Move Stock Prices?", *Journal of Financial and Quantitative Analysis*, 34, 191-209.

Copeland, T. and D. Friedman, 1991, "Partial Revelation of Information in Experimental Asset Markets", *Journal of Finance*, 46, 265-295.

Cornell, B. and E.R. Sirri, 1992, "The Reaction of Investors and Stock-Prices to Insider Trading", *Journal of Finance*, 47, 1031-1059.

Cutler, D.M., J.M. Poterba and L.H. Summers, 1990, "Speculative Dynamics and the Role of Feedback Traders", *American Economic Review*, 80, 63-68.

Cutler, D.M., J.M. Poterba and L.H. Summers, 1991, “Speculative Dynamics”, *Review of Economic Studies*, 58, 529-546.

Dejong, F., R. Forsythe and W. Uecker, 1988, “A Note on the Use of Businessmen as Subjects in Sealed Offer Markets”, *Journal of Economic Behavior and Organization*, 9, 87-100.

DeLong, B., A. Shleifer, L. Summers and R. Waldmann, 1990, “Noise Trader Risk in Financial Markets”, *Journal of Political Economy*, 98, 703-738.

Franciosi, R., P. Kujal, R. Michelitsch, V. Smith and G. Deng, 1996, “Experimental Tests of the Endowment Effect”, *Journal of Economic Behaviour and Organisation*, 30, 213-226.

Flood, M.D., R. Huisman, K.G. Koedijk and R.J. Mahieu, 1999, “Quote Disclosure and Price Discovery in Multiple-Dealer Financial Markets”, *Review of Financial Studies*, 12, 37-59.

Forsythe, R., R. Lindholm and T. Reitz, 1999, “Cheap Talk, Fraud and Adverse Selection in Financial Markets: Some Experimental Evidence”, *Review of Financial Studies*, 12, 481-519.

Froot, K.A., D. Scharfstein and J. Stein, 1992, “Herd on the Street: Informational Inefficiencies in a Market with Short-Term Speculation”, *Journal of Finance*, 47, 1461-1484.

Garfinkel, J.A. and M. Nimalendram, 1998, “Market Structure and Trader Anonymity: An Analysis of Insider Trading”, *Working Paper* No. 99041912, SSRN.

Glosten, L. R. and P.R. Milgrom, 1985, “Bid, Ask, and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders”, *Journal of Financial Economics*, 14, 71-100.

Grossman, S.J, 1976, “On the Efficiency of Competitive Stock Markets when Trades have Diverse Information, *Journal of Finance*, 31, 573-585.

Guth, W., J.P. Krahnen and C. Rieck, 1997, “Financial Markets with Asymmetric Information: A Pilot Study Focusing on Insider Advantages”, *Journal of Economic Psychology*, 18, 235-257.

Jobert, T, (1992), “Tests de Racine Unitaire: une Stratégie et sa Mise en Oeuvre”, *Cahier de Recherche EMA-MAD*, University of Paris 1, No. 9244.

Kyle, A., 1989, “Informed Speculation with Imperfect Competition”, *Review of Economic Studies*, 56, 317-355.

Lamoureux, C.G. and C.R. Schnitzlein, 1996, “When it’s not the Only Game in Town: the Effect of Bilateral Search on the Quality of a Dealer Market”, *Journal of Finance*, 52, 683-712.

Leland, H.A., 1992, “Insider Trading: Should it be Prohibited?”, *Journal of Political Economy*, 100, 859-887.

Madhavan, A., 1992, “Trading Mechanisms in Securities Markets”, *Journal of Finance*, 47, 607-642.

Meulbroek, L., 1992, "An Empirical Analysis of Illegal Insider Trading", *Journal of Finance*, 47, 1661-1699.

Neuberger, A. and O. Hansch, 1996, "Strategic Trading by Market Makers on the London Stock Exchange", *IFA Working Paper 224*, London Business School.

Osterwald-Lemun, M., 1992, "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics", *Oxford Bulletin of Economics and Statistics,* 54, 461-467.

Pagano, M. and A. Roell, 1996, "Transparency and Liquidity : A Comparison of Auction and Dealer Markets with Informed Trading", *Journal of Finance*, 51, 579-612.

Plott, C.R. and S. Sunder, 1982, "Efficiency of Experimental Security Markets with Insider Information: An Application of Rational Expectations Models", *Journal of Political Economy,* 90, 663-698.

Scharfstein, D. and J. Stein, 1990, "Herd Behavior and Investment", *American Economic Review*, 80, 465-479.

Schnitzlein, C.R., 1996, "Call and Continuous Trading Mechanisms under Asymmetric Information: An Experimental Investigation", *Journal of Finance*, 51, 613-636.

Shiller, R.J., 1984, "Stock Prices and Social Dynamics", *Brooking Papers on Economic Activity,* 2, 457-498.

Spotton, B. and R. Rowley, 1998, "Efficient Markets, Fundamentals and Crashes: American Theories of Financial Crises and Market Volatility", *American Journal of Economics and Sociology*, 57, 663-690.

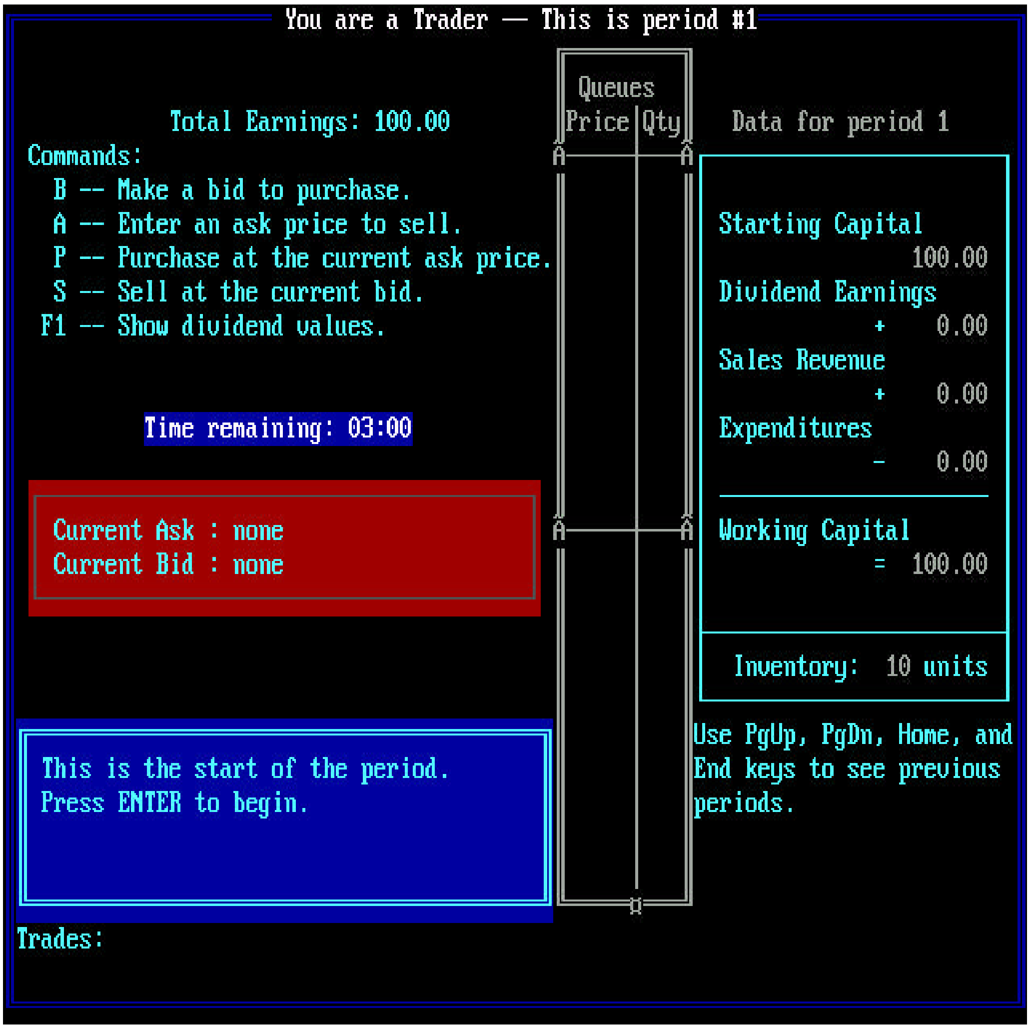
Sunder, S., 1992, "Market for Information: Experimental Evidence", *Econometrica*, 60, 667-695.

Topol, R., 1991, "Bubbles and Volatility of Stock-Prices - Effect of Mimetic Contagion", *Economic Journal*, 101, 786-800.

Tuttle, B., M. Coller and F.G. Burton, 1997, "An Examination of Market Efficiency: Information Order Effects in a Laboratory Market", *Accounting Organisations and Society,* 22, 89-103.

Appendix 1. The Electronic Trading Screen and the Summary Instruction Sheet .

The Electronic Trading Screen (Dummy Information)



SIMPLE GUIDE TO THE PROGRAMME

ATTENTION: This is an interactive programme! When you hit a key the programme will issue simple instructions for you to follow. On the computer screen you will find a quotation panel, illustrated below:

TO **PURCHASE**

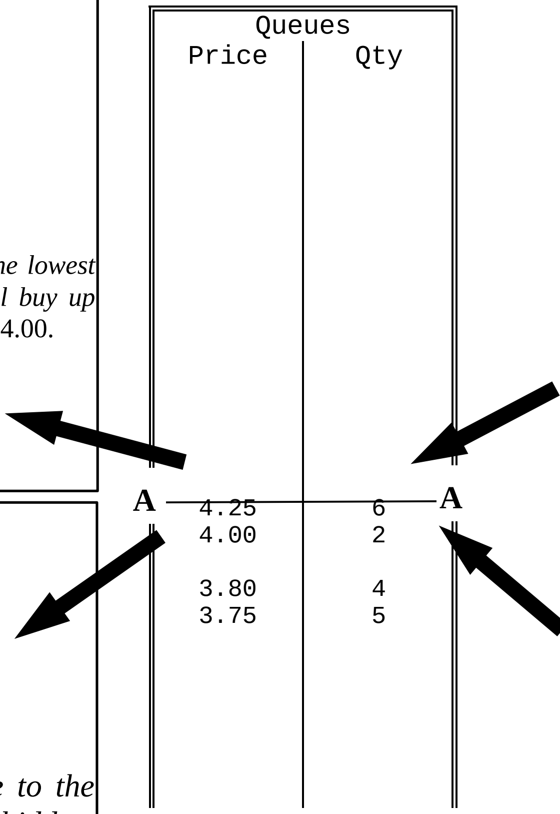
Type <**P**> followed by:
a quantity
<Enter>

In this case you agree to the lowest price being asked: you will buy up to two shares at a price of $4.00.

PROPOSE A SALE
To **ASK:**

Type <**A**> followed by:
a price
<space>
a quantity
<enter>

In this case you have proposed to sell 2 shares at a price of $4.00



TO **SELL**

Type **S** followed by
a quantity
<enter>

In this case you agree to the price of the highest bidder: you will sell up to 4 shares at a price of $3.80.

PROPOSE A PURCHASE
To **BID:**

Type **B** followed by
a price
<space>
a quantity
<enter>

In this case you propose to buy 4 shares at a price of $3.80

You may cancel either a bid or an ask, but you cannot cancel a purchase or a sale.