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Stock Market Bubbles in the Laboratory

David P. Porter and Vernon L. Smith

Trading at prices above the fundamental value of an asset, i.e. a bubble, has been verified and replicated in laboratory asset markets for the past seven years. To date, only common group experience provides minimal conditions for common investor sentiment and trading at fundamental value. Rational expectations models do not predict the bubble and crash phenomena found in these experimental markets; such models yield only equilibrium predictions and do not articulate a dynamic process that converges to fundamental value with experience. The dynamic models proposed by Caginalp et al. do an excellent job of predicting price patterns after calibration with a previous experimental bubble, given the initial conditions for a new bubble and its controlled fundamental value. Several extensions of this basic laboratory asset market have recently been undertaken which allow for margin buying, short selling, futures contracting, limit price change rules and a host of other changes that could effect price formation in these assets markets. This paper reviews the results of 72 laboratory asset market experiments which include experimental treatments for dampening bubbles that are suggested by rational expectations theory or popular policy prescriptions.

Introduction

Rational expectations models predict that if individuals have common expectations (or priors) as to the value of an asset, and this common value is equal to the dividend value of the asset, then trades, if they occur, will be at prices near the intrinsic dividend value (Tirole [1982]). Consider the data in Figure 1 which lists the average weekly share price and corresponding net asset value (NAV) for the Spain Fund. The price of the Spain Fund shares from July 1989 to August 1990 begins at a discount from NA V and rises to a premium of 250% over NA V by week 15, and ultimately "crashes" back to a discount by week 61. There is much controversy over the behavior of closed-end funds which still remains a puzzle for a rational expectations theory of asset pricing (see Lee et al. [1991]). Explanations of deviations from NA V rely on models that focus on distinct investor types and their expectations. Instead of entering the debate concerning the interpretation of the price behavior of closed-end funds, we shall rely on laboratory methods in economics which allows us to investigate propositions on price formation in a controlled fundamental value environment. In the economy, control over fundamental value and investor information is rarely possible, and therefore minimal conditions for studying the role of expectations in stock market valuations cannot be identified. Smith et al. [1988] (hereafter SSW) report the results of laboratory asset markets in which each trader receives an initial portfolio of cash and shares of a security, with a dividend horizon of 15 trading periods. Before the tth trading period, the expected dividend value of a share, e.g. \$0.24(15 – t + 1), is computed and reported to all subjects to guard against any possibility of misunderstanding. Thus, the situation is like that of a stock fund whose net asset value is reported to investors daily or weekly. Each trader is free to trade shares of the security using double auction trading rules similar to those used on the major stock exchanges. At the end of the experiment, a sum equal to all dividends received on shares, plus initial cash plus capital gains minus capital losses is paid in US currency to the trader.

The data in Figure 2 shows a typical result from a laboratory asset market. With inexperienced traders, bubbles and crashes are standard fare. However, this phenomenon disappears as traders become experienced. That is, cohort traders who are twice experienced in laboratory asset markets will trade at prices that reflect fundamental value. Figure 2 contrasts the mean contract prices and volume for inexperienced traders in a laboratory asset market. The data points show the mean contract for each period and the numbers next to the price shows the number of contracts

David P. Porter is currently Professor of Economics at George Mason University and a research scholar in the Interdisciplinary Center for Economic Science.

Vernon L. Smith, Nobel Prize winner in Economics, 2002, is currently Professor of Economics and Law at George Mason University, a research scholar in the Interdisciplinary Center for Economic Science, and a Fellow of the Mercatus Center all in Arlington, VA

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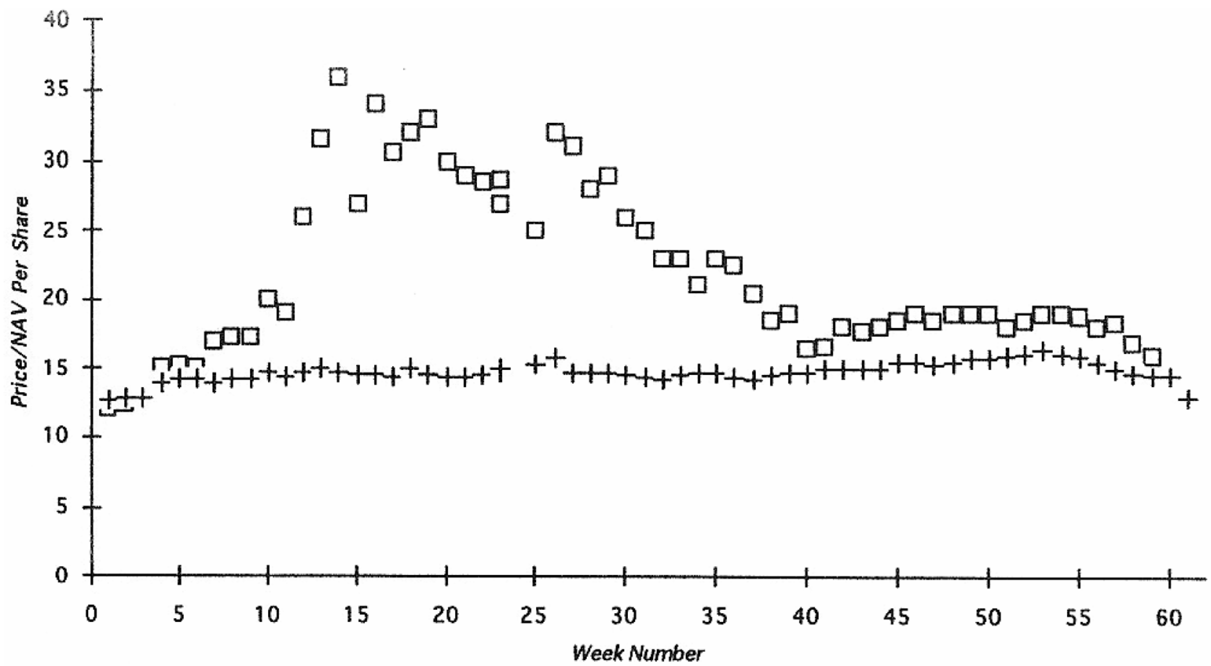
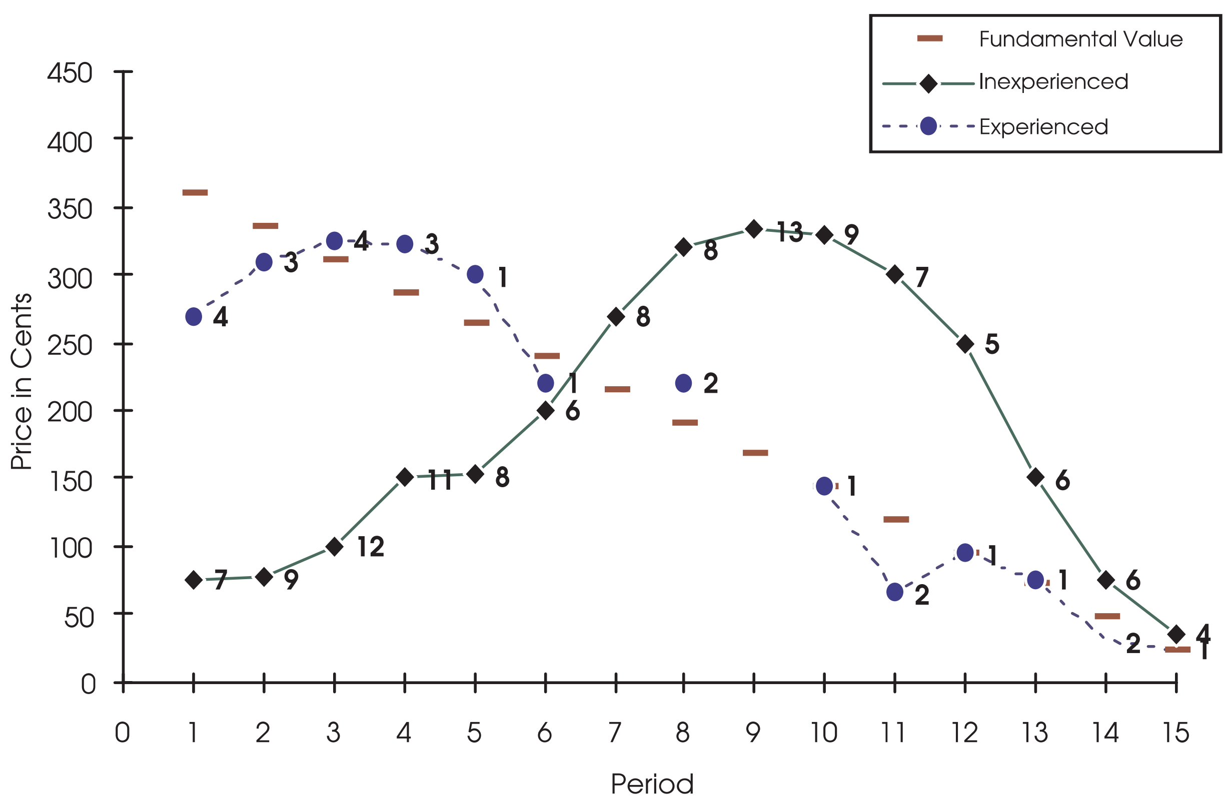
FIGURE 1
Share Price and NAV: The Spain Fund 6/30/89–8/24/90



Note: Price per share, + NAV per share.

FIGURE 2
Mean Contract Price and Total Volume



made in that period. Note the substantial reduction in exchange volume with experience.

Two possible explanations for the existence of bubbles in laboratory asset markets concern the expectations formation of traders and the market structure under which they operate. The data from these experiments suggest that a more dynamic model of price formation is required if one is to try to predict price patterns that have boom and busts or to develop "policies" that reduce such volatility in asset market. Recently, two models have been developed that focus on investor expectations and price formation and that allow for a wide range of price dynamics.

Day and Huang, [1990] have a model which consists of investors who base their buy and sell decisions either on the long run investment value of a security (α-investors) along with a weighting function over possible estimates of market high and lows with a fixed horizon, or more adaptive investors β-investors) who base their decisions on current market fundamentals. The price adjustment equation is then defined as a function of market excess demand in which market makers adjust inventory and prices linearly. Specifically, the excess demand equation for α-investors is based on a fixed parameter, a, of α-investor demand along with two parameters that define the support over the market top and bottom for the asset price; a single parameter, b, for β-investor demand; and finally a parameter, c, which is the speed of price adjustment based on excess market demand. This model can produce dynamic properties with irregular bull and bear markets and short-run chaotic price fluctuations. However, this model is of limited applicability to the experimental asset markets since most of the crucial parameters (a, b and e) are exogenous and are unaffected by underlying market variables or structures.

Caginalp and Ermentrout [1990, 1991], have developed a complete dynamical system for investor behavior that results in a system of ordinary differential equations. The model assumes a kinetic reaction among investors that relies On a fundamental value component ζ_2, and a trendbased component ζ_1. The latter is based on a memory of price history that decays in time, and which captures the tendencies among investors to buy in a recently rising market and sell in a recently declining market.

Given that each unit of asset is either in cash, stock, or a transition from stock to cash (stock submitted for sale), or cash to stock (buy order placed for a stock), rate equations can be established for these variables as a function of stock price changes. The transition equations along with the investor sentiment component (ζ_1, ζ_2) equations, can be manipulated to obtain a dynamical system that can be solved numerically to yield a price path for the security. Using one of the experiments conducted by Porter and Smith [1990] Caginalp and Balenovich [1993] obtain base line estimates for two parameters in the price change equation. Given the parameter estimates, the price path for any experiment can be determined solely from the intrinsic value of the security and the opening price. They report their predictions of peak prices in nine experiments in Porter and Smith [1989] and find prediction errors ranging from 1 to 20%.

The purpose of this paper is to summarize the results of laboratory asset market bubbles and the effect of proposed changes in the asset market environment and institution that *a priori* should mitigate bubbles. From these results and the dynamic models alluded to above, suggestions *for* further modeling directions and specific experiments to investigate the robustness of the Caginalp et al. model are provided.

Empirical Results from Laboratory Asset Markets

Figure 3 supplies the structure of the baseline experiment of SSW where the theory would predict prices that track the fundamental value line. In this environment, inexperienced traders produced high *amplitude*[1] bubbles that are 2–3 times intrinsic value. In addition, the span of a boom tends to be of long *duration* (10–11 periods) with a larger *turnover* of shares (5–6 times the outstanding stock of shares over the 15-period experiment). In nearly all cases, prices crash to fundamental value by period 15.

Table 1 lists the treatments discussed in this paper along with their hypothesized effect on the bubble characteristics. Table 2 lists the mean values of amplitude, duration and turnover *for* each treatment. (For the results listed in this paper we have constructed regression models and their parameter estimates as reported in Appendix A.)

From the values in Table 2, we can conclude that *for* the baseline asset market:

Result 1: Public information in intrinsic dividend (or net asset) value is not to induce common expectations and trading at fundamental value.

Result 2: In replicable laboratory experiments, experience, particularly common group experience, together with common information is sufficient to yield trading near fundamental value.

The game theoretic assumption of common knowledge, as a means of finessing the explicit modeling of a pre-game or repeated-game learning process, does not appear justified. Certainly common information on

FIGURE 3
Baseline Asset Market Experiment Parameters

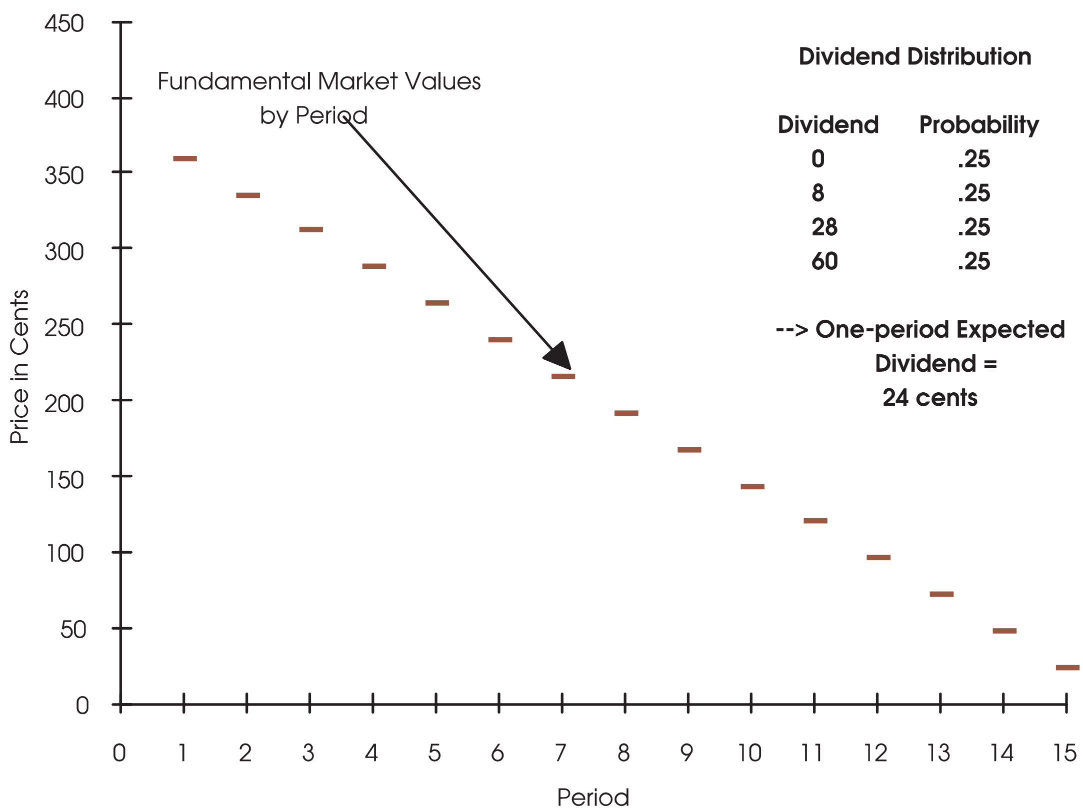


Table 1. *Treatments and Hypotheses*

Treatment	Description	Hypothesis
Baseline	Declining dividend value (see Figure 3)	Rational expectations equilibrium has trading at fundamental values
Short-selling	Traders are given the capacity to sell units to be covered by last period	Traders can leverage sales and counter ebullient expectations
Margin Buying	Traders are given interest-free loan to be paid back by last period	Purchases can be leveraged to raise prices that are below dividend value
Equal portfolio endowment	Each trader is given the identical amounts of cash and shares	Traders do not need to use the market to balance portfolios
Brokerage fees	Buyer and seller in transaction pay 10 cents each for the trade	Should reduce trading based on cost of transacting
Informed insiders	Specially informed traders who are given bid ask adjustment model	Expert traders aware of bubble characteristics eliminate bubble
Dividend certainty	Security pays a fixed and known amount each period	Trading based on dividend risk preferences is eliminated
Futures contracting	Agents can trade a mid-horizon (period 8) security in advance	Futures contracts should hasten the formation of common expectations
Limit price change rule	Asset price can only change a fixed limited amount from the previous period closing price	This rule has been recommended by expert advisory groups to reduce price volatility and crashes.

dividend value does not imply common knowledge expectations.

Given these results, a natural question to ask is whether these bubbles can be related systematically to individual reported price expectations. Towards answering this question, SSW asked subjects to forecast the mean price *for* the next period with a monetary reward *for* the best forecaster across all periods. The consensus (mean) forecast results revealed that: (1) bullish capital gains expectations arise early in these experiments; (2) the mean forecast always fails to predict price jumps and turning points; (3) the mean forecasts are highly adaptive, i.e. jumps in the mean price as well as turning points are only reflected in

Table 2. *Mean Values by treatment*

Treatment	Inexperienced			Once-experienced			Twice-experienced		
	Amplitude	Duration	Turnover	Amplitude	Duration	Turnover	Amplitude	Duration	Turnover
Baseline	1.21	9.23	5.79	0.75	5.51	3.00	0.10	3.00	1.60
				(0.10)	(0.19)	0.00	0.00	0.00	0.00
	n = 19			*n=4*			*n=3*		
Short-sell	1.61	9.50	6.67	0.76	5.80	4.19	0.40	3.67	1.74
	(0.40)	(0.30)	(0.49)	(0.48)	(0.78)	(0.03)	(0.02)	(0.69)	(0.27)
	n=4			*n=5*			*n=3*		
Margin buy	3.64	8.00	5.48	1.15	2.00	2.33			
	0.00	(0.66)	(0.59)	(0.09)	(0.21)	(0.58)			
	n=2			*n=1*					
Equal portfolios	1.87	10.00	6.29						
	(0.12)	(0.44)	(0.84)						
	n = 4								
Brokerage fees	0.73	10.00	5.56	0.63	4.00	4.92			
	0.00	(0.44)	(0.67)	(0.62)	(0.90)	(0.10)			
	n=2			*n=3*					
Informed insiders	0.63	13.00	2.68	0.25	6.00	4.05			
	0.00	0.00	0.00	(0.04)	(0.92)	(0.40)			
	n=2			*n=3*					
Dividend certainty	1.10	11.00	8.84	0.52	9.67	2.71			
	(0.98)	(0.05)	(0.13)	(0.29)	(0.24)	(0.51)			
	n=3			*n=3*					
Futures contracting		10.00	6.85	0.60	5.50	2.63			
	(0.11)	(0.73)	(0.81)	(0.19)	(0.60)	(0.50)			
	n=3			*n=2*					
Limit price change	2.51	10.50	4.84	1.77	5.50	2.22	0.70	1.50	1.89
	(0.07)	(0.46)	(0.01)	(0.05)	(0.71)	(0.15)	(0.04)	(0.17)	(0.79)
	n=2			*n=2*			*n=2*		

Note: *p*-values in parentheses.

forecasts after a one period lag. These observations parallel the performance of professional forecasters (Zarnowitz, [1986]).

> Result 3: Subjects have a strong early tendency to develop home-grown expectations of rising prices; their forecasts are adaptive and have a universal tendency to misprice jumps and turning points.

The dynamics of these price adjustments can be characterized empirically by a Walrasian price adjustment equation which stipulates that price responds in the direction of the excess demand for the asset. Specifically, $dp/dt = F(D(p) - S(p))$ where $F(0) = 0$ and $F' > 0$. The following ordinary least squares (OLS) Walrasian excess demand model has been estimated (SSW p. 1142).

$$P_t - P_{t-1} = \alpha + \beta(B_{t-1} - O_{t-1}) + \epsilon_t \tag{1}$$

where P_t is the mean price in period t, α is minus the one-period expected dividend value (adjusted for any risk aversion), β is adjustment speed, B_{t-1} is the number of bids to buy tendered in period t–1, and O_{t-1} is the number of offers to sell tendered in period t–1. Price change in this model has three components: (1) the risk-adjusted per-period expected dividend payout; (2) an increase (decrease) due to excess demand arising from home-grown capital gains (losses) expectations, a Walrasian measure of which is excess bids $B_{t-1} - O_{t-1}$, and (3) unexplained noise, ϵ_t. The R^2 values for the asset markets experiments in our sample range from 0.04 to 0.63. The variance in the estimates is large.

This model explains and predicts price changes better than subjects' forecasts in that it frequently anticipates turning points. A rational expectations prediction for this model is that $\alpha = -24$, the expected one period dividend, and $\beta = 0$. The pooled results over all experiments with treatment effects can be found in Appendix B. The results in Appendix B show that we cannot reject the hypotheses that $\alpha = -24$ and that $\beta = 0$. In addition, experience causes a significant decrease in the capital gains expectations coefficient β. However, this model provides values of R^2 that are much below unity, leaving much of the change in prices unexplained.

From the experimental results, which show a dampening of the bubble with experience, Renshaw [1988] hypothesizes that the *severity* of price bubbles and crashes depends upon trader experience with extreme market price changes. He examines the relationship between major declines in the Standard and Poor index and the length of time between major declines. The time between crashes is his proxy for investor inexperience. An OLS regression of the measured extent of the index's decline, Y, on the time since the previous decline, *X,* yields the estimate:

$$Y = 5.5 + 0.90X;\ R^2 = 0.98.$$
$$(t = 15.1)$$

The longer it has been since the previous crash in prices, the greater the magnitude of a new crash.

The baseline market developed by SSW omits many institutional features that are present in the field. Since some of these factors may very well dampen bubbles, they have provided the impetus for several new experiments reported in two recent studies: (1) King et al. [1992] report experiments that introduce short selling, margin buying, brokerage fees, informed "insiders", equal portfolio endowments and limit price change rules; (2) Porter and Smith [1994] (hereafter PS) report new experiments examining the effect of a futures market and the effect of dividend certainty. Table 1 lists these structural changes, the associated data, and the predictions of the effect of these treatments on the market. Such structural changes are a response to suggested explanations by others of the bubbles reported in SSW.

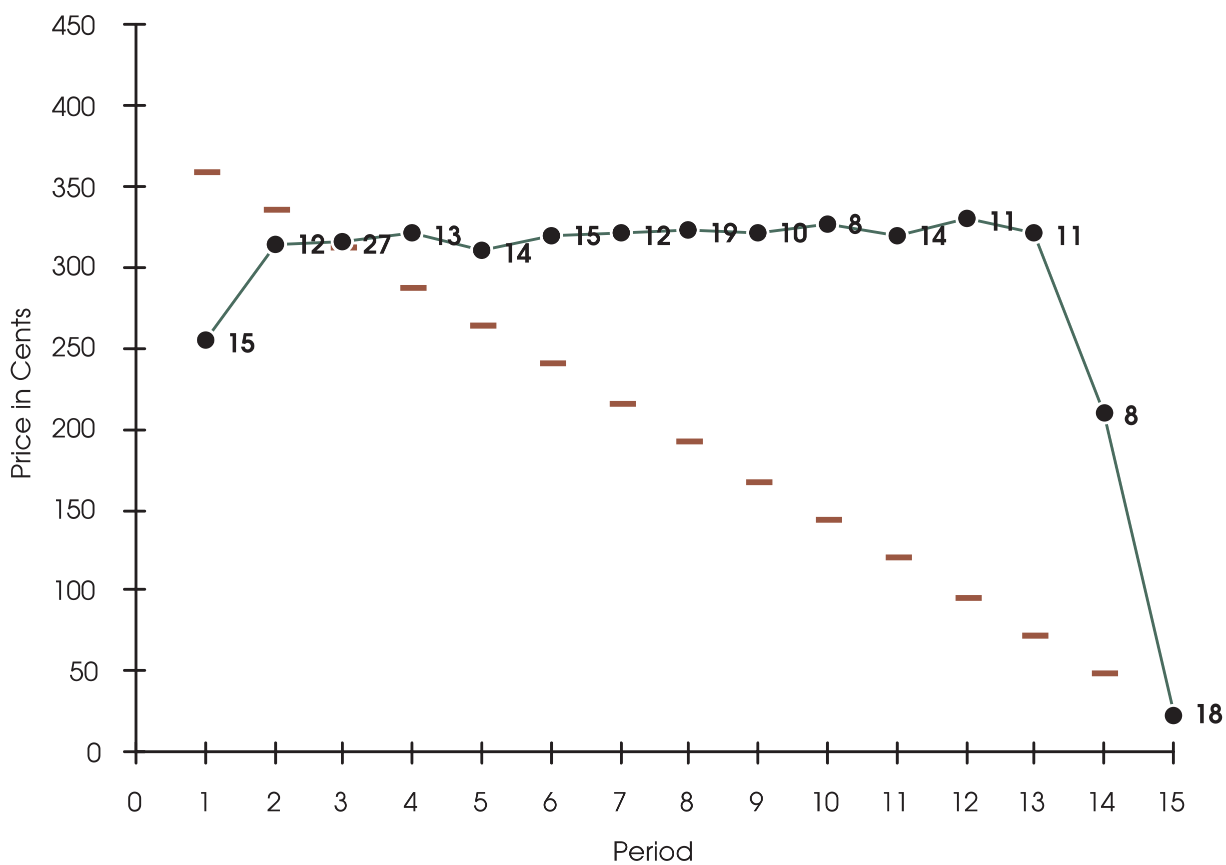
Recall that in the baseline experiments individual traders were endowed with different initial portfolios. A common characteristic of first-period trading is that buyers tend to be those with low share endowments, while sellers are those with relatively high share endowments. This suggests that risk averse traders might be using the market to acquire more balanced portfolios. If liquidity preference accounts for the low initial prices, which in turn lead to expectations of price increases, the making the initial trader endowments equal across subjects would tend to dampen bubbles:

Result 4: Observations from four experiments with inexperienced traders show no significant effect of equal endowments on bubble characteristics.

If risk aversion about price expectations due to dividend uncertainty causes a divergence of common expectations, then the elimination of such uncertainty should reduce the severity of bubbles. The PS experiments demonstrate otherwise (see Figure 4 for example).

Result 5: When the dividend draw each period is set equal to the one-period expected dividend value, so that the asset divi-

FIGURE 4
Mean Contract Price and Total Volume: Certain Dividend



dend stream is certain, bubbles are not significantly reduced relative to dividend uncertainty.

In Table 2 we note that the duration of bubbles is significantly increased with dividend certainty. The results in Appendix B for the Walrasian adjustment equation suggest, however, that dividend certainty does not have a significant effect on the capital gains expectations coefficient, β.

Results 4 and 5 are directed at changing the underlying induced value parameters of the baseline experiments but not the basic structure of the market. Stock markets in the field allow traders to take a position on either side of the market and leverage their sales by taking a short position or leverage their purchases by buying with borrowed funds. Consequently, a small number of traders who have counter-cyclical expectations would be able to offset the ebullient expectations of others. These considerations led to an explanation of the hypothesis that allowing subjects the right to short sell or to buy on margin would dampen bubbles.

Result 6: Short-selling does not significantly diminish the amplitude and duration of bubbles, but the volume of trade is increased significantly; Figure 5 provides an example.

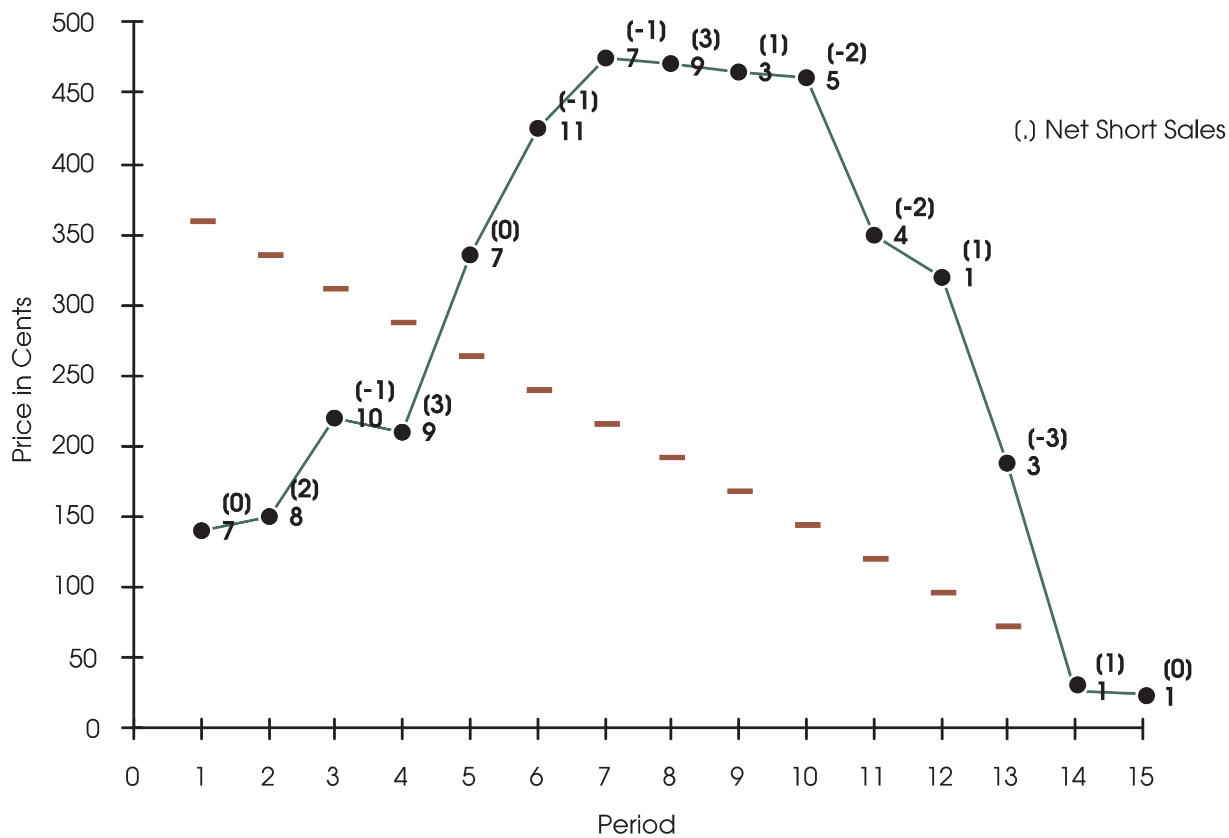
Result 7: Margin buying opportunities cause a significant increase in the amplitude of bubbles for inexperienced ($p < 0.01$), but not for experienced subjects.

Consequently, if anything, short selling and margin buying tend to exacerbate some aspects of observed bubbles.

The laboratory double auction has low participation costs *of* trading, since subjects only have to touch a button to accept standing bids or asks. This, coupled with the conjecture that laboratory subjects may believe that they are expected to trade may result in laboratory bubbles. However, the claim that subjects trade because they believe they are expected to, merely predicts trade, not bubbles; nor is the claim consistent with the tendency for turnover' to fall sharply with experience. One way to test the transactions cost hypothesis is to impose a transactions fee on each trade.

Result 8: A brokerage fee of 20 cents on each trade (10 cents on the buyer and seller) significantly reduced the amplitude, but not the duration, or share turnover measures of bubbles.

FIGURE 5
Mean Contract Price, Volume and Short Sales



The results suggest that bubbles are robust against significant structural and environmental changes. The endogenous process by which expectations are being formed has no difficulty surviving these first-order changes. The observation that individuals do not form common expectations, given common information on asset value, raises the question of whether these bubbles are sensitive to the subject pool. Most of the experiments have been conducted at the University of Arizona and Indiana University, using volunteers from the student population.[2] Could the use of professional traders and business executives eliminate this uncertainty concerning the rationality of others' behavior?

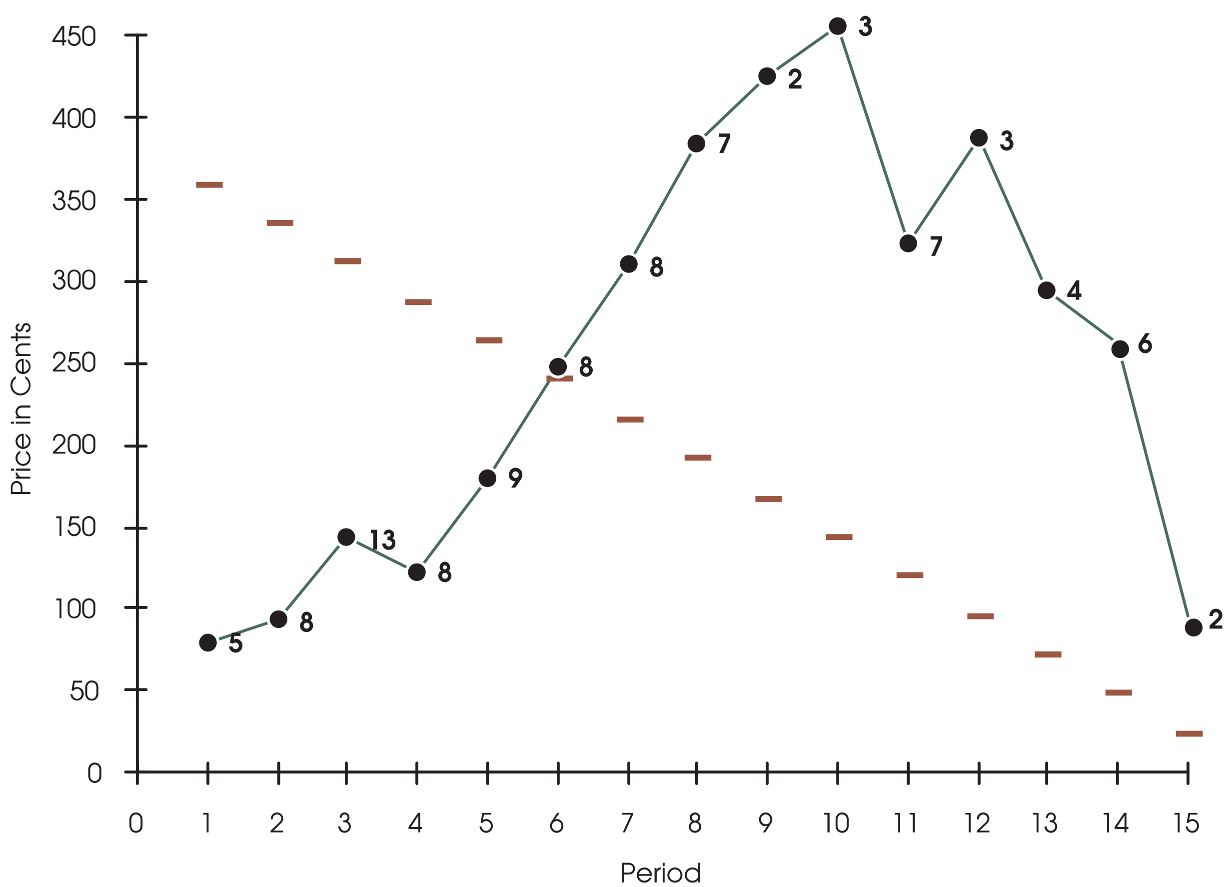
Result 9: The use of subject pools of small business persons, mid-level corporate executives, and over-the-counter market dealers has no significant effect on the characteristics of bubbles with first-time subjects.

In fact, one of the most severe bubbles among the original 26 SSW experiments was recorded in an experiment using small businessmen and women from the Tucson Arizona community (see Figure 6).

Rational expectations theory predicts that if irrational trading patterns create profitable arbitrage, then knowledgeable traders will take advantage of these opportunities and this will eliminate such trading patterns. This hypothesis was tested by having three graduate students read the SSW paper. In addition to seeing past data on laboratory bubbles, these "experts" were given information on the bid and offer count each period. As discovered in SSW, the excess of bids over offers was found to be a leading indicator of average price changes. These informed subjects then participated in a market with six or nine uninformed traders recruited in the usual way.

Result 10: The results support the rational expectations prediction provided that the informed traders are endowed with a capacity to sell short and the uninformed traders are once experienced. When the uninformed traders are inexperienced, the bubble forces are so strong that the informed traders are swamped by the buying wave; by period 11 they reach their maximum selling capacity, including short sales.

FIGURE 6
Mean Contract Price and Volume, Arizona Executives



The failure of the informed traders to eliminate the bubble when the uninformed traders are inexperienced is illustrated by the experiment in Figure 7.

It should be noted in Figure 7 that since short sales had to be covered by purchases to avoid penalties, when facing inexperienced traders short covering by informed traders prevented the market from crashing to dividend value in period 15. Thus, short selling against the bubble prevented convergence to the rational expectations value at the end.

A futures contract provides a mechanism by which each trader can get a reading on all traders' expectations concerning a future event. In effect, one runs a future spot market in advance. If a price bubble arises because of the failure of common information to induce common expectations, but the latter are achieved through repeat experience, then a futures contract should have the effect of speeding up this expectations homogenizing process. To test this hypothesis, PS ran two sequences of two experiments with the same subjects trained in the mechanics of a futures market. In the new experiments, a futures contract due in period 8 was utilized, where agents could trade both the spot and futures contracts in periods 1–8; after period 8, only the spot market was active. This market mechanism may help traders focus on their expectations of share value at midhorizon, and provide observations (futures' contract prices) on the group's period 8 expectations during the first seven periods of the market. Figure 8 shows the results of one of these futures market experiments.

Result 11: Futures markets dampen, but do not eliminate, bubbles by speeding up the process by which traders form common expectations.

Appendix B supplies estimates of an ANOVA model on the Walrasian price adjustment equation stated in equation (1) with treatment effects for futures market and certain dividend experiments. The results clearly demonstrate that the futures market has a significant dampening effect on capital gains expectations. In addition, the combination of one time experience and a futures market significantly reduces the capital gains adjustment coefficient, β.

In the wake of the worldwide stock market crash of 19 October, 1987, it was widely recommended by various investigatory groups that limit price change rules be implemented on US stock market exchanges. King et al. [1992] (KSW) report six experiments in which ceiling and floor limits were placed at plus (or minus) twice the expected one-period dividend value.

Result 12: Price limit change rules do not prevent bubbles; if anything they are more pronounced.

FIGURE 7
Mean Contract Price, Volume and Insider Purchases

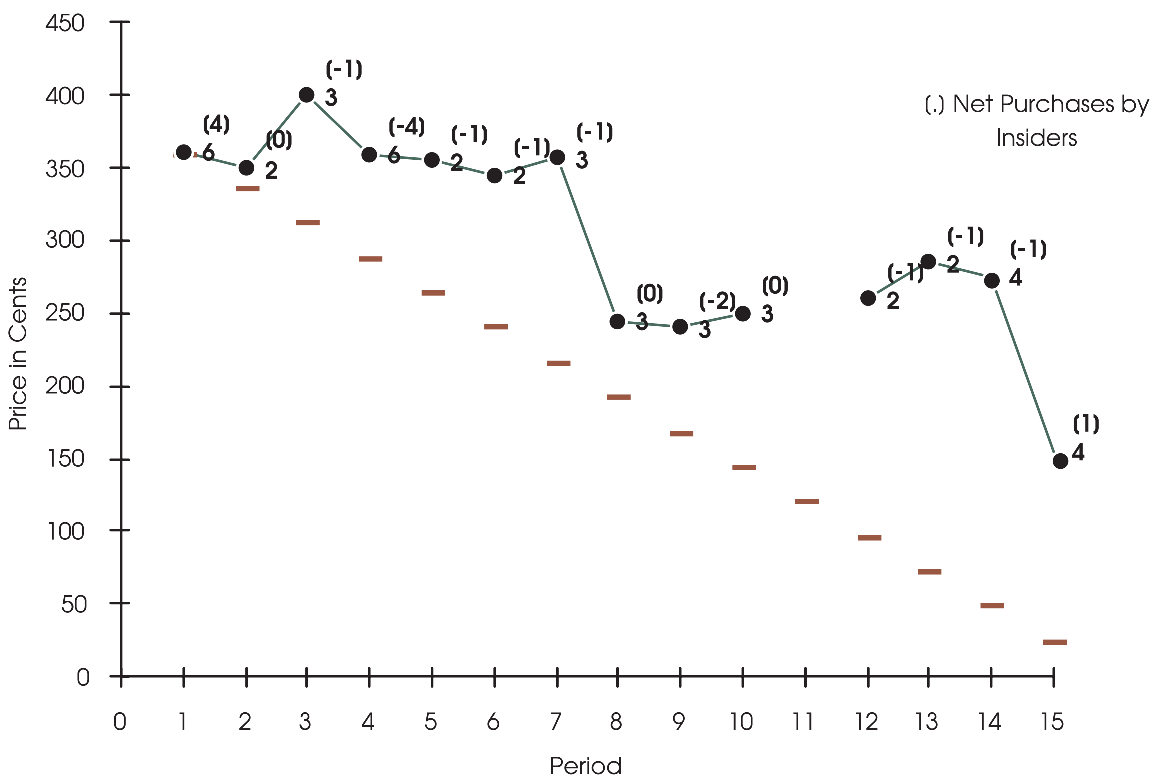
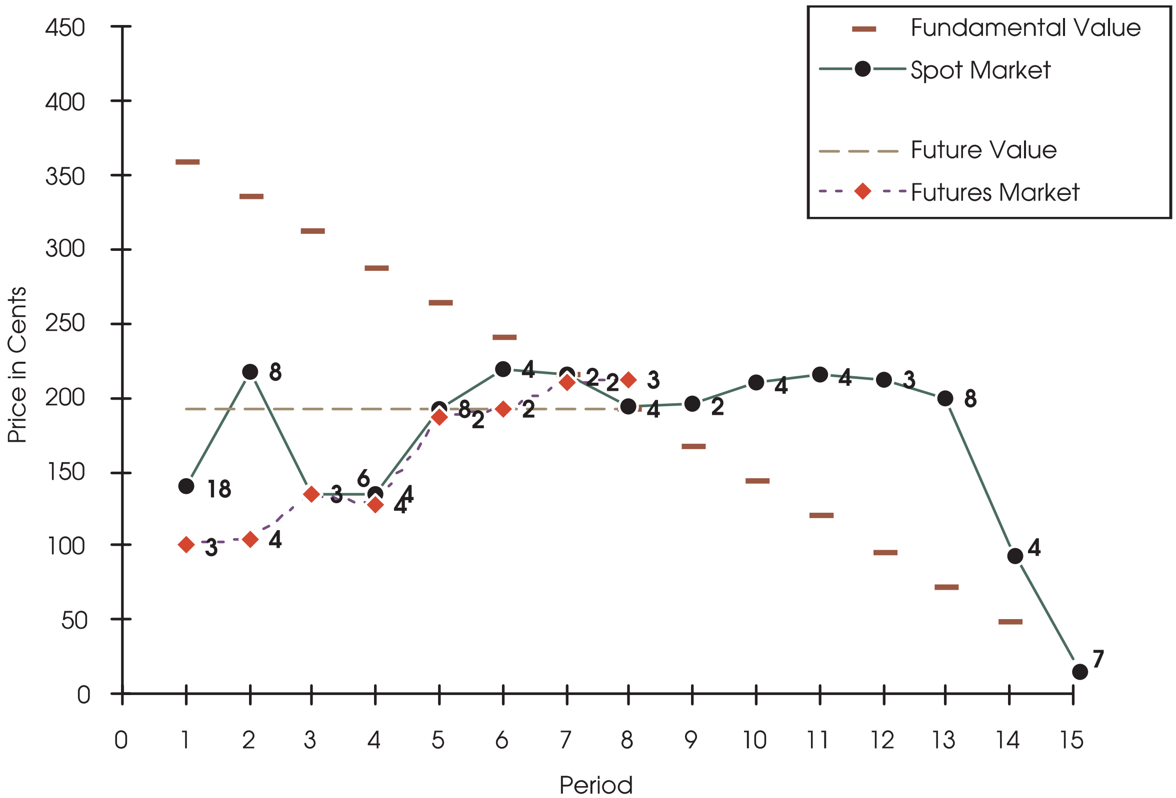


FIGURE 8
Mean Spot and Futures Contract Prices and Total Volumev



KSW conjectures that bubbles are more severe with limit price change rules because traders perceive a reduced down-side risk inducing them to ride the bubble higher and longer. But, of course, when the market breaks, it moves down by the limit and finds no buyers. Trading volume is zero in each period of the crash as the market declines by the limit each period (see Figure 9, for an example).

Summary

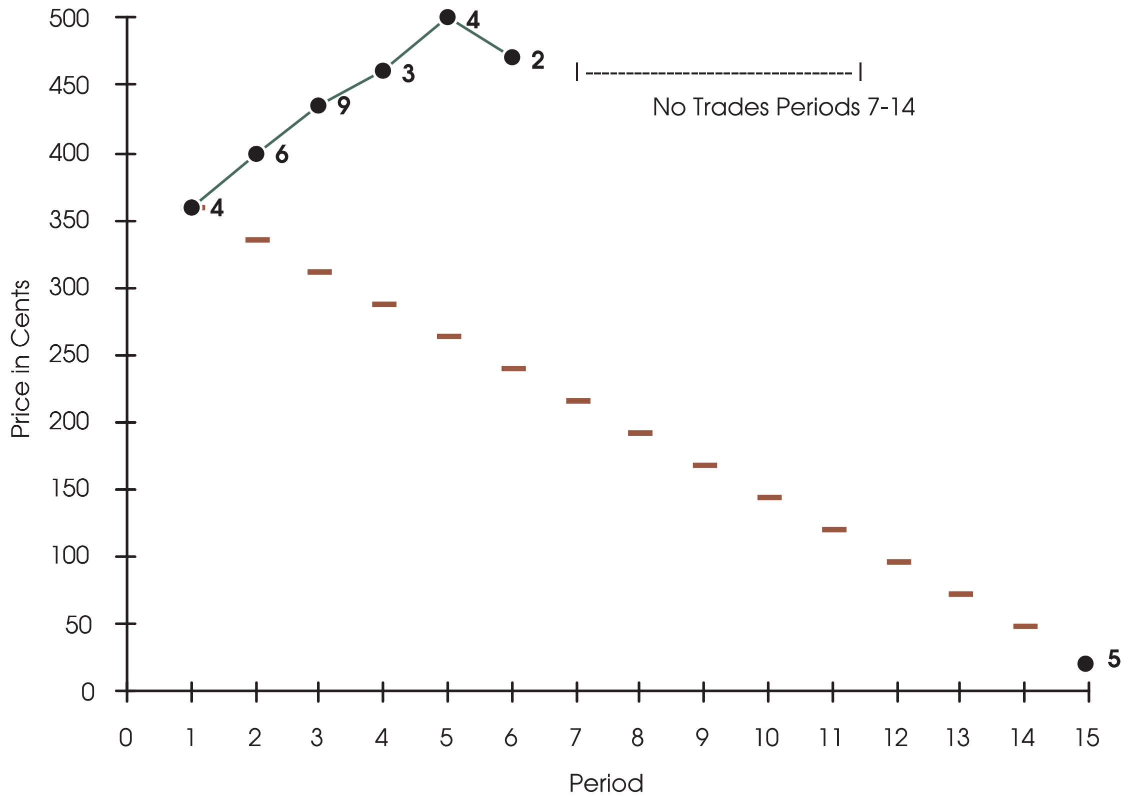
Laboratory stock markets in which shares have a well-defined expected fundamental (dividend) value, that is common information, exhibit strong price bubbles relative to fundamental value. These bubbles diminish with experience; trades fluctuate around fundamental values when the same group returns for a third trading session. Thus, common information is not sufficient to induce common rational expectations, but eventually through experience in a stationary environment, the participants come to have common expectations. If we suppose that investors are more "inexperienced" the longer it has been since the last stock market crash, the laboratory results are corroborated by a study showing a 98% correlation between the severity of declines in the Standard and Poor index and the length of time since the last crash.

More detailed analysis of the laboratory data shows that expectations of a rising market, as measured by trader price forecasts, occur early in a market. Traders' forecasts invariably miss price jumps and turning points. A more accurate predictor of mean price changes is lagged excess bids: a count of last period's bids minus the offers submitted.

The baseline experiments have been criticized for omitting a number of factors that might account for the propensity to bubble. A new generation of experiments evaluated these factors. Briefly, short-selling does not have a significant impact on bubble characteristics; margin buying fails to moderate, and even increases the amplitude of bubbles for inexperienced subjects; brokerage fees designed to raise transactions cost significantly reduced the amplitude of bubbles; the use of subjects from pools of small business persons, mid-level corporation executives and over-the-counter stock dealers had no significant effect on bubbles; the use of subjects who had an opportunity to study SSW, and who were given information on excess bids at the close of each period, support the rational expectations equilibrium, but only when the informed traders could leverage their sales with short selling, and when the uninformed subjects were experienced.

Finally, bubbles seem to be due to uncertainty about the behavior of others, not to uncertainty about dividends, since making dividends certain does not signifi-

FIGURE 9
Mean Contract Price and Total Volume: Limit Price Change Rule



cantly affect bubble characteristics; futures markets help to dampen (but do not eliminate) bubbles by allowing trades in a future spot market to occur in advance and thus speed up the process of creating common expectations; limit price change rules make bubbles worse, apparently by giving traders a perception of reduced downside risk, causing the bubbles to carry further and longer.

Further experimental tests

How can we use the laboratory to define the environment for an entirely new set of experiments designed to test Caginalp and coworkers' (Caginalp et aI., [990, 1991] Caginalp and Balenovich, [993] differential equation model of stock market price movements? The Caginalp et al.model requires baseline experiments for calibration. The predictions of the model for any new experiments are then contingent on two conditions: (a) the experiment's specified dividend structure and (b) the experiment's initial trading price level. Therefore, we propose the following experimental testing program.

(i) Conduct a new series of baseline experiments with a given uncertain dividend structure. These experiments will serve to parameterize the model, including its sampling error characteristics (four experiments).

(ii) Using the same dividend structure as in (i) conduct four new experiments in which the first period of trading is bounded by a ceiling and floor plus or minus 10 cents from some selected .initial price level, *Po*. The controlled level of *Po* would be set at one value for two of the experiments, and another value for the remaining two experiments. After the first period of trading in each experiment, the controls would be removed, and prices allowed to move freely for comparison with the predictions of the model.

(iii) The dividend distribution in (i) would be doubled in a third series of four experiments. In each experiment the initial period trading will be constrained by a price floor and ceiling as in (ii).

Given the baseline calibration experiments, the predictive ability of the model would be evaluated using the four distinct prediction paths defined by the controls specified in (ii) and (iii).

Acknowledgements

We are grateful to the National Science Foundation for Research Support and to Mark White for the example charted in Figure 1.

Notes

1. We calculate amplitude as the difference between the highest deviation of mean contract price from its fundamental value and the lowest deviation of mean contract from its fundamental value. This value is then normalized but the expected dividend value over 15 periods.
2. Bubbles have been observed with inexperienced student traders in two experiments at the California Institute of Technology and three experiments at the Wharton School.

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APPENDIX A

The following results are based on seemingly unrelated regression estimates of amplitude, duration and turnover simultaneous dummy variable equations.

ANOVA Estimates of Treatments on Amplitude, Duration and Turnover

Equation 1

Dependent variable:		AMPLITUDE	
Valid cases:	72	Missing cases	0
Total SS:	45.9484	Degrees of freedom:	61
Residual SS:	17.8081	Standard error of estimates:	0.5156
		Log likelihood	–53.5848

Treatment	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
Short sales	–0.0481	0.1708	–0.2816	0.7791
Certain dividend	0.0626	0.2530	0.2472	0.8055
Futures	–0.6796	0.3800	–1.7884	0.0782
Limit price rule	0.8843	0.2452	3.6072	0.0006
Equal endowments	0.5073	0.2824	1.7960	0.0770
Insiders	–0.5646	0.2559	–2.2066	0.0308
Transaction fee	–0.3434	0.2628	–1.3066	0.1958
Margin buying	0.8375	0.2505	3.3438	0.0013
Inexperienced	1.3602	0.1154	11. 7849	0.0000
Once experienced	0.7889	0.1624	4.8568	0.0000
Twice experienced	0.1680	0.2267	0.7410	0.4613

Equation 2

Dependent variable:		DURATION	
Valid cases:	72	Missing cases	0
Total SS:	1034	Degrees of freedom:	61
Residual SS:	482.7757	Standard error of estimates:	2.6843
		Log likelihood	–187.2307

Treatment	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
Short sales	0.9235	0.8895	1.0382	0.3029
Certain dividend	2.7896	1.3175	2.1174	0.0379
Futures	–0.3107	1.9785	–0.1571	0.8757
Limit price rule	0.1196	1.2764	0.0937	0.9256
Equal endowments	0.7583	1.4706	0.5156	0.6078
Insiders	1.2659	1.3321	0.9503	0.3454
Transaction fee	0.6200	1.3685	0.4530	0.6520
Margin buying	0.4967	1.3042	0.3808	0.7045
Inexperienced	9.2417	0.6010	15.3779	0.0000
Once experienced	5.4722	0.8457	6.4706	0.0000
Twice experienced	2.4272	1.1802	2.0567	
			0.0436	

Equation 3

Dependent variable:		TURNOVER	
Valid cases:	72	Missing cases	0
Total SS:	568.1284	Degrees of freedom:	61
Residual SS:	209.2946	Standard error of estimates:	1.7674
		Log likelihood	–153.3804

Treatment	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
Short sales	1.5514	0.5857	2.6488	0.0101
Certain dividend	–0.7395	0.8675	–0.8525	0.3969
Futures	–2.7666	1.3027	–2.1237	0.0374
Limit price rule	–0.1561	0.8404	–0.1858	0.8532
Equal endowments	1.0584	0.9683	1.0931	0.2783
Insiders	–1.0879	0.8771	–1.2403	0.2192
Transaction fee	–0.3911	0.9011	–0.4340	0.6656
Margin buying	–0.1470	0.8587	–0.1712	0.8646
Inexperienced	5.2291	0.3957	13.2150	0.0000
Once experienced	2.6124	0.5568	4.6916	0.0000
Twice experienced	1.5769	0.7770	2.0293	0.0464

APPENDIX B
ANOVA Estimates of Treatments for Walrasian Price Adjustment

The model that is estimated in this appendix is as follows:

$$\begin{aligned} P_t - P_{t-l} = {} & \alpha + \omega \cdot X + \partial \cdot C + \Phi \cdot Cx + \phi \cdot F + \gamma \cdot Fx \\ & + \eta \cdot S + \lambda \cdot L + \beta \cdot (B_{t-l} - O_{t-1}) \\ & + \rho \cdot [X \cdot (B_{t-1} - O_{t-1})] + \mu \cdot [C \cdot (B_{t-1} - O_{t-1})] \\ & + \nu \cdot [Cx \cdot (B_{t-1} - Q_{t-1})] + \theta \cdot [F \cdot (B_{t-1} - O_{t-1})] \\ & + \upsilon \cdot [Fx \cdot (B_{t-1} - O_{t-1})] + \zeta \cdot [S \cdot (B_{t-1} - O_{t-1})] \\ & + \tau \cdot [L \cdot (B_{t-1} - O_{t-1})] + \epsilon \end{aligned}$$

where:
P = mean contract price
B = number of Bids tendered
a = number of Offers tendered
X = experienced baseline
C = Certain dividend treatment dummy
Cx = experienced Certain dividend treatment dummy
F = Futures market treatment dummy
Fx = experienced Futures market treatment dummy
S = Switch treatment dummy
L = LAN market treatment dummy

Dependent Variable: ΔMean Contract Price

Certain Dividend Experienced	Coefficient	Standard Error	t-Statistic
α	–0.1273	0.0697	–1.8249
Baseline experienced	–0.0118	0.0942	–0.1249
Certain Dividend	0.0056	0.1185	0.0477
Certain dividend experienced	–0.0082	0.1229	–0.0674
Futures Market	–0.0512	0.1299	–0.3944
Futures market experienced	–0.0188	0.1512	–0.1246
Switch	0.0065	0.1631	0.0399
LAN	0.0041	0.0305	0.1357
β	0.0329	0.0050	6.5923
Baseline experienced	–0.0071	0.0036	–1.9722
Certain Dividend	–0.0136	0.0091	–1.4981
Certain dividend experienced	–0.0146	0.0093	–1.5577
Futures Market	–0.0237	0.0062	–3.7882
Futures market experienced	–0.0278	0.0095	–2.9072
Switch	–0.0312	0.0135	–2.3012
LAN	–0.0021	0.0946	–0.0211

Number of observations: 364
R^2: 0.2571
SSR: 0.0113
SER: 0.5782
D-W: 2.0679