THE RESEARCH INSTITUTE OF INDUSTRIAL ECONOMICS

Working Paper No. 588, 2003

Bubbles and Experience: An Experiment on Speculation

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January 20, 2003

Abstract: We investigate experimentally how the share of experienced traders in double-auction asset markets affects trading, in particular the occurrence of bubble-crash pricing patterns. In each session, six subjects trade in three successive market rounds and gain experience. In a fourth round, depending on the treatment, two or four experienced subjects are replaced by inexperienced subjects. The results are compared to earlier findings when all traders were either inexperienced or experienced. We explore what can be learned by analogy between these laboratory findings and the performance of naturally occurring markets.

Keywords: asset market, bubble, crash, experience, experiment, speculation

JEL code: C92, G12

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* We thank Dan Friedman, Uri Gneezy, Henrik Horn, Steffen Huck, Kai Konrad, Wieland Müller, Rosemarie Nagel, Charles Noussair, Bob Slonim, Hans Wijkander, and participants at CEEL'01 in Trento, ESA'01 in Tucson, the Workshop on Experimental Economics in Siena, MERSS'02 in Mannheim, ESA'02 in Boston, METU'02 in Ankara, ESA'02 in Strasbourg, and seminars at IUI, Stockholm School of Economics, and Stockholm University for helpful comments. We are grateful to Urs Fischbacher for permission to use the z-Tree software; the Laboratory for the Study of Human Thought & Action at Virginia Tech where the experiment was run; and the Swedish Competition Authority for financial support.

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1. INTRODUCTION

History contains many colorful examples where speculative trade in some commodity or financial asset generated a phase of rapidly increasing prices, followed by a sudden collapse (see e.g. Chancellor, 1999 or Kindleberger, 2001). One famous case cited by many economists (see Garber 1990, pp. 36-37 for references) is the Dutch "tulipmania" of the 1630s. The prices of certain tulip bulbs reached peaks in excess of several times a normal person's yearly income, and then suddenly lost almost all value in February 1637 (see Dash, 1999). In more recent times, we have the development of the NASDAQ share index up till March 2000, and the subsequent dramatic loss of value in that market.

It is hard to describe such developments in other than bubble-crash terms, where the term “bubble” is meant to suggest that prices exceed the traded asset's "fundamental" value. Commentary often invokes terms suggestive of folly or hysteria, like "mania", "panic", or (Alan Greenspan's) "irrational exuberance", as in the titles of Kindleberger's (1994) and Shiller's (2000) books on the topic. However, it is difficult to establish empirically the degree (or nature) of "the madness of the market", because it is hard to pin down what is the fundamental value of an asset. In fact, skeptics have called to question the bubble-crash description, arguing that what at first glance appears like a bubble-crash hype at closer scrutiny becomes explicable with reference to fundamentals. See, *e.g.*, the work of Peter Garber (1989, 1990, 2000).[1]

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[1] One example of a fundamental explanation could be that present value calculations are very sensitive to discount factors, so sudden shifts of interest rates may create dramatic shifts in valuation. Garber (1990; see p. 35) mentions several other fundamental explanations: "the perception of an increased probability of large returns [which] might be triggered by genuine economic good news, by a convincing new economic theory about payoffs or by a fraud launched by insiders acting strategically to trick investors. It might also be triggered by uninformed market participants correctly inferring changes in the distribution of dividends by observing price movements generated by the trading of informed insiders." He adds: "While some of these perceptions might in the end prove erroneous, movements in asset prices based on them are fundamental and not bubble movements."

A strong case against this view, or at least a case for the independent relevance of bubble-crash phenomena, can be articulated with reference to results obtained by experimental economists. In a classic paper, Smith, Suchanek & Williams (1988) report results from several laboratory financial markets. In the settings they consider it is pretty clear what the fundamental value of the assets traded should be. The experimenters control both the (stochastic) dividend process and the time span of the assets, and this information is made public so that valuations can be derived by backward induction. Yet, in the experiments, bubble-crash phenomena are frequent and strong. This suggests drawing an analogy: *bubbles and crashes may be relevant in financial markets since they are relevant in the lab*.

Several subsequent papers have corroborated the Smith *et al* findings.[2] Lei, Noussair & Plott (2001, p. 831) summarize the evidence, and explain how the observed bubble-crash phenomena seem robust with respect to a variety of manipulations. They do, however, point out that bubbles can be eliminated if the trading subjects are experienced: "The only manipulation that has been shown to reliably eliminate bubbles and crashes is prior participation in at least two sessions in the same type of assets market". This interesting finding does not, however, detract that much from the lab-reality analogy. In most experimental sessions that have been run either none or all subjects were experienced, but in non-laboratory financial markets there is likely to be a *mixture* of experienced and inexperienced traders. Although Smith *et al* (1988) and Peterson (1993) ran a few markets with a mixture of inexperienced and experienced subjects, the issue of heterogeneity of experience levels was not the main focus of these studies and was not systematically

[2] See King, Smith, Williams & Van Boening (1993), Peterson (1993), Van Boening, Williams & LaMaster (1993), Porter & Smith (1995), Fisher & Kelly (2000), and Lei, Noussair & Plott (2001).

explored.[3] It is thus natural to seek deeper insights regarding what happens in the lab if there is a mixture of experienced and inexperienced traders. Does it take many, or only a few, experienced traders for bubble-crash patterns to vanish? Believers in the analogy between laboratory and other financial markets may be curious. Such curiosity has inspired this study!

We examine laboratory financial markets with a mixture of experienced and inexperienced traders. We consider two treatments with different proportions of experienced traders. The setup is as follows: Six subjects trade in three successive market rounds and gain experience. In a fourth round, depending on the treatment, *two or four experienced subjects are replaced by inexperienced subjects*.

We consider these two treatments because if bubbles and crashes occur or vanish in an environment with a mixture of experienced and inexperienced traders, then it is interesting to learn something about how many experienced or inexperienced traders this takes. The issue is related to the literature on "noise-trading" in financial markets (see *e.g.* De Long, Shleifer, Summers & Waldmann, 1989, 1990; Palomino 1996; Abreu & Brunnermeier 2002). How many irrational noise-traders does a market need to work very differently from a market without noise trading? Our lab markets may be viewed as one particular test-bed for this issue, given that one adopts the view that the inexperienced subjects of the design may be regarded as noise-traders.

The introduction so far (and the abstract) has been written in an *ex ante* mode, describing the motivation for our study such as it appeared to us *before* we ran the experiment. We have not yet mentioned any results. At this point we would like to invite you,

[3] King *et al* (1993) performed a related test, but instead of using a mixed experience population they let some "insiders" read Smith *et al* (1988) in preparation for the experiment. The bubbles remained, except in a market that allowed for short-selling. For a completely different game, mixed-experience conditions similar to ours are examined by Slonim (2002). Some features of his and our results are similar. We discuss this in section 3.3.

our reader, to test your strategic and financial intuition by *guessing the results*, before we report them:

> **Quiz:** It is known from previous research that in markets where no traders are experienced bubble-crash pricing patterns are common, and that in markets where all traders are experienced, bubble-crash pricing patterns tend to vanish. We consider markets where, respectively, *one third* or *two thirds* of the traders are experienced. For which of these markets do you think the bubble-crash pricing patterns vanish?

You may find it interesting to compare your answer to the answers we received at the 2002 meeting of the *Economic Science Association* in Tucson, Arizona. In the session where we presented our paper about thirty participants ventured a guess. Three of them guessed that having one third experienced traders is enough for bubbles to vanish. One of them guessed that it takes two thirds experienced traders for bubbles to vanish. The remaining vast majority guessed that both markets typically would exhibit bubble-crash pricing patterns.

Bear with us for a few more pages and we shall report the actual results in due course. Section 2 spells out the design; section 3 reports results; section 4 concludes.

2. DESIGN & TESTING PROCEDURES

We consider markets in which assets that generate stochastic streams of dividends are bought and sold. An asset has a finite life of ten periods. In each period it pays a dividend of 0 or 20 cents, with equal probability. Trade takes place in each period, before dividends are determined. The dividend process coupled with a backward inductive argument defines time-dependent theoretical asset values. Our main interest lies in comparing actual pricing in the lab to these theoretical values, controlling for the experience levels of the traders. The rest of this section decribes our approach in detail.

The experiment was conducted in October 2001 at the Laboratory for the Study of Human Thought & Action at Virginia Tech. The subjects were undergraduate students with no previous experience in any similar experiment.

We used the double auction environment of the z-Tree software.[4] Double auction markets mimic the key features of stock exchange markets. Since the pioneering work of Smith (1962, 1964), they are known to possess extraordinarily competitive properties.[5]

Each market involved six traders, who could both buy and sell assets, and lasted for ten distinct two-minute trading periods. Trade was denominated in US cents. Before a market opened, half of the subjects, *i.e.* three subjects, each started with a cash endowment of 200 cents and six assets; the other half each started with 600 cents and 2 assets. Each asset held at the end of a trading period paid a dividend of either 0 or 20 cents, with equal probability for each of these two outcomes. A trader's cash holding at any point in time differed from his or her cash endowment by accumulated capital gains or losses via market trading, and accumulated dividend earnings via asset units held in inventory at the end of each trading period.

Since the expected dividend in each period is 10 cents (= ½ × 0 cents + ½ × 20 cents), the expected monetary value of holding an asset is 10 cents for each of the remaining periods. Assuming risk-neutrality, one may calculate a theoretical value of the asset by backward induction. We shall refer to this value as the *fundamental value*. In the last period, the fundamental value is 10 cents. If traders anticipate that this will be the trading price in the last period, then with two periods remaining the price should be 20 cents (2 periods × 10 cents per period). If traders anticipate this, then with three periods remaining the price should

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4 See Fischbacher (2003) for a description of the software.

5 Plott (1989; section 3.1) and Holt (1995; especially sections V.D and VII.B) survey the experimental double auction market literature.

be 30 cents, etc. Using this logic it is evident that the fundamental value of an asset with *k* periods remaining is $k \times 10$ cents. A bubble obtains if prices in some period are considerably higher than the fundamental value.

The experiment includes two treatments, each of which involves four consecutive markets. In the following, we shall talk in terms of four different *rounds*. Note the distinction between rounds and periods; a round (being a market) consists of ten periods. In both treatments, rounds 1-3 retain the same six-subject groupings so that these subjects gain experience over these rounds. Previous research has indicated that three rounds of repetition is sufficient for bubbles to virtually vanish. The treatments differ only in terms of who interacts in round 4, and our treatment variable concerns the introduction of inexperienced subjects in this round. Depending on treatment, *two* or *four* experienced subjects that had participated in the first three rounds were randomly selected, removed, and replaced by the same number of inexperienced subjects.[6] We shall name our two treatments in terms of the share of experienced traders in the fourth round, referring to the ⅔-EXPERIENCED and ⅓-EXPERIENCED treatments.

Let the notation *t*-exp mean that a subject has *t* previous rounds trading experience. Table 1 shows the experience level for the subjects in all the rounds and treatments. For example, in the fourth round of the ⅔-EXPERIENCED treatment there were four 3-exp subjects (that hence had three previous rounds trading experience), and two 0-exp subjects (that hence had no previous rounds trading experience) in the market.

[6] The same number of subjects from each initial endowment class (with 200 cents and six assets *or* with 600 cents and 2 assets) were replaced.

TABLE 1: Experience levels in the two treatments

	Round				
Treatment	**1**	**2**	**3**	**4**	
	0-exp	1-exp	2-exp	3-exp	0-exp
⅔-EXPERIENCED	6	6	6	4	2
⅓-EXPERIENCED	6	6	6	2	4

At the start of each session we read through the instructions (reproduced in the Appendix) for all of the subjects, and then let them play one two-minute practice period. The subjects then made a draw from a box of chips; six chips implied that the subject was seated at a computer, while the other chips (two or four of them, depending on treatment) implied that the subject was sent to another room. The subjects who went to the other room would participate in the fourth round as inexperienced traders, and they had to wait (approximately one hour) until the others had completed their three rounds of trading.

We faced the problem of what to do with the waiting subjects. Our objective was that they should be reimbursed, not be bored, not be allowed to communicate, not interact in some other market, in fact not even strategically interact at all. We instructed them to complete as much as possible of a crossword puzzle, without communicating to any other subjects. For this task they were paid a fixed amount of $10.

At the end of the experiment participants were privately paid, in cash, the amount of their final cash holdings from each round in addition to the show-up fee of $5. Each session (four rounds) lasted for approximately 2 hours and 30 minutes. The expected earnings for a subject participating throughout all the four rounds were on average $37, including the show-up fee.

We focus primarily on comparing *pricing* in the rounds 1 and 4. We are interested in whether mixed-experience markets behave like inexperienced markets. Does the entry, in round 4, of inexperienced traders cause the pattern of pricing to resemble a first round market. In particular, do bubble-crash phenomena "return"? The null hypothesis is that rounds 1 and 4 are similar; the alternative hypothesis is that prices in round 4 are closer to fundamentals.

If the alternative hypothesis is relevant, we can gain some further insight into *how* "fundamental" the fourth round mixed experience market is by comparing it to the third round market consisting solely of traders with considerable experience. As mentioned above, previous research has indicated that if a market is thrice repeated, this is sufficient for bubbles to virtually vanish. Our experienced traders start round 4 with the corresponding experience level.

We also make comparisons of additional market characteristics other than pricing (volatility, trade volume, opening bids, earnings differences), in order to learn as much as possible about the impact of mixed experience of traders on market outcomes.

We run five sessions of each treatment, which is more than in most previous bubble-experiments. Five is a large enough number to allow us to take a somewhat conservative statistical approach and count one session as one observation. Observations come costly, but each data point has a high degree of independence and there is still enough data to make hypothesis testing meaningful if one is willing to settle for moderate significance levels. The appropriate statistical tool for our significance testing is the permutation test for paired replicates. This is a nonparametric statistical test used for comparisons in dependent two-sample cases (see, for example, Siegel & Castellan (1988) for a detailed description). The test has power-efficiency of 100 percent because it uses all of the information in the sample.

Now you know the details of the design. *Do you wish to revise the guess you made for the quiz in section 1?*

3. RESULTS

In sections 3.1 and 3.2 we report our results on price formation for each of our respective treatments. Section 3.3 presents a bundle of complementary results regarding volatility, trade volume, opening bids, and earnings differences.

3.1 Pricing in the ⅔-EXPERIENCED treatment

Before we report our results in a more systematic fashion, it is intriguing to first visit a particular session as a case study of sorts. This may enhance the intuitive understanding of the setup. We shall get back to whether the results exhibited are typical.

Figure 1 presents the evolution of prices in *one* particular session, out of the *five* we ran for this treatment.

[Insert Fig. 1 here]

As seen in Figure 1, in the first two rounds the market exhibits a distinct bubble (with prices at times exceeding twice the fundamental price), but in round 3 trading prices are fairly close to the fundamental values. When we introduce two inexperienced subjects in round 4, there is little indication that a new bubble occurs. The prices are well below those in round 1. In fact, the prices in round 4 seem to fit the fundamental values just as well as the prices in round 3. (*End of case study!*)

We now move to formal statistics based on the entire data set. We shall evaluate the goodness-of-fit between observed and fundamental values using the Haessel-R^2 statistic, which is appropriate since the fundamental values with which we compare are exogenously given (by backward induction on the expected dividend).[7] The Haessel-R^2 takes values between 0 and 1, where 1 is a perfect fit. Therefore, as trading prices conform to the fundamental values, the Haessel-R^2 approaches 1. Table 2 reports Haessel-R^2 values for the five sessions.

TABLE 2: Goodness-of-fit in ⅔-EXPERIENCED treatment

Session	Round 1	Round 2	Round 3	Round 4
1	0.014	0.290	0.239	0.001
2	0.082	0.256	0.806	0.924
3	0.822	0.856	0.903	0.925
4	0.268	0.311	0.772	0.868
5	0.582	0.270	0.541	0.954

Our main interest is to examine differences between rounds 1 and 4, comparing how well trading prices conform to fundamental values in inexperienced and mixed-experience markets. From Table 2 we observe that the goodness-of-fit increases in all but the first session.[8] Overall, we can reject the null hypothesis of a similar fit in the two treatments at reasonable significance levels (p=0.063). Therefore, a market with a two thirds majority of experienced traders is trading closer to fundamental values than a market where every trader is inexperienced.

We also wish to get some grip on *how* much closer. We evaluate this by comparing round 4 prices to round 3 prices. Recall that the received wisdom is that bubbles virtually vanish by the third time a market is repeated. We find that the entry of the inexperienced traders in round 4 does not affect prices relative to the outcome in round 3. The null

[7] By contrast, the standard R^2 measure considers goodness-of-fit between a set of data points and a regression line *endogenously* generated from those points.

[8] In session 1, the Haessel-R^2 starts and ends very low. Prices actually *increase* across the ten periods, a pattern opposite to the fundamental. We suspect some subjects in this session did not understand the market.

hypothesis of a similar goodness-of-fit in rounds 3 and 4 (against the alternative hypothesis of a better fit in round 3) cannot be rejected (p=0.719). With two thirds experienced traders, prices are as close to the fundamental price as in a thrice-repeated market (*i.e.*, a market consisting solely of traders with considerable experience).

Overall, the prices illustrated in Figure 1 turn out to be rather typical for the ⅔-EXPERIENCED treatment. We propose the following:

> **Main result in the ⅔-EXPERIENCED treatment:** Bubble-crash pricing phenomena do not occur in a market containing a majority of experienced subjects.

3.2 Pricing in the ⅓-EXPERIENCED treatment

The results from section 3.1 naturally raise the question of whether bubble-crash pricing patterns occur if the experienced subjects are in the minority. We next report on our second treatment where, in round 4, we mix four inexperienced and two experienced traders.

Table 3 reports Haessel-R^2 values for the five sessions.

TABLE 3: Goodness-of-fit in ⅓-EXPERIENCED treatment

Session	Round 1	Round 2	Round 3	Round 4
1	0.895	0.948	0.986	0.978
2	0.834	0.976	0.969	0.951
3	0.065	0.395	0.296	0.027
4	0.002	0.134	0.123	0.118
5	0.112	0.217	0.773	0.799

The goodness-of-fit increases in all but the third session (again an outlier!). Just as before, we can reject the null hypothesis of a similar fit between rounds 1 and 4 at reasonable significance levels (p=0.063). A market with a minority of experienced traders is also trading closer to fundamental values than a market without experienced traders.

How much closer? Again, we evaluate this by comparing round 4 prices to round 3 prices. We find that the entry of the inexperienced traders in round 4 does not affect prices relative to the outcome in round 3. The null hypothesis of a similar goodness-of-fit in rounds 3 and 4 (against the alternative hypothesis of a better fit in round 3) cannot be rejected (p=0.281). We propose the following:

> **Main result in the ⅓-EXPERIENCED treatment:** Bubble-crash pricing phenomena do not occur in a market containing a minority of experienced subjects.

3.3 Additional results

So far we have only looked at market prices, but other characteristics of the market may differ between rounds. In this section we report results concerning volatility, trade volumes, market openings, and earnings differences.

Volatility

Does the volatility of prices vary with the experience composition in the market? Table 12 presents the standard deviations of prices for each of the sessions.

TABLE 4: Market Volatility

	⅔- EXPERIENCED TREATMENT				⅓-EXPERIENCED TREATMENT			
SESSION	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**
1	19.3	8.1	10.5	8.8	32.3	28.7	30.6	34.5
2	31.0	53.7	59.1	45.7	38.8	42.8	46.9	22.4
3	14.3	16.4	19.1	19.1	17.4	6.2	5.5	11.9
4	8.2	20.3	30.8	39.6	9.8	9.5	9.7	18.1
5	12.6	6.1	14.3	26.8	23.7	31.6	28.1	14.2
Average	*17.1*	*20.9*	*26.8*	*28.0*	*24.3*	*23.8*	*24.2*	*20.2*
p-value: **R1=R4**	0.937				0.188			
p-value: **R3=R4**	0.813				0.500			

The null hypothesis of the same volatility in rounds 1 and 4 cannot be rejected in either treatment (p=0.937 and p=0.188, as indicated in Table 4); the null of the same volatility in rounds 3 and 4 cannot be rejected in either treatments (p=0.813 and p=0.500). To summarize:

> **Result on Volatility:** Markets where traders have a mixture of experience levels exhibit the same price volatility as markets where all traders are inexperienced, and as markets where all traders are relatively experienced.

Trade Volume

Our findings on pricing suggest that there is no considerable difference between mixed-experience markets (round 4) and markets where all of the traders are experienced (round 3). However, we find significant differences between the mixed-experience markets and markets where all of the traders are inexperienced (round 1). Do analogous results carry over to trade volumes? Table 5 presents the trade volumes from all of our ten sessions (counting any asset changing hands in any period as one unit of trade.)

TABLE 5: Volume of Trade

	⅔-EXPERIENCED TREATMENT				⅓-EXPERIENCED TREATMENT			
SESSION	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**
1	170	189	130	162	74	63	61	87
2	93	68	47	82	82	48	45	151
3	120	169	137	165	185	124	124	86
4	107	66	64	38	155	90	63	102
5	133	105	50	81	171	132	125	248
Average	*124.6*	*119.4*	*85.6*	*105.6*	*133.4*	*91.4*	*83.6*	*134.8*
p-value: **R1=R4**	0.125				0.438			
p-value: **R3=R4**	0.063				0.094			

Our results on trade volumes are *not* analogous to those on prices. There is little evidence of differences in the volume of trade between rounds 1 and 4 in either treatment (p=0.125 and p=0.438), but there is such a difference between rounds 3 and 4. In both of the treatments, the null hypothesis of the same number of trades in rounds 3 and 4 is rejected at reasonable significance levels (p=0.063 and p=0.094), in favor of the alternative hypothesis of a larger number of trades in round 4. Our finding:

> **Result on Trade Volumes:** The trade volume in mixed-experience markets is as high as in markets where all traders are inexperienced, and is greater than in markets where all traders are relatively experienced.

This result made us curious. Is it the experienced or the inexperienced traders who are responsible for the increased trade in round 4? The data shows that both categories have similar trade volumes. It seems like the experienced traders tried to exploit the inexperienced traders, and that in this process the trading volume increased.[9]

Market Openings

Who takes the initiative in the mixed-experience markets? That is, who is first to enter the market and propose a trade? To answer this question we look into the data in round 4, where traders have mixed experience, for all of the sessions. In the beginning of round 4 of each session, *i.e.* the first seconds of period 1, we observe who first offers a bid or makes an ask (not necessary implying a trade). These "market openings" are made visible on the screen for all traders.

It turns out that *no* inexperienced trader was ever the first to enter in period 1, in any of the ten sessions. In the ⅔-EXPERIENCED we did not observe any inexperienced trader as second enterer either.

In the ⅓-EXPERIENCED treatment two of the six traders are experienced. Assuming random entering, the probability that all traders first entering period 1 are experienced in all of the five sessions of this treatment is $(2/6)^5$, which is less than 0.005. The corresponding probability that all first *and* second traders are experienced is 0.017 ($\approx(4/6)^{10}$) in the ⅔-EXPERIENCED treatment. We conclude that random entering can be rejected in both treatments.

Result on Market Openings: Experienced traders always open the market.

Earnings Differences

Do differences in experience generate differences in earnings? One may suspect that in a mixed-experience market the experienced traders somehow manage to take advantage of the inexperienced traders, the "fresh meat" that just entered. We begin our test of this "fresh meat" conjecture by summarizing the average fourth round earnings in Table 6.

TABLE 6: Earnings

Subject type	Average Earnings for One Subject	
	⅔- EXPERIENCED treatment	**⅓- EXPERIENCED treatment**
Inexperienced	\$6.45	\$6.97
Experienced	\$8.53	\$9.10
p-value: *same earnings*	0.048	0.075

The average expected earning in each round is \$8 (by design), but the realized earnings may deviate from \$8 depending on the realizations of the dividends. As seen in Table 6, on average the experienced traders earn more, and the inexperienced traders less, than \$8. In the ⅔-EXPERIENCED treatment, 3 out of 10 inexperienced traders and 13 out of 20 experienced traders earned above \$8. In the ⅓-EXPERIENCED treatment, 6 out of 20 inexperienced traders versus 7 out of 10 experienced traders earned above the expected average.[10]

[9] This motivation was mentioned by many subjects during the debriefing after the experiment.

[10] An additional inexperienced subject earned exactly \$8.00 in the ⅓-EXPERIENCED treatment.

Statistical tests confirm that this picture is systematic. We use unpaired *t*-tests to examine the hypothesis that mean earnings are the same for each trader category, and reject the hypothesis for each treatment at reasonable significance levels (p=0.048 in the ⅔-EXPERIENCED treatment; p=0.075 in the ⅓-EXPERIENCED treatment). The “fresh meat” hypothesis is thus supported.

Result on Earnings: Experienced traders earn more than inexperienced traders.

It is interesting to compare this result to recent findings by Slonim (2002), who studies the nature of mixed-experience interaction in so-called "beauty contest games". He finds that inexperienced persons do not condition their behavior on their co-players' experience levels, but learn to do so as they gain experience. In Slonim's design, experienced players have higher earnings than inexperienced ones. His findings rhyme well with ours.

4. CONCLUDING REMARKS

Are prices in financial markets driven by irrational exuberance or market fundamentals? The outlook varies among scholars, but it is hard to determine the truth because fundamental values are usually not observable. In this connection experiments may be useful. Fundamental values may be induced and compared to actual prices in laboratory markets. The flip side of such "wind-tunnel" experimenting is obviously that one simplifies or abstracts from certain aspects of non-laboratory markets. One may still hope that the laboratory results give insights about the “real” world.

The analysis of laboratory asset markets, starting with Smith *et al* (1988), has shown that bubble-crash pricing patterns tend to occur if *none of the* market participants are experienced, while prices are close to fundamental values if *all* of the participants are reasonably experienced. The starting point of our investigation is that this work provides a somewhat incomplete analogy to non-laboratory financial markets, where there is likely to be a *mixture* of experienced and inexperienced traders.

We investigate experimentally how the share of experienced traders in double-auction asset markets affects pricing and other trade characteristics. We consider markets where, respectively, *one third* or *two thirds* of the traders are experienced. In either of these mixed-experience markets bubble-crash pricing patterns were not common. Many researchers will probably find this result surprising, as suggested by the fact that almost all participants at the 2002 ESA meeting in Tucson (and in fact also at other presentations later on) guessed that bubble-crash pricing patterns would be common in both treatments (cf. the results mentioned toward the end of our introduction).

It is time to admit that we were surprised too. When we designed our experiment, we expected to corroborate the finding that bubble-crash pricing patterns are robust with respect to a long list of variations. However, we show that this list does not extend to mixed-experience markets. Our results therefore support the fundamentalist position.

This does not mean that mixed markets function just as markets where all traders are experienced. The number of trades increased when inexperienced subjects entered the market, and even though the market prices stay pretty much in line with fundamentals there is a difference in the earnings of the different subject categories. The experienced subjects fare better than the inexperienced ones.

These results stands in some contrast also to the literature on "noise-trading" in financial markets (see, e.g., De Long et al. 1989, 1990; Palomino 1996; Abreu & Brunnermeier 2002), which examines how the presence of a small portion of somehow irrational traders influences market outcomes. The wisdom seems to be that the effect can be dramatic, causing significant deviations from fundamental pricing and in some cases even allowing the noise-traders to make more money than the other traders. However, if one adopts the view that the inexperienced subjects of our design may be regarded as noise-traders, then our results do not lend support.

Of course, one should not oversell these conclusions. Laboratory markets are not the same as naturally occurring markets, and analogies only carry so far. Moreover, our study leaves several potentially relevant aspects unexplored.[11] Nevertheless, our finding may induce some shift of the burden of proof between those who believe in "the madness of the market" and the "market fundamentalists". Our results provide arguments in favor of the latter rather than the former position.

We conclude our paper with the following perspective, which to us seems reasonable given the state of knowledge today: The history of finance contains many seeming bubble-crash stories, but it is actually not full of them *all the time*. For example, judging by price-earnings ratios, the U.S. stock market of the twentieth century contains but few examples, spearheaded by the events culminating in the crashes of the fall of 1929 and spring of 2000.[12] Perhaps markets are best understood as being in a fundamental mood, *most of the time*. It may be that only *every now and then* the majority of traders get caught up in a speculative bubble. Our experimental findings do not contradict this view. In the laboratory one can run many sessions and get many observations, but it is impossible to get so many observations that one can systematically record very rare events. Perhaps the best way to understand our results is as suggesting that *bubbles in mixed-experience markets are rare.*

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[11] Out of the possible suggestions for future research, let us name three: First, inexperience may relate to other things than market participation. What is the effect, for example, of changing after a few rounds the stochastic dividend structure? Second, most markets outside the laboratory do not have an exogenously given duration. Examining markets with a stochastically determined last period may be interesting. Third, in our design the experienced traders knew when and how many inexperienced participants entered the markets. It may be realistic to consider alternative designs where this information is not given.

[12] See Shiller (2000, ch. 1) for an account up till early 2000. What constitutes a bubble/crash is of course a definitional matter. Events in 1901, 1966, and 1987 may qualify too. Five in a century is still not a huge number though.

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APPENDIX: INSTRUCTIONS

1. General instructions

This is an experiment in the economics of market decision-making. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The experiment will consist of a sequence of trading periods in which you will have the opportunity to buy or sell in a market. All trading will be in terms of *cents*. Please do not speak with any other participants during this experiment. The experiment will last for approximately three hours, including one hour of instructions and practice.

Market description:
At the beginning of the market half of you will have an endowment of 6 goods (called X) and 200 cents and the other half will be endowed with 2 goods (called X) and 600 cents. 6 traders will participate in the market.

The market has 10 periods. In each period, you may buy or sell units of a good called X. X can be considered an asset with a life of 10 periods, and your inventory of X carries over from one trading period to the next. Each period lasts for 2 minutes.

At the end of each trading period, each unit of X pays a dividend. The dividend will be either 0 or 20 cents, which is randomly decided by the computer with a 50 % chance of each dividend. Thus, the average dividend per period is 10 cents.

Your profits in the market will be equal to the total of the dividends that you receive on units of X in your inventory at the end of each of the market periods plus the cash you have at the end of the market. The way to calculate your earnings is described in section 3.

Experimental procedure:
The market, as described above, will be repeated four times. Before the first market starts, two (four) people in this room will be randomly selected and asked to leave the room for one hour. These people will not participate in the first three markets and they will not be doing anything connected with this experiment during these markets. In the fourth market they will replace two (four) randomly selected persons among the six that already have participated in three markets.

2. Average Value Holding Table

You can use the table in section 4 to help you make decisions. There are 5 columns in the table. The first column, labeled Ending Period, indicates the last trading period of the market. The second column, labeled Current Period, indicates the period during which the average holding value is being calculated. The third column gives the number of holding periods from the period in the second column until the end of the market. The fourth column, labeled Average Dividend Value Per Period, gives the average amount that the dividend will be in each period for each unit held in your inventory. The fifth column, labeled Average Holding Value Per Unit of Inventory, gives the expected total dividend for the remainder of the experiment for each unit held in your inventory for the rest of the market. That is, for each unit you hold in your inventory for the remainder of the market, you receive in expectation the amount listed in column 5. The number in column 5 is calculated by multiplying the numbers in columns 3 and 4.

Suppose for example that there are 4 periods remaining. Since the dividend paid on a unit of X has a 50% chance of being 0 and a 50% chance of being 20, the dividend is in expectation 10 per period for each unit of X. If you hold a unit of X for 4 periods, the total dividend paid on the unit over the 4 periods is in expectation 4×10 = 40.

3. Calculate Your Earnings

Your earnings in each period equal the value of the dividends you receive at the end of the period for the units of X in your inventory at the end of the period. That is,

YOUR EARNINGS FOR A PERIOD =
DIVIDEND PER UNIT × NUMBER OF UNITS IN INVENTORY AT THE END OF PERIOD.

However, when you spend money to buy units of X, the total amount of cash that you have after period 10 is reduced by the amount of the purchase. If you sell units of X, the total amount of cash you have after period 10 increases by the amount of the sale. Your total earnings for one market are the total of your earnings for periods 1-10 plus the amount of cash that you have at the end of period 10. That is

YOUR TOTAL EARNINGS IN THE MARKET =
EARNINGS FOR PERIOD 1 + EARNINGS FOR PERIOD 2 + EARNINGS FOR PERIOD 3 + EARNINGS FOR PERIOD 4 + EARNINGS FOR PERIOD 5 + EARNINGS FOR PERIOD 6 + EARNINGS FOR PERIOD 7 + EARNINGS FOR PERIOD 8 + EARNINGS FOR PERIOD 9 + EARNINGS FOR PERIOD 10 + CASH ON HAND AT THE END OF PERIOD 10.

Your profit for the entire experiment is the sum of the profits from all of the markets that you participate in. Note that you do not have to calculate your profit by yourself. The computer does all the work.

There will also be a show up fee of $5 to all participants. The two people that have to leave for one hour will receive an extra $10 each (plus the $5).

4. Average Value Holding Table

Ending Period	Current Period	Number of Holding Periods	×	Average Dividend Value Per Period	=	Average Holding Value Per Unit of Inventory
10	1	10		10		100
10	2	9		10		90
10	3	8		10		80
10	4	7		10		70
10	5	6		10		60
10	6	5		10		50
10	7	4		10		40
10	8	3		10		30
10	9	2		10		20
10	10	1		10		10

5. Information about the screen

Remaining time (sec)	This shows the time remaining in the period in seconds. Each period lasts two minutes so the timer counts down from 120 seconds to 0 seconds.
Period	This shows the number of the period you are in for each market. There are 10 periods in each market.
Cents	The number of cents that you have.
Units of good X	The number of units of good X that you have.

Buttons at the bottom of the screen

Sales ask	Type the amount, in cents, that you are willing to sell a unit of good X for in the box marked "Sales ask". Then press the "Sales ask" button at the bottom of the screen to offer the unit for sale.
Purchase bid	Type the amount, in cents, that you are willing to pay for a unit of good X in the box marked "Purchase bid". Then press the "Purchase bid" button at the bottom of the screen to place your bid.
Sell	Press the "Sell" button if you would like to sell a unit of good X for the highlighted amount in the "Purchase bid" column.
Buy	Press the "Buy" button if you would like to buy a unit of good X for the highlighted amount in the "Sales ask" column.

Columns in the middle of the screen

Sales ask column	Shows all of the available "Sales asks" in descending order so that the lowest price is at the bottom.
Transaction price column	Shows all of the prices at which a unit of good X has been bought or sold in the current period.
Purchase bid column	Shows all of the available "Purchase bids" in ascending order so that the highest price is at the bottom.

Earnings Report

The earnings report appears at the end of each period. After seeing your earnings, press the "Continue" button to go to the next period. The next period will begin once all of you press the "Continue" button.

FIGURE 1: Example of a ⅔-EXPERIENCED treatment