Economics Letters 41 (1993) 179–185

Price bubbles and crashes in experimental call markets*

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Received 3 September 1992
Accepted 4 November 1992

Abstract

Price bubbles relative to intrinsic dividend value are observed using a call market trading institution. Market prices tend to track intrinsic value only when the same group of highly experienced traders participate in three consecutive 15-round markets.

1. Introduction

This study extends previous research examining the phenomenon of speculative price bubbles and crashes in laboratory spot asset markets. Smith, Suchanek and Williams (1988) (SSW) first reported the existence of price bubbles relative to 'intrinsic value' (the expected dividend stream of an asset share) in experimental markets with a finite time horizon of 15 trading periods. Subsequent research by King, Smith, Williams and Van Boening (1993) (KSWV) demonstrated that the occurrence of the bubble–crash phenomenon was robust to a number of treatments, including margin buying, short selling, identical endowments, limit price-change rules, informed insiders, and brokerage fees. KSWV suggest that running the same group of traders through three successive 15-period markets appears to be a sufficient condition for eliminating the bubble–crash price pattern. In a related study, Porter and Smith (1992) (PS) found that simultaneous futures and spot markets attenuate, but do not eliminate, bubbles. All of these studies have used the double continuous auction trading institution.

* Financial support from the National Science Foundation and the Arizona Economic Science Laboratory is gratefully acknowledged. The data generated by this research are permanently archived on the NovaNET computer system. Contact the authors for information on accessing the data archive or the market software via microcomputer dialup or the Internet.
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Building on work by Van Boening (1991) and Smith and Williams (1992), this study reports 12 new 15-period asset markets – six double continuous auctions and six call markets. Our primary objective is to test the conjecture that the bubble–crash phenomenon observed in double continuous auctions will be significantly reduced or eliminated if the trading institution is changed to a call market (a.k.a. a double sealed auction, a single-price auction, a clearinghouse auction, a sealed bid-offer auction, a uniform-price double auction). A priori, our reasoning was that the stark informational environment of a 'closed book' call market (where traders are not able to view the bid and ask arrays for the current period) would inhibit the market dynamics that give rise to endogenous capital gains expectations in double continuous auctions, and would thus eliminate price bubbles. A secondary objective is to evaluate the robustness of the bubble–crash phenomenon to a change in the underlying dividend structure relative to previous studies. All of the 15-period asset markets reported to date have used a discrete (four points with 0.25 probability) asymmetric distribution to generate dividends. The markets reported here use a discrete (five points with unequal probability) symmetric dividend distribution with a unique mode equal to the expected dividend draw.

Our computerized call market is described more fully below, but its essence is that all exchanges in a trading period occur at a single market-clearing price determined by the intersection of the bid array (buy orders ranked from high to low price) and ask array (sell orders ranked from low to high price) submitted by traders. This trading institution, studied experimentally over a decade ago [Smith et al. (1982)] has become increasingly important as financial asset markets evolve into fully computerized exchanges. Recent academic research has responded to this heightened importance [for example, see Cason (1992), Friedman (1992), McCabe et al. (1992)]. The Arizona Stock Exchange (formerly Wunsch Auction Systems) which opened in the Spring of 1992 utilizes a fully computerized call market to execute trades (see, for example, the *Wall Street Journal*, December 1991).

2. Experimental design

Table 1 lists the 12 markets reported here. All of the markets used cash rewards and were conducted on the NovaNET computer system. Each group of subjects (student volunteers from the University of Arizona and Indiana University) participated in a series of three markets: first as inexperienced asset traders, then as once-experienced traders, and finally as twice-experienced traders. The three markets in each of the four series were conducted on different days; all subjects from the first market in each series returned for the second and third markets in that series. All traders started the first period of each market with $7.20 in cash and two asset shares. Cash and share holdings did not carry over across the three markets in each sequence. Margin buying and short selling was prohibited. At the conclusion of each market subjects were paid privately in cash their final 'working capital' (initial cash endowment + net capital gains + dividend earnings).

At the end of each trading period a common dividend was paid on asset shares. The following per-share dividends (and probabilities) were utilized: $0.05 (1/9), $0.15 (2/9), $0.25 (3/9), $0.35 (2/9), $0.45 (1/9). This distribution was chosen in an attempt to focus subjects' attention on expected value. (All previous 15-period asset markets used only two asymmetric dividend structures; in one of these structures the expected dividend was not a possible draw.) It was verbally announced prior to the beginning of the first trading period that everyone faced the same dividend distribution and actual dividend draw in each period. The intrinsic value of a single share in period t of an experiment $E(\tilde{D}_t)$ is the expected one-period dividend value, $E(\tilde{d})$, times the

Table 1
Market summary statistics

	Price amplitude	Share turnover	Absolute I.V. price deviations
Double continuous auctions			
Series 1 [a]			
Inexperienced	3.93	6.20	7.73
Once-experienced	2.11	4.53	3.10
Twice-experienced	1.00	4.00	1.17
Series 2 [b]			
Inexperienced	0.77	7.86	3.04
Once-experienced	3.14	6.04	5.15
Twice-experienced	0.90	3.93	1.09
Call markets			
Series 3 [c]			
Inexperienced	5.22	3.27	5.07
Once-experienced	2.88	1.53	0.87
Twice-experienced	1.00	2.07	0.36
Series 4 [d]			
Inexperienced	6.85	2.88	5.00
Once-experienced	5.99	1.83	1.33
Twice-experienced	2.61	2.04	0.37

[a] Series 1 markets had 15 traders. NovaNET archive names: az425, az426, az427.
[b] Series 2 markets had 14 traders. NovaNET archive names: az428, az429, az430. A confirmed typographical error resulting in a transaction at \$5 in period 14 of the twice-experienced market (az430) is not included in the calculation of the summary statistics.
[c] Series 3 markets had 15 traders. NovaNET archive names: sob046, sob047, sob048.
[d] Series 4 markets had 12 traders. NovaNET archive names: sob049, sob050, sob051.

number of periods remaining: $E(\tilde{D}_t) = E(\tilde{d})(16\text{-}t) = (\$0.25)(16\text{-}t)$, $t = 1, 2, \ldots, 15$. Prior to each trading period a computer display reminded participants of the dividend distribution and that the market would end after period 15. They were also shown the maximum, minimum and 'average' holding value of a single share, and the maximum, minimum and 'average' holding value of their current portfolio.

3. The trading institutions

The double continuous auction and call market trading institutions used in this research are both implemented on the NovaNET computer system. The trader interfaces are similar in appearance and utilize identical accounting methods. Trading periods in both institutions end after 240 s of elapsed time or when traders unanimously agree to move on to the next period. The information displays provided to subjects between periods are identical across institutions.

In the double continuous auction, the highest bid to buy and lowest offer to sell an asset share are publicly displayed as the standing bid–ask spread. Contracts are made when a trader accepts the bid or offer submitted to another trader. The contract is immediately recorded on the relevant subjects' display screen. All bids, offers, and transactions in the continuous auction are for single

shares. A bid–ask spread improvement rule was used in the markets reported here as was a 'rank-queue' where bids and offers that are away from the standing bid–ask spread are ordered by price priority – after a contract the highest queued bid and lowest queued offer are automatically entered as the new bid–ask spread. A more detailed description of the computerized double continuous auction asset markets used here is given in Smith et al. (1988) or Van Boening (1991, available upon request).

In call markets, all trades occur at the calculated market price rather than at the submitted bid or offer prices. Thus, all bids to buy and offers to sell are really 'limit orders' specifying the highest acceptable purchase price or lowest acceptable sale price. During each period of our call markets, a trader may submit up to six price–quantity orders to buy and/or sell asset shares. Traders are permitted to submit both buy and sell orders in any period (subject to cash and share constraints), but they are not permitted to 'churn' shares and create false volume by trading with themselves; for each individual, the highest bid price must be less than the lowest offer price.

At the end of each trading period the computer sorts the set of all bids to buy from high price to low price and sorts the set of all offers to sell orders from low price to high price. The two arrays are then crossed; the intersection of the downward-sloping array of bids to buy and the upward-sloping array of offers to sell determines the market price and market exchange volume at this price. Buy orders at or above the market price trade, as do sell orders at or below the market price. If there is an excess of buy or sell orders at the market price, a random selection of the excess orders are excluded from trade. Note that it is possible for the array of buy orders to lie entirely below the array of sell orders. In this case the exchange volume is zero; each trader is informed of the highest bid to buy and the lowest offer to sell.

Immediately after a crossing of orders, each trader receives feedback on the market price, market volume, and the status of his/her submitted orders. The market then proceeds to the next period. A 'closed book' is utilized in all of the markets reported here – at no time do subjects receive information on the market bid array or offer array which determined the market price and trading volume. A more detailed description of the computerized call markets used here is given in Van Boening (1991, available upon request).

4. Experimental results

Figures 1 and 2 plot the mean price and volume data for each series of three markets. For both trading institutions, the data illustrate that increasing subject experience with the asset market environment tends to decrease the magnitude of deviations from intrinsic value (shown as a dashed line in Fig. 1). This trading pattern is generally consistent with double continuous auction data reported by KSWV (1993); however, the Series 2 markets are an interesting exception. In the inexperienced-subject market, the mean price tracks intrinsic value quite well, although the intra-period price variance (not reflected in Fig. 1) is quite high. Considering the dozens of bubble–crash markets reported by SSW (1988), KSWV (1993) and PS (1992), this is a very unusual observation. It was particularly interesting to see the bubble–crash pattern appear in the second market in this series. In the third market using the same traders, mean prices again approximate intrinsic value, but with much smaller intra-period variance than in the inexperienced-subject market.

Table 1 presents statistics summarizing the performance of each market. The *amplitude* of a price series is defined as the difference between the maximum and minimum mean price deviations from intrinsic value across the 15 trading periods of a market: $\max_t[\bar{P}_t - E(\tilde{D}_t)] -$

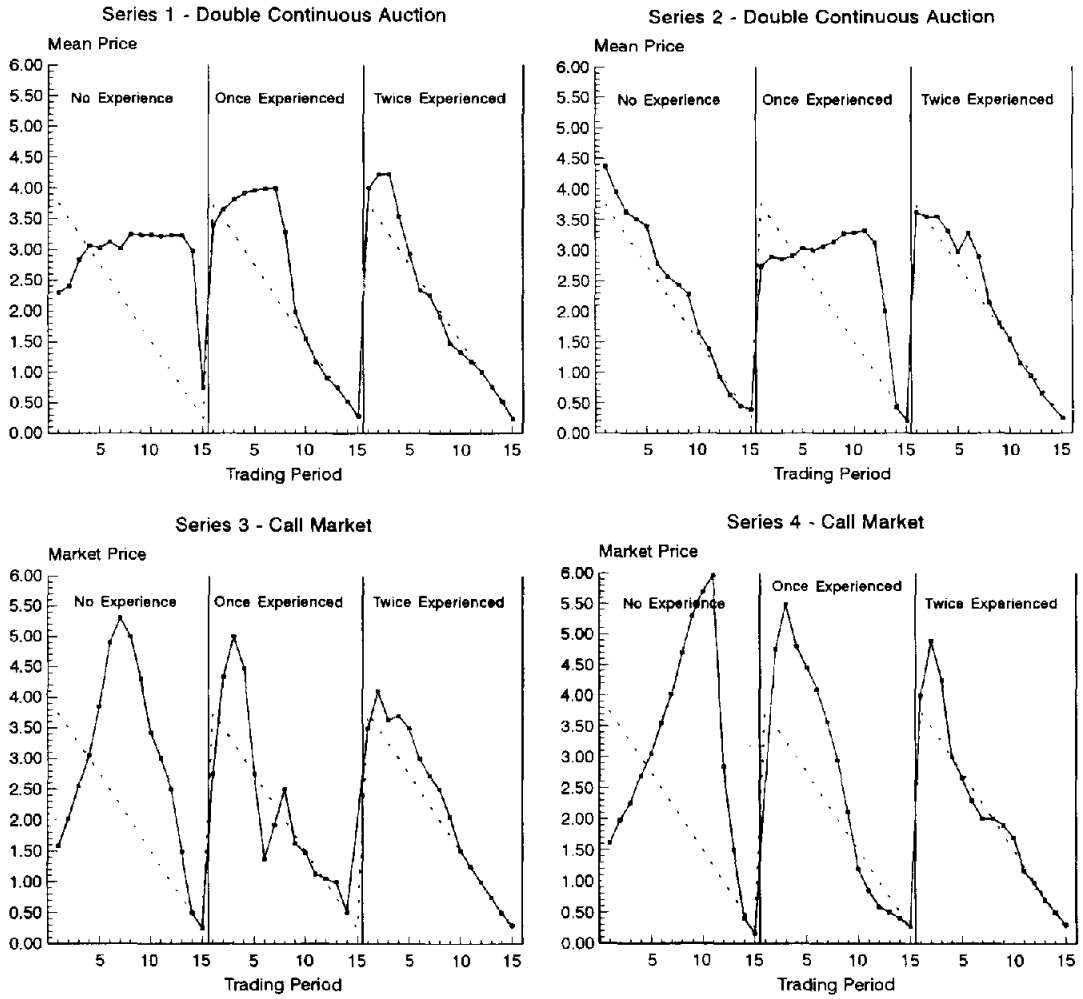

Fig. 1. Observed prices relative to intrinsic value

$\min_t[\bar{P}_t - E(\tilde{D}_t)]$, $t = 1, 2, \ldots, 15$. *Turnover* is the volume of shares traded divided by the total number of outstanding shares. *Absolute IV deviations* is the absolute value of price deviations from intrinsic value in a market divided by the number of outstanding shares. Note that these summary measures use aggregate trading data from all 15 periods in a market.

The market data suggest the following general conclusions. The bubble–crash phenomenon described in previous research using double continuous auction asset markets is not eliminated by (1) switching to a closed-book call market, or (2) the use of a discrete, symmetric dividend distribution where the unique modal dividend is also the expected dividend. In both trading institutions, price deviations from intrinsic value are substantially reduced as trader experience increases. Call markets with experienced traders do exhibit smaller absolute price deviations from intrinsic value than comparable double continuous auctions, but the double continuous auctions tend to have smaller amplitude. Similar findings are reported in Van Boening (1991). Given our small sample size and the similarity of price patterns across institutions, formal comparisons of the

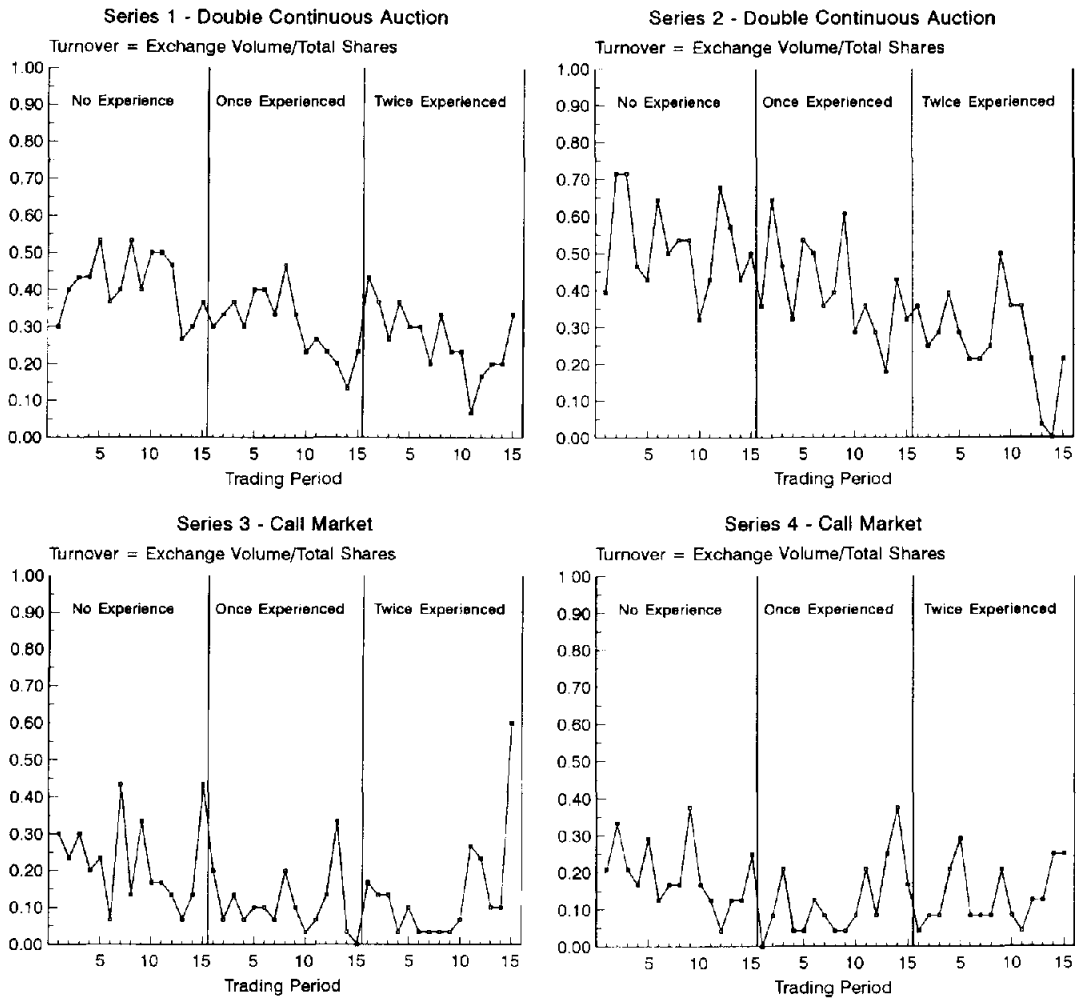

Fig. 2. Trading volume expressed as turnover.

relative performance of call versus double continuous auction asset markets await further research.

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