2014

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Recommended Citation

Deck, C., Porter, D., and Smith, V. (2014). "Double Bubbles in Assets Markets with Multiple Generations," *Journal of Behavioral Finance*, 15(2), April 2014, pp. 79-88.
DOI:10.1080/15427560.2014.908884?journalCode=hbhf20

Double Bubbles in Assets Markets with Multiple Generations*

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February 2012

We construct an asset market in a finite horizon overlapping-generations environment. Subjects are tested for comprehension of their fundamental value exchange environment, and then reminded during each of 25 periods of its declining new value. We observe price bubbles forming when new generations enter the market with additional liquidity and bursting as old generations exit the market and withdrawing cash. The entry and exit of traders in the market creates an M shaped double bubble price path over the life of the traded asset. This finding is significant in documenting that bubbles can reoccur within one extended trading horizon and, consistent with previous cross-subject comparisons, shows how fluctuations in market liquidity influence price paths. We also find that trading experience leads to price expectations that incorporate fundamental value.

Key Words: Asset Markets, Price Bubbles, Laboratory Experiments, Overlapping Generations

JEL codes: C91, D83, G12

* The authors wish to thank Michael Kirchler for helpful comments on this paper. Support from the Bank of America Research Fund Honoring James H. Penick is gratefully acknowledged.

1. Introduction

Markets are a critical feature of national economies. Market prices serve as signals, coordinating the activities of dispersed individuals. (Hayek 1945). Markets are theoretically efficient if prices reflect all available information as posited in standard economic and finance theory (Muth 1961, Fama 1970). This property has long been supported empirically in experimental supply and demand markets for flows of commodity where each unit transacted realizes an immediate current surplus for each agent identified in the transaction.[1]

However, there are many instances where asset market prices have become unhinged from the underlying value of the asset being traded, sometimes for extended periods, often with negative effects that ripple through the broader economy when the market corrects. The housing market collapse beginning in 2007 has led to a severe negative equity condition for households, and, since the banks hold mortgage claims on homes, the banks also suffer from the same condition. Naturally occurring markets, however, offer limited ability to study price bubbles. In part this is because an asset's fundamental value is not normally objectively verifiable and thus, empirical work that compares prices to some estimated value necessarily represents a joint test of efficient markets and the accuracy of the estimated "true" value.[2] Similarly, it is difficult to determine if price movements are due to real or fundamental changes in information or not.

As discovered initially in Smith, Suchanek and Williams (1988; hereafter SSW), the laboratory can provide a replicable environment in which to study market behavior and explore factors that lead to the formation and collapse of asset price bubbles. In SSW subjects were endowed with cash and shares receiving dividend realizations from a common information distribution in each of a known number of periods. As in rational expectations theory the fundamental value of shares in any period is simply the expected value of the remaining dividend payments. Hence, fundamental value declines monotonically over time.[3] There are hundreds of laboratory experiments replicating and extending the results of SSW. With inexperienced traders, prices grow relative to fundamental value creating a bubble followed by a collapse as the endpoint of

[1] Such markets converge in minutes. See Smith (1962) and Holt (1995) for a comprehensive survey.
[2] An exception is to be found in closed-end stock funds where large bubbles have sometimes occurred; the Spain and Iberian funds are examples (See Porter and Smith 2003). See also Xiong and Yu (2010) for a discussion of bubbles in Chinese warrant markets.
[3] See Noussair, et al. (2001) and Noussair and Powell (2001) for discussions of asset market experiments with non-standard fundamental value paths.

the trading horizon is approached. That is, a single bubble is commonly observed. With additional experience bubbles become progressively less pronounced, and approach fundamental value. As explained below, however, recent studies have greatly illuminated the economic conditions that account for these bubbles, and established that instructional treatments that focus on subject comprehension can substitute for experience in moderating or extinguishing these bubble tendencies.

One shortcoming of the standard asset market experiments is that the lives of the traders and the assets are identical, and that other market conditions such as the initial amount of liquidity in the system or the inflow of new liquidity (cash dividends) is fixed. Thus, studies that have examined the effects of liquidity have largely emphasized using across-subjects market comparisons. This paper extends the experimental asset market literature by varying market conditions within the trading horizon while otherwise maintaining the structure common to that literature. Specifically, this paper presents the results of asset market experiments where traders enter and exit the market within the longer life of the traded asset. Entry is associated with bubble formation as the market absorbs the increased liquidity. Exit is associated with bubble collapse as traders remove money. The cycling of trading generations leads to a pattern of bubble formation, collapse, and reformation within the continuous trading life of the asset.

The remainder of the paper is organized as follows. Section two provides a detailed review of the asset market literature and section three describes our experimental design. The results are presented in section four and a final section offers concluding remarks.

2. Background Literature

In the canonical asset market environment, with complete probabilistic information and declining fundamental value, experience in three separate sessions with the same subjects has been identified as the one reliable treatment that yields convergence toward the predicted rational expectations equilibrium. (Sunder, 1995: Porter and Smith, 2003) The conclusions of SSW were that: (1) the results were entirely consistent with rational expectations as an equilibrium concept; (2) but complete common information was not alone sufficient to yield equilibrium except through an experiential learning process in which people come to have common rational expectations with experience (SSW, pp 1148, 1150). This conclusion has been modified by the work of Lei, et al. (2001). They report experiments in the SSW environment with inexperienced subjects wherein buyers (endowed with cash) can only buy against dividend value, and sellers (endowed with shares) can only sell shares. Contract prices persist in varying degrees above fundamental dividend value in all three of the sessions reported, showing that buyers violate individual rationality, and that the phenomena of conscious rational speculation—buy low in expectation of capital gains, then sell high—is not necessary for such mispricing to occur with inexperienced subjects.[4] This contribution implies that experience across three sessions in SSW accomplishes rather more than creating common expectations: in the process it also eliminates or corrects initial violations of individual rationality by inexperienced subjects.

Various treatment conditions have been identified that reduce or eliminate mispricing and bubbles within the same general instructional treatments:

(1) Smith et al, (2000) find that when a single dividend realization is paid on terminal share holdings, bubbles are essentially eliminated with inexperienced traders. Hence, with trader attention refocused on end-of-horizon realizations and away from myopic period-by-period realizations, trader behavior changes dramatically from the bubble behavior reported by SSW (also see Noussair, et al. 2001 and Noussair and Powell 2010 who further extend the investigation of the timing of asset return realizations.) Caginalp et al. (1998) had shown that bubbles were larger if initial cash to asset value ratios are increased, but Kirchler et al. (2011) perceptively observe that when incoming dividends are realized each period in an environment of declining asset FV, the ratio of cash to asset value escalates throughout the experiment. Hence, in comparison with SSW a second important condition in Smith et al, (2000) is being changed simultaneously: when all dividends are realized at the end of the horizon, rather than at the end of each period, it removes the flow of incoming cash to fuel momentum trading sentiment. Smith et al. (2000) also reported a series of experiments in which half of each dividend realization is paid at the end of each period, and half at the end of the experiment. The result was more modest bubbles than in SSW, consistent with the effect of the rising cash to asset value emphasized by Kirchler, et al. (2011). Hence, the strong association of bubbles with incoming

[4] Similar wholesale violations of individual rationality were evident in the recent housing-mortgage market bubble. Thus, in 2005, 45% of first time borrowers paid no money down. (National Association of Realtors, 2006, Exhibit 5-3). Hence, lenders were exposed asymmetrically to the entire risk of their loan in the event that prices turned down. If prices continued to rise the entire increase translated into equity for borrowers, who had an incentive to abandon the home if prices turned down.

flows of new cash.[5] These informative results may also help to explain why information asset trading markets in the field tend not to bubble like those in SSW environments. Information markets are designed to predict a wide array of future events such as company sales (Chen and Plott 2002), the outcome of political elections (Berg, et al. 2008) and the popularity of movies (Pennock, et al. 2001). A characteristic feature of these markets is that they create asset claims on event-contingent outcomes realized at the end of a finite trading horizon.

(2) Noussair and Tucker (2006) add a futures market to the SSW environment on each period ahead in addition to the current spot market in shares, and this also is quite effective in squelching bubbles in spot shares. As in (1) this important result may be interpreted as also requiring traders to focus on value (and actually produce corresponding prices) in future periods; moreover, it aids backward induction and reduces uncertainty about future behavior of others by allowing that behavior to be experienced simultaneously in the current period. It demonstrates what may be the most important role of futures markets: to give individuals advance information on traders' own expectations of the future and aid the formation of common expectations.

Several studies have focused on the use of instructions and other pre-experiment exercises (rather than only experience for given instructions as in SSW) to assess the effect of improved individual comprehension on group convergence to fundamental value: Kirchler et al. (2011) emphasize better subject understanding of the declining FV process as a means of greatly reducing bubbles; Lei and Vesely (2009) give subjects pre-experiment experience with the dividend process; Huber and Kirchler (2011) show that subjects perform better with training devices in which the declining FV process is exhibited in graphical rather than tabular form, or when subjects are administered a questionnaire that reward-motivates them to answer correctly each period what the FV is for that period. Graphical devices and incentives matter in teaching the economic principles of rationality that translate into better asset market performance.

All these technical and aberrant conditions that exacerbate bubbles—higher cash to asset ratios, absence of a futures market, and sources of trader error, irrationality and misunderstanding of

[5] This property, however, did not extend to a new series of six long-horizon experiments reported by Lahav (2011) who studied asset markets over 200 periods using a call market each period. Dividends of 0 or 0.3 "francs" with equal probability were paid per share each period, adding to the stock of cash. Across the six replications there was no consistent pattern; in particular, none associated with a single bubble rising with the ratio of cash to shares and collapsing near the end of the trading horizon. The bubbles observed were erratic in timing, duration and amplitude, and sometimes crashed and resumed several times, apparently independent of any external change.

declining FV—are all corrected by three times experienced subjects in the SSW environment. However, the easiest and most effective way to foreclose the emergence of a bubble in SSW environments seems to require no change in the instructions and no experience: eliminate the period by period inflows of cash (dividends) by paying one dividend realization at the end of the experiment.

3. Experimental Design

Assets and Trading

In our economic environment shares last 25 periods and have a redemption value of zero at the end of the 25th period. Following Hussam, et al. (2008), a dividend is paid each period and the amount is randomly drawn from {0, 8, 28, 60} in cents. A total of 18 shares exist in the market and every share is paid the same dividend in a given period. In actuality, one dividend stream was drawn and used in every experimental session.

The fundamental value of a share in period t is $24 \times (26 - t)$ cents since the expected dividend payment is 24 cents each period and dividends are paid at the end of the period. Thus, before the first dividend is paid, a share of the asset is worth 600 cents. The fundamental value then decreases by 24 cents with each passing period until the 25th period during which the value is only 24 cents. This creates the familiar declining stair step pattern for fundamental value used in the vast majority of asset market experiments.

During each trading period active traders can use cash to buy shares and/or sell shares for cash. Trading occurs via an electronic double auction market. Active traders can post offers to sell shares assuming they currently own shares (i.e. short selling is not allowed). Active traders can also post offers to buy shares assuming they have enough cash (i.e. borrowing is not allowed). New offers to buy and sell must improve upon existing offers, but displaced offers remain in the open bid book unless cancelled.[6] At any point, an active trader can accept the current best offer to buy or sell. Completed contracts are displayed graphically in chronological order.

[6] The effect of an open book, with all orders standing and visible to the participants, on asset trading behavior has not to our knowledge been studied in a double auction market. We note that U.S. stock markets do not implement

Trader Generations and Predicted Behavior

There were 18 participants in the experiment, each assigned to one of three generations of traders. A third of the subjects were randomly assigned membership in Generation 1, a third to Generation 2, and a third to Generation 3. Traders in the same generation were indistinguishable from one another. Each member of Generation 1 was endowed with three shares and 1500 cents cash for a total expected portfolio value of $3 \times 600 + 1500 = 3300$. Members of Generations 2 and 3 were endowed with 0 shares and 3300. Cash holdings for Generation 1 were set such that the ratio of cash to fundamental value was 2.5, as in Hussam et al. (2008).

Generation 1 traders were active, meaning members of that generation could buy and sell shares and receive dividends, in periods 1 through 10. Generation 2 was active in periods 6 through 20 and Generation 3 was active in periods 16 through 25. With our overlapping generations framework, the market cycles through five-period sequences of a single generation trading and five period sequences in which two generations are trading.[7] Each time a generation becomes active, new cash is brought into the market. Each time a generation becomes inactive, cash is withdrawn from the market.

Generation 3 faces a problem similar to that faced by subjects in standard asset markets as they are trading assets they can hold until all dividends are paid. However, Generation 2 faces a more complicated problem in that Generation 2 subjects have to anticipate what Generation 3 will be willing to pay in period 20 when five dividend payments remain. Generation 1 faces an even more difficult problem as they have to anticipate how much Generation 2 will be willing to pay for shares that will in turn be sold to Generation 3.

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an open book. What is made public are the following: the most recent trade price, the standing best bid and ask, and the "stock ahead" (quantity offered) at the standing bid and ask prices. These items are all updated in real time as they change. We note also that SSW originally followed these information displays and trading rules. Caginalp, et al. (1998) consider the effect of an open versus closed bid book with a call market institution and find that bubble amplitudes are dampened with an open book.

[7] To maintain the number of shares in the active market, any shares held by a trader after he or she became inactive were automatically sold to the experimenter at a price of 0 and then resold by the experimenter in the next period at random intervals by accepting the highest offer to buy. This process was explained to the subjects in the directions. Traders were also reminded of this in their penultimate active period. On average 1.625 shares were purchased by the experimenters when a generation exited the market with 46% of these purchases occurring in Session 2 when Generation 2 stopped trading after period 20.

Under standard assumptions, including common knowledge of the rationality of others, traders should be able to infer that the price in the last period will be 24, the expected value of a single period. Working backwards the price would equal fundamental value every period. As an alternative, myopic traders would only value the asset for the dividends they themselves could receive. Under this assumption prices would decline within each five period increment, experiencing sizeable jumps or falls when new traders enter or exit respectively, but always remaining below fundamental value until period 21 at which point price would equal fundamental value. A third alternative is suggested by Caginalp et al. (1998) and Kirchler et al. (2011) in which the entry and exit of traders increases and decreases the cash to asset FV ratio, causing prices to rise relative to fundamental value with entry and the converse occurring as traders exit. These considerations suggest that we would observe a bubble in periods 6-10 followed by collapse in periods 11-15 followed by another bubble in periods 16-20 and a second collapse in periods 21-25.

Price Forecasts

While inactive, subjects were asked to forecast the average price in the next trading period. At the end of the experiment one inactive period was selected for each generation. Subjects received $10.00 if their price forecast was within 5% of the actual observed price in the selected period. Answers that were within 10% of the actual price received $5.00 and predictions that were within 25% of the actual price received $2.50.

Predictions were made during the summary time between periods. While inactive traders could not observe market trading on their own screens, a market observer screen was projected at the front of the lab throughout the experiment. The screen listed the bid book, graphed contracts, provided dividend realizations, showed the average price, and displayed messages about generations entering and exiting the market as well as the fundamental value. This procedure also served to provide common information to all subjects and reinforced the commonality of dividends and the trading process information.

Participants and Procedures

A total of 72 subjects participated in the study, 18 unique people in each of the four replications. The experiments were conducted at the Behavioral Business Research Laboratory at the

University of Arkansas. Participants were all undergraduate students at the institution who had previously registered in the lab's subject pool. No subject had previously participated in any related experiments at the lab. The experiment lasted two and half hours and subjects received a participation payment of $10 in addition to their salient earnings. Because of the length of the experiment, all sessions were conducted in the evening. The average total subject payment was $52.14.

Upon arriving at the lab, subjects were randomly assigned seats, which had privacy partitions. The directions were presented as a slide show at the front of the room and the text was read aloud by a researcher. After the directions were finished and any questions had been answered, subjects completed an online multiple response comprehension quiz. Three of the nine quiz questions addressed subject understanding of the dividend structure or the declining average value of dividends remaining to be paid per share; e.g., one question asked "During round 3 trading, the average total future dividend payment for a Share would be;" another, asked "After the dividend following period 25 is paid, a Share is worth." After the quiz, subjects learned of their own generation and the experiment began.

At the end of each round of trading, traders are shown the realized dividend amount and summary information that includes the average price in the preceding period and (if active) the subject's own holdings of shares and cash (inclusive of the dividend payment). During trading, everyone is informed of the fundamental value of a share based on the expected dividend realization and the number of dividend realizations remaining. Specifically, the subjects are shown a statement on the screen such as "This is round 14. The expected total future dividend payment is 24*12=288." Consequently, subjects are not expected to hold in memory the declining FV process, on which their understanding had been tested at the end of the instructions.

Each trading period lasted three minutes and the break between periods was approximately 30 seconds. Trading was electronic via the Zocalo program while price forecasts were hand written.[8] After the final dividend realization, subjects were privately paid their earnings in cash and dismissed from the experiment.

[8] Copies of the directions, the quiz, and the price forecasting handouts are available from the authors upon request. The Zocalo software is available at zocalo.sourceforge.net.

It is worth emphasizing that we are focusing on subjects who experience the market only once. Thus, our results are comparable to those of inexperienced subjects in asset market experiments. Based upon the entirety of the asset market literature, as well as data from other experiments where backwards induction is expected to play a role,[9] we speculate that with sufficient repetition prices would approach fundamental value. However, naturally occurring markets are not replayed with the same participants and it is this environment that we seek to capture in the laboratory as it is the domain where bubbles occur and policy is applicable.[10] Similarly, and for the same reason we do not follow the procedures in the background literature above where instructions and various pre-experiment training exercises are used as a treatment and shown to substitute for experience in reducing bubble formation.

4. Experimental Results

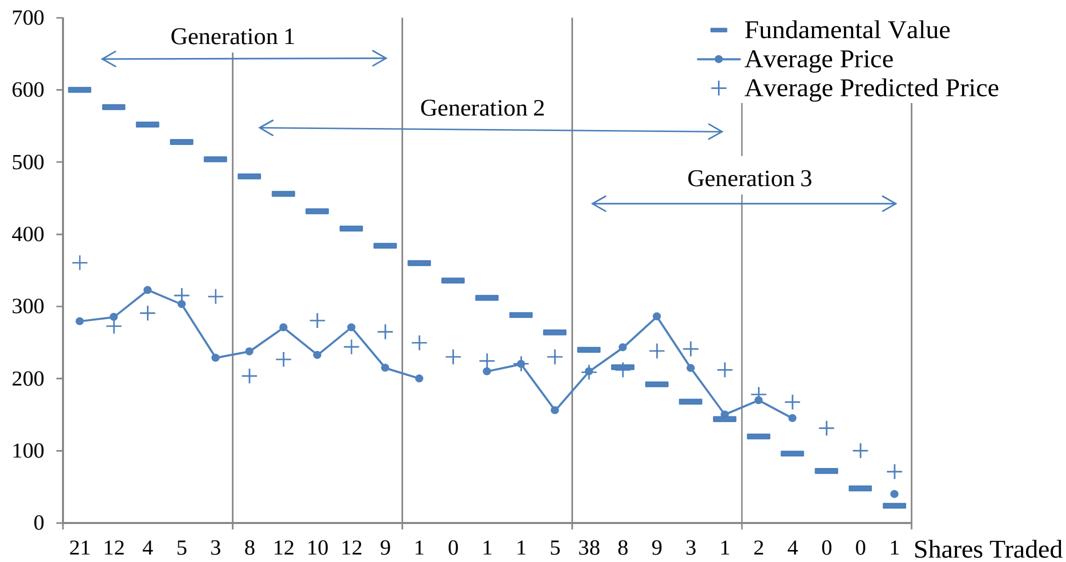
Figure 1 shows the price pattern relative to fundamental value for each session. The main result is clear from this figure; three of the four sessions show a clear double bubble pattern consistent with the bubbles being driven by the influx of cash and the bursts being driven by cash being pulled out of the system. In every session, shares trade well below fundamental value in the first five periods. In three of the sessions (all except session 1) share prices are above fundamental value in period 6 when generation 2 enters the market and continue to bubble in the 7th period. However, in all three of these sessions, by the 10th period, the last period in which generation 1 is active, the bubble is bursting and prices are falling. Even in session 1, where prices remained below fundamental value for the first 16 periods, prices were higher in periods 6 through 9 than in period 5 and were lower in period 10 than in any preceding period yielding the same directional price changes as in the other sessions. All four sessions experience a bubble in periods 16-20. Three of the sessions (all expect session 4) see prices near fundamental value by period 20 with trading remaining relatively close to this level in the last five periods. The second bubble in Session 4 inflated and burst more gradually than those of the other sessions, but even here the prices began to fall as generation 2 was exiting the market and the bubble had burst by the end of trading.

[9] See for example, McCabe (1989) on the unraveling of fiat money with experience.
[10] In motivating his work Lahav (2011, p 22) asks, “However, if the cause of bubbles and crashes is lack of experience, why are there typically multiple bubbles and crashes in field asset markets? After all, even if inexperienced traders enter the market, they all have access to the price history of assets.”

Traditionally, asset market experiments have focused on the size and duration of a single bubble. To examine multiple bubbles, we need to delineate each episode. Therefore, we define a price trough to occur in period t when $p_t \leq p_{t+x}$ for $x \in \{-4, -3, \ldots, 4\}$ where p_t denotes the average price in period t. We define a peak in the analogous way.[11] In one instance (Session 4), this definition does not lead to a unique trough between the first and second peaks. In this case we take the period with the lower price to be the trough. All four sessions experience a trough in the first five periods, followed by a peak occurring between periods 7 and 9 (with the peak remaining below fundamental value in session 1), followed by a trough between periods 10 and 15, followed by another peak between periods 16 and 19 and a final trough in period 20.

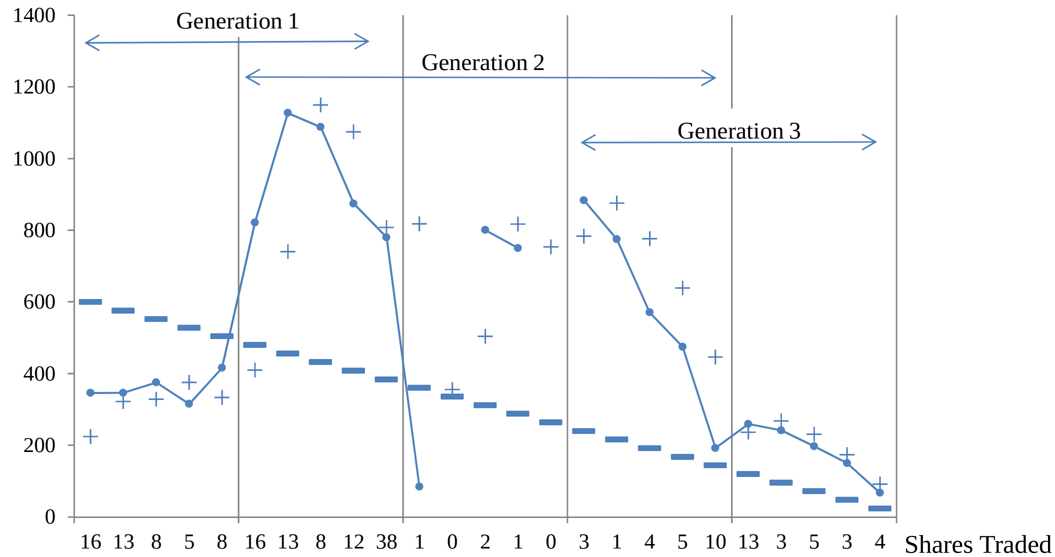
Figure 1. Market Behavior by Session

Session 1

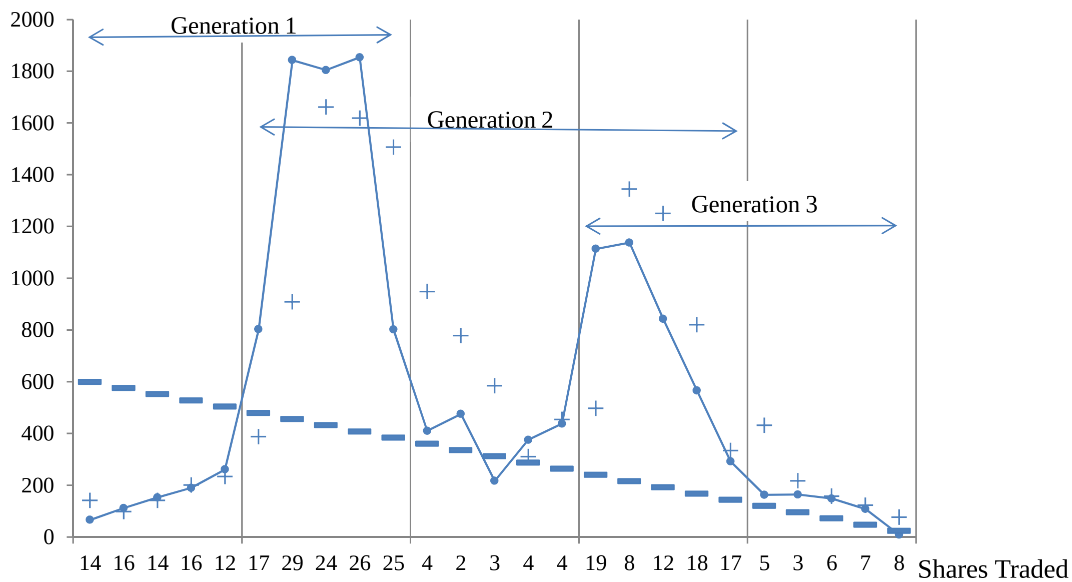


[11] For periods in which no trading occurred, a linear price trend was assumed to exist between the most recent average price observed and the next average price observed.

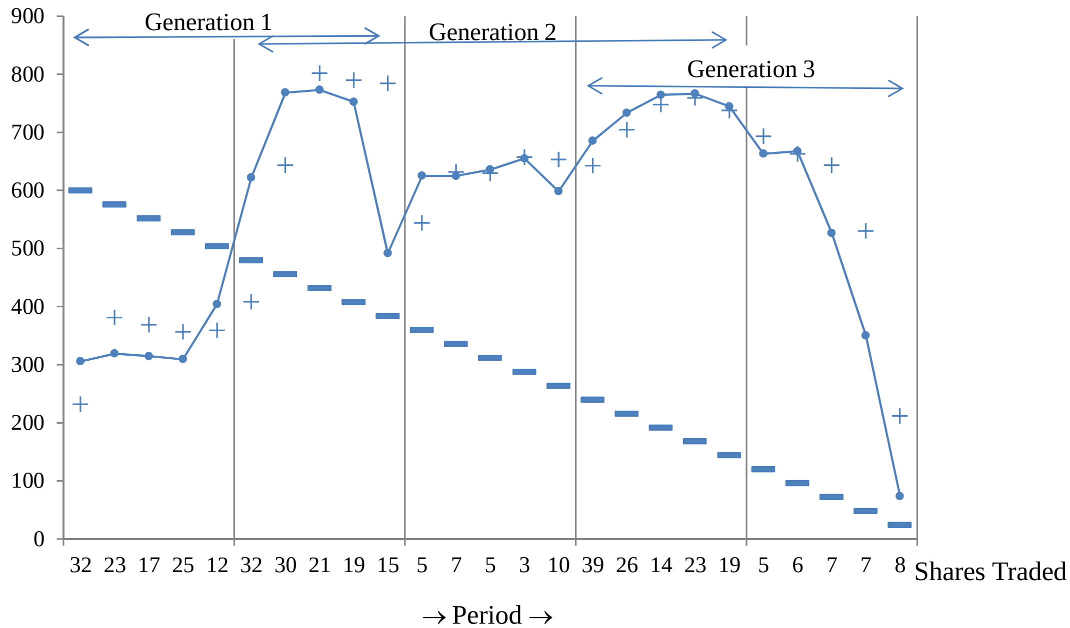
Session 2



Session 3



Session 4



For each bubble, Table 1 presents three primary characteristics: Amplitude, Duration, Turnover, and Relative Absolute Deviation (RAD). Let B = $\{b_1, \ldots, b_{P-1}, b_P, b_{P+1}, b_T\} \subset \{1, ..., 25\}$ be the periods over which a bubble occurred with b_1 and b_T denoting the periods of the starting and ending troughs respectively and b_P denoting the peak period. Amplitude is maximum change in the difference between price and fundamental value. It is measured as max $\{(p_t - F_t)/F_{b_1}: t \in B\}$ – min $\{(p_t - F_t)/F_{b_1}: t \in B\}$ where F_t is the fundamental value of the asset in period t. Duration is the length of time in periods that prices increase. We provide two measures of Duration. Trough to Peak Duration is simply the number of periods between the trough and the peak, that is b_P-b_1. Standard Duration as typically measured in asset market experiments is measured as max $\{m: p_t - F_t < p_{t+1} - F_{t+1} < \ldots < p_{t+m} - F_{t+m}$ for $t \in (b_1, \ldots, b_{P-1})\}$. The former definition ignores fundamental value and does not require a monotonic increase. Turnover measures trading activity in the market. It is defined as $\sum_{t \in B} V_t / S$ where S is the number of shares in the market and V_t denotes the trade volume in period t. RAD is measured as $\frac{1}{T}\sum_{t=1}^{T} \frac{|p_t - F_t|}{|\bar{F}|}$ where $\bar{F}$ denotes the average value of F over B. RAD was introduced by Stöckl et al. (2010) as a means to compare bubbles across markets with different characteristics. As compared to other asset markets evaluated using RAD in Stöckl et al. (2010), the bubbles we observe are relatively large.

Table 1. Summary Characteristics for Each Bubble

Session	Bubble	Periods	Peak Period	Amplitude	Trough to Peak Duration[a]	Standard Duration[a,b]	Turnover[c]	RAD
1	1[d]	5-15	9	0.41	4 (36%)	4 (36%)	4.13(0.38)	0.39
	2	15-25	18	0.76	3(27%)	3(27%)	4.73(0.43)	0.27
2	1	4-11	7	1.79	3(38%)	3(38%)	6.73(0.84)	0.87
	2	11-25	16	2.55	5(33%)	2(13%)	3.67(0.23)	1.29
3	1	1-13	9	3.30	8(62%)	8(62%)	13.47(0.96)	1.22
	2	13-25	17	3.26	4(31%)	4(31%)	7.60(0.58)	1.65
4	1	1-10	8	1.06	7(64%)	8(73%)	15.07(1.37)	0.48
	2	10-25	19	1.43	9(56%)	5(31%)	13.27(0.83)	1.94

a. Numbers in parentheses in this column give duration as a percentage of the number of periods between troughs.
b. For the purpose of calculating duration, periods in which no trading occur are treated as though prices followed a linear trend from the preceding observed price to the subsequent observed price.
c. If the only trading activity involved the intergenerational transfers of shares the turnover would be 1. Numbers in parentheses in the turnover column give the average turnover per period.
d. Prices in bubble 1 of session 1 remained below fundamental value, but did create a peak and a trough as prices rose and fell.

We now turn to the relationship between liquidity and bubble behavior. Figure 2 shows the available cash inclusive of dividend payments in the system each period. By design, the amount of cash differs across sessions due only to profit taking by generations exiting the market. Therefore, available cash is the same through the first 5 periods, rises with the entrance of generation 2, holds constant through period 10 in every session and falls in period 11, after the first generation exits. It falls most (least) dramatically in session 4(1), indicating that generation 1 traders in that session made relatively more (less) profit than their counterparts in the other sessions. The increase in cash between periods 15 and 16 was constant across sessions since this change reflects the cash endowment of generation 3 and the dividend payment after period 15. The available cash falls again in period 21 when generation 2 exits the market.

Figure 2. Available Cash Each Period by Session

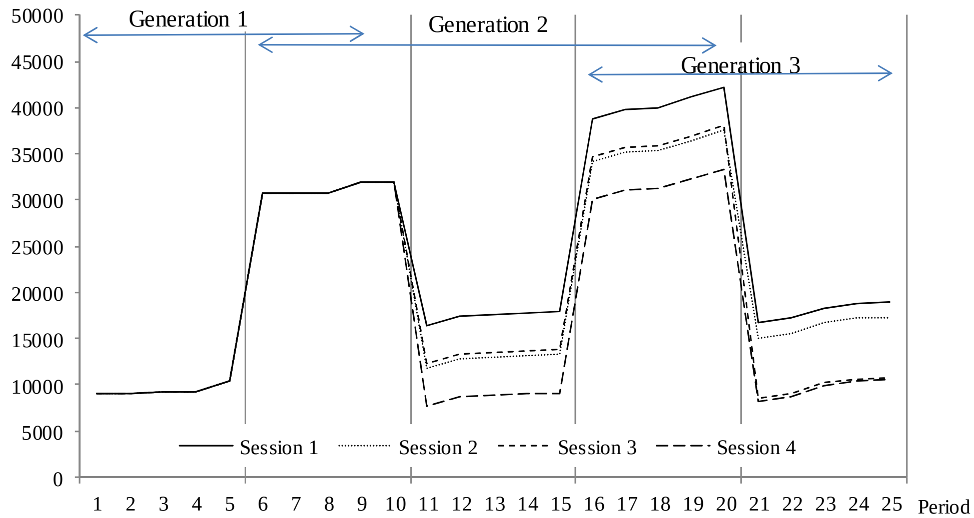


Figure 3 plots the average deviation of price from fundamental value in each block of 5 periods. This figure reveals a clear "M" shape pattern, consistent with the bubbles forming as liquidity enters the market and bursting as cash is removed. Two of the four sessions fit the "M" perfectly and the other two are off on a single segment. If the direction of changes in price deviation were random, the pattern shown in Figure 3 would only occur with probability less than 0.001.[12]

Figure 4 plots the average trade turnover per period for each block of 5 periods. Here the pattern is even more consistent with changes in liquidity driving trader behavior and leading to bubble formation and collapse. There is only a single segment (the change in turnover when generation 2 exits the market in Session 2) that is inconsistent with an "M" pattern. If changes in turnover were random, this pattern would occur with probability less than 0.0003.[13]

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[12] There are 4 price changes per session (from periods 1-5 to 6-10, from 6-10 to 11-15, etc.) and thus $2^4 = 16$ possible patterns for each session. Therefore, there are 16^4 possible patterns that could be observed in Figure 3. Of these, 1 would show an "M" pattern for all four sessions and ${}_4C_1 \times {}_4C_1$ = (number of choices for session with mistake) × (ways to have one inconsistent segment out of four changes in a session) = 16 would show only a single segment inconsistent with an "M" pattern out of four sessions. There are 48 ways that exactly two segments could be inconsistent with an "M pattern; $24 = {}_4C_1 \times {}_4C_2$ in which one session has two mistakes and $24 = {}_4C_2 \times {}_4C_1$ in which two sessions have one mistake each. Therefore, there are only 48+16+1=55 out of 16^4 ways to observe a pattern at least as consistent with an "M" shape as what we observe.

[13] As in footnote 6, there are 16^4 possible patterns, 1 of which exactly matches an "M" pattern and 16 that match it except for a single segment in one of the sessions. Thus, there are only 17 patterns that are at least as consistent with an "M" shape as what we observe in Figure 4.

Figure 3. Average Deviation of Price from Fundamental Value per 5 Period Block by Session

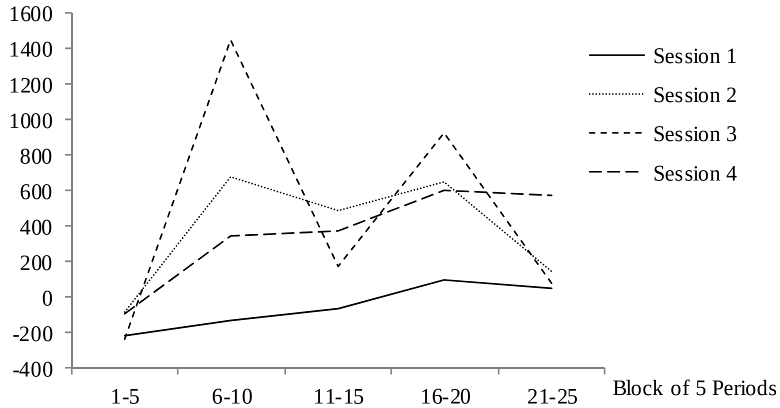
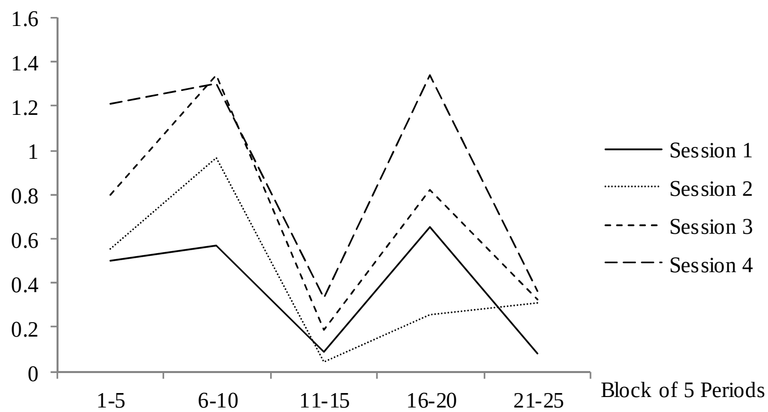


Figure 4. Average Trade Turnover per 5 Period Block by Session



Finally, we examine the one period forward price forecasts made by inactive traders. The average predictions each period are shown above in Figure 1 along with the realized average trading price. Casual inspection of Figure 1 suggests that people rely heavily upon the price in the previous period when making forecasts. This pattern is also borne out econometrically as reported in Table in 2. Specifically, we estimate a linear random effects model where the dependent variable is the individual's price forecast in a given period and the independent variables are the average trading price in the previous and contemporaneous periods, the fundamental value, a dummy variable for periods when two generations are actively trading, a fixed effect for the individual forecaster and a random effect for each session.

Table 2. Estimated Price Predictions of Inactive Traders

	Generation 3 pre-trading experience	Generation 2 pre-trading experience	Generation 2 post-trading experience	Generation 1 post-trading experience
Forecast Periods	2-15	2-5	21-25	11-25
Fundamental Value	-0.162 (0.103)	-0.100 (0.210)	1.404** (0.265)	0.226* (0.098)
Lagged Average Price	0.816** (0.038)	0.959** (0.199)	1.025** (0.164)	0.899** (0.054)
Contemporaneous Average Price	0.138 (0.040)	-0.001 (0.125)	-0.089 (0.116)	0.229** (0.054)
Two Generations Active	-12.272 (24.169)	NA	NA	-54.755* (21.920)
Constant	208.295** (64.910)	86.737 (169.96)	-137.864* (62.597)	-42.818 (48.888)
Observations	306	96	102	306

* and ** indicate significance at the 5% and 1% levels, respectively. Standard errors are given in parentheses. Subject fixed effects are suppressed for brevity.

The econometric results in Table 2 are presented separately for each generation because their experiences are very different. Generation 3 predicts prices in the first 15 periods of trading without the benefit of any personal trading experience whereas Generation 1 predicts prices in the last 15 periods of trading after acquiring market experience. Members of Generation 2 make predictions both before and after their trading experience and thus we analyze their behavior separately for each level of experience. The results are revealing. Both Generation 3 and Generation 2 before gaining trading experience rely heavily upon lagged prices, but not fundamental value. However, Generation 1 and Generation 2 after gaining trading experience do rely upon fundamental value in addition to lagged prices. Thus, experience leads subjects to anticipate that prices will reflect fundamental value. This experience-driven change in price expectation helps explain why replication so consistently dampens price bubbles; trading experience leads people to expect that others will trade based upon fundamental value. Interestingly, only Generation 1 is able to anticipate price changes as evidenced by the significance of the contemporaneous price.

Conclusions

This paper examines the role that liquidity plays in the formation and collapse of asset market price bubbles. As is standard in the literature, the assets in our experiments pay a known number of dividends from a known distribution creating a declining fundamental value pattern. Unlike previous studies, we create a framework of overlapping generations where no one can hold the asset over its entire life, but the older generation can sell their shares to the younger generation.

Subject comprehension of their task and of the declining fundamental dividend value structure is tested by a quiz at the end of the instructions. Moreover, subjects are reminded of the declining fundamental value by informing them what this value is during each round.

The liquidity in our experiments varies as traders enter and exit the market, resulting in a repeating pattern of bubbles and busts. As new traders bring money into the market a bubble forms and as exiting traders take money out of the market the bubble collapses.[14] Our double bubbles are, to the best of our knowledge, the first instance in which multiple bubbles associated with the entry and exit of generations have systematically been observed in the laboratory over the life of a single asset. Our results also provide strong evidence of the role liquidity plays in bubble formation.

When participants in our study were not actively trading, they forecast average price in the next period. While each group of forecasters relied upon the observed price in the previous period, those who had already gained trading experience also relied upon fundamental value, but those who lacked trading experience did not. That trading experience leads subjects to focus on fundamental value helps explain why bubbles consistently disappear with experience or are less likely to form with some pre-experiment training exercises.

[14] The boom may be driven in part by the desire of members of the new generation to balance their portfolios and the busts may be driven in part by the older generation needing to liquidate its holdings and the resulting decrease in opportunities to hold shares for speculative reasons.

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