Price Patterns in Experimental Asset Markets with Long Horizon

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Abstract

We investigate the generality of the bubble and crash price pattern observed in previous asset market experiments. The deviation of prices from fundamental values can be explained by either a failure of subjects to backward induct, a learning effect, or some other explanation. We conduct experiments with a longer horizon – 200 periods – to find a possible reason for the timing of the crash. If the reason for the crash is the inability of subjects to backward induct, a long bubble should be observed. If, on the other hand, it is a learning effect, then the crash should occur after approximately 13 periods. Our results show that while prices generally deviate from fundamental values, price patterns are different than in the 15-period markets, featuring multiple bubbles and crashes..

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1. Introduction

Smith et al. (1988) initiated the study of experimental markets for long-lived assets. In their experiments a group of traders, endowed with cash and shares, have the ability to trade the shares with each other for fifteen market periods. Each share pays a stochastic dividend (from a distribution known to the traders) at the end of each period. At the end of the 15 periods, after the last dividend has been paid, the life of the asset ends and it has no value.

The results were surprising from the point of view of traditional financial theory: the markets typically exhibited a significant difference between the fundamental value of the share (calculated as the present value of the expected cash flow of future dividends) and the actual market transaction price. Although traditional theory implies that prices should be fairly close to the fundamental values, the observed prices increase in the first few periods, depart further and further from the fundamental value, reach a peak somewhere close to the last period, and then fall rapidly.

This price pattern, known as the 'bubble and crash' phenomenon, has been documented extensively within similar experimental designs. King et al. (1993) developed and measured the magnitude of bubbles and crashes, the influence of different environments on the size of the bubble and the timing of the crash was studied (Van Boening et al. 1993, Porter & Smith, 1995, Noussair, 2001, Lei et al. 2001, Dufwenberg et al. 2004, Haruvy & Noussair, 2006) and models to predict future prices were developed (Cason & Friedman, 1995, Caginalp et al. 2000).

The evolving literature, along with the growing interest in this field, raises an important question: is the observed price pattern, at least to some extent, a result of the specific parameters used in the experiment? This question is important if the purpose of this experimental approach is to explain price patterns in field asset markets, because it addresses the robustness and generality of the bubble and crash phenomenon. If the answer to this question is yes, it limits the usefulness of results collected from these experiments to guide analysis and understanding field asset markets or other experimental environments.

The timing of the crash is a good example to illustrate this problem. In almost all experiments involving inexperienced traders[1], the crash occurs fairly close to the last period, and prices track fundamental values afterwards. Two hypotheses[2] can explain this. The first is the inability of traders to backward induct, and the second is traders' adaptive expectations. According to the first hypothesis, the crash occurs when traders realize that since the trader asset has no termination value, they should get rid of it (by selling) before the end. Backward induction in this case should keep rational traders from buying (selling) the asset when the price is higher (lower) than the intrinsic value. Traders' inability to backward induct is the reason for the price increase during the majority of periods, and the crash close to the end. If this hypothesis is correct, then regardless of the number of periods, we should observe a bubble, stretched over most of the horizon, followed by a crash around the end of the market.

The second hypothesis is the fact that traders' expectations are adaptive[3]. They use historical information of prices to predict future prices. A price increase (decrease) in the past implies, at least by traders' beliefs, that it will keep increasing (decreasing) in the

[1] Inexperienced traders are defined as traders who did not participate in a similar experiment in the past.
[2] As far as we know, these hypotheses were not previously tested, and we offer them merely as possible reasons for the described phenomenon.
[3] As shown, among others, by Haruvy et al. (2007).

future. If this hypothesis is correct, then it should take about 12-13 periods for traders to realize the difference between their expectations and the intrinsic value of the asset. When this realization takes place, prices fall. If this hypothesis is correct, then regardless of the length of trade, we should observe a bubble in the first 13 periods or so, followed by a crash and convergence to intrinsic values.

Because most asset markets experiments consist of approximately 15 periods, we cannot tell which hypothesis is correct. Furthermore, in the particular design that has been studied extensively, there is typically exactly one crash. Again, if this is specific to a particular experimental parameterization, then no conclusions can be drawn to understand asset markets, such as those in the field, which may exhibit no or multiple bubbles and crashes.

The purpose of this paper is to study the robustness of the bubble and crash phenomenon to a lengthening of the trading horizon. We consider whether the existence of one bubble and one crash close to the end of the market is specific to markets with a relatively small number of periods used in previous experiments. For our study, we conducted a series of asset market experiments, with a long horizon. In each experiment, traders have the chance to trade the asset they hold for 200 periods (instead of 15 periods in most previously reported experiments). We then compare the price patterns and the different bubble measures from our experiments to those of existing experiments. Finally, we use the aggregate data gathered from our experiments to check whether models and relationships between variables discovered in previous experiments, still hold in experiments with long horizons.

The structure of this paper is as follows: section two reveals some suspicious results from existing research. Section three describes the experimental design; section four describes the results and conclusions presented in section five.

2. Relevant evidence from existing studies

2.1 The crash as 'end game' effect

Hirota & Sunder (2004) constructed two different kinds of asset markets, which they called the '"short horizon" and the "long horizon". Their "long horizon" experiments consisted of 15 trading periods. The dividend for each share was given at the end of the session. In their "short horizon" design, the traders were informed that the session would last 30 periods, but would likely be terminated sooner. The participants did not know what would be the termination period, if any. If the session were terminated, the value of the shares would be determined by the existing market price. According to their findings: "*…in long horizon sessions … prices converge to the fundamental levels derived from dividends through backward induction. In short horizon sessions … prices levels and paths become indeterminate and investors tend to form their expectations of future prices by forward, not backward, induction*'.[4]

In other words, there is no crash in the short horizon treatment. There is also a difference in behavior between the two versions of the experiment: in one case (the "long horizon"), traders can realize the termination value of the asset at the end of the session. They also know the termination value of the asset they hold. Knowing these two features, traders can best-respond to this information. In the other case (the "short horizon"),

[4] The price patterns reported by Hirota & Sunder (2004) in the long horizon sessions (15 periods) do not reflect price patterns reported in other experiments. While other experiments report a bubble and a crash, they report a strong convergence to fundamental value.

traders do not know the termination value of the asset, because they do not know when the trading would end. They have a strong reason to believe that the session will end before the 30th period and the fundamental value as they know it will be irrelevant as a result. Not having any information about the future, traders project past prices into the future, assuming that changes in prices from one period to another do not change.

In the “long horizon” treatment, there is an ‘end game’ effect, which drives traders to behave in a certain way, which results in convergence of prices towards the fundamental value. If prices are above the fundamental value before the convergence takes place, prices crash.

It is obvious that the differences between the two treatments lead to significant differences in the price pattern. After all, prices did not crash (or at least did not converge to fundamental values) in the short horizon treatment. The difference in price patterns stems from the difference between the two treatments. Therefore, it is possible that the only reason for the observation of crashes (or convergence towards fundamental values) is the fact that the trade is about to end. If so, then the relevance of experimental asset markets with a small number of periods to asset markets in the field is limited.

Although every asset market experiment eventually terminates, an experiment with a long horizon can shed some light on traders’ behavior when they perceive the end of the game as being in the distant future. Such an experiment can allow richer market dynamics before any ‘end game’ effect sets in.

2.2 Experienced traders and the role of beliefs

The influence of experience on the formation of prices in experimental asset markets is well documented in the literature. Studies show[5] that the more experienced traders are, the more prices tend to track fundamental values, and the sooner the peak (highest price over the course of the operation of the market) appears. 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. If experiments show that prices track fundamental values, then there is no reason why prices would start to deviate from fundamental values again, unless all traders are replaced by inexperienced ones with no information.

Consider the elicitation of traders' forecasts (or predictions) regarding future prices to measure beliefs. In the experimental asset markets literature, an example for using beliefs can be found in Smith et al. (1988), who use traders' beliefs regarding the price at time $t+1$ to find whether traders' beliefs are 'accurate' and to learn about the dynamics of the formation of beliefs.

But the question is what does experience have to do with beliefs? In order to answer that, we describe a study about beliefs in experimental asset markets, conducted by Haruvy et al. (2007). For their research, they conducted experiments, where traders gained experience by trading under the same design four times. The writers define a 15 period interval as a 'market'. In addition, at the beginning of each period of every market,

[5] See, for example, Smith et al. 1988, King et al. 1993, Van Boeing et al. 1993 and Dufwenberg et al. 2004 among many others. In the first three studies, traders become experienced by participating in the same session several times, using the same participants. In the last study, experienced traders are mixed with inexperienced ones.

traders were asked to state their beliefs regarding prices in all future periods, from the present period to the last (or 15th) period.

Some of their results are relevant to the issue here. First, they find that beliefs are adaptive. When forming beliefs, traders look at past prices and project them into the future, assuming that there is a pattern in price changes. Second, they find that in the first market (when traders are inexperienced) traders fail to predict a crash, which nevertheless occurs. In early periods of the first market, traders believe that prices will not change over time. Only after observing increasing prices for several periods, do traders start to believe that prices will continue to rise. At the beginning of the second market, traders believe that the price pattern in the second market will be the same as in the first market. At the beginning of the third market, traders believe that the change in the timing of the peak will be the same as the previous change (from the first market to the second) and so on. The writers conclude that the reason for the convergence to fundamental values (and the earlier occurrence of the peak) is the fact that traders best-respond to what they believe will be the future price pattern.

So it is experience that causes the convergence of prices to fundamental values, but the type of experience depends on the experimental design. The only source of information that traders have is the past. That past is divided into 15 period markets. The reason for the crash at the end of the second market is because a crash occurred in the first market. But the reason a crash occurred in the first market is the ‘end game’ effect. Furthermore, traders project changes they observe in previous periods of the present market, along with changes that took place in the same period in previous markets. But traders are able to do so only because periods are marked in the same order in each market. If the time horizon was not divided into blocks of 15 periods each, it is not certain that traders will be able to best respond in the same way. It is possible that traders will even fail to observe any kind of price patterns once the experimental design is changed.

A design with a long horizon can provide traders with a price history that is organized differently. Instead of dividing the past into blocks of periods with the feedback derived from experiencing the end of an asset's life, traders should face the past as the history of the current market: a time series, starting at $t=1$, and ending after the last period. The division of time should be made by each trader according to his/her own judgment.

2.3 Is the crash an endgame effect or due to adaptive dynamics in traders' expectations?

When traders are inexperienced, the price pattern that consists of one bubble and one crash is the most commonly observed in all of the studies that make up the literature. The bubble typically starts near the beginning of the session (in the first few periods) with prices usually below the fundamental value and the crash typically occur around the end of the session (usually within the last 3 periods). This price pattern is consistent with at least two hypotheses. The first was discussed earlier in section 2.1 and was referred to as the 'end game' effect. According to this effect, the existence of the crash is driven by the fact that the game is about to end shortly. One reason this may be the case is that individuals who had been trading to seek capital gains earlier in the market come to feel that since the shares have no value at the end of the game[6], it would be wise to get rid of

[6] In some cases (Hirota & Sunder, 2006) there is a positive termination value to the asset. In cases like these, the convergence will be towards the termination value of the asset.

the shares before the end, if prices are greater than fundamentals. This belief among traders increases the supply of asset. The same logic also drives traders to stop purchasing shares at the end of the game, and this decreases the demand simultaneously. As a result, prices fall rapidly as the end of the session approaches.

According to this hypothesis, prices converge to fundamental values a short number of periods before the end of the market, and this number is independent of the total length of the market. If all traders were rational, and this rationality was common knowledge, then backward induction over the full life of the asset would lead prices to track fundamental values. In practice, this process fails. The reason for the inability of traders to fully backward induct can be either the lack of rationality among traders[7], or the fact that rationality is not common knowledge. If the reason for the bubble and the crash in experimental asset markets with 15 periods is indeed a limited capacity of backward induction, then this price pattern should be observed in every asset market experiment, regardless of the number of periods. Namely, in any session of experimental asset market, we should observe a bubble, stretched over the whole time horizon, and then a crash close to the end of the session, with convergence to fundamental values thereafter.

The second intuition for the single bubble and crash price pattern is that the bubble reflects a disequilibrium phase after which convergence to fundamentals is characterized by a crash. This could come about if traders' expectations are adaptive. Traders observe the past and extrapolate into the future. If traders observe a price increase (either in the current session or in the same period in previous sessions), they project this increase into the future and act accordingly. If they observe a decrease in

[7] This irrational behavior was examined and showed to be present in Lei et al. (2001).

prices in the past, they form their beliefs and act accordingly. The reason for the crash in this case is a realization among the traders that their adaptive expectations are unsustainable. We hypothesize that this understanding of the market environment occurs after a fairly constant number of periods that is independent of the total length of the life of the asset. In other words, it takes the traders around 12 periods or so to realize that forward looking generates biased beliefs and this is why prices fall. The lack of variability of length of the life of the asset in previous experiments, where the asset usually has a life of about 15 periods, does not allow us to separate this explanation from the hypothesis that the crash is an endgame phenomenon. If the reason for the bubble and the crash in experimental asset markets is indeed the fact that traders' expectations are adaptive, then in every asset market experiment, regardless of the number of periods, we should observe one bubble at the beginning, stretched over 13 periods or so, and followed by prices fairly close to fundamental values until the end of the session.

An asset market experiment with a longer horizon can distinguish between the two conjectures advanced above about the origin of the price pattern of a bubble and a crash. This kind of experimental asset market can either be consistent with the limited backward induction or the convergence explanation, or disprove both explanations by permitting the emergence of multiple bubbles and of crashes, which would imply an inconsistency with both of the possible explanations advanced above.

3. Experimental design

The data were gathered in six experimental sessions conducted at Emory University, located in Atlanta, Georgia, USA. All participants were undergraduate students who were inexperienced in asset market experiments. Nine subjects participated in each session, and no individual participated in more than one session. Each session lasted approximately two and a half hours, including the first 30 minutes during which the experimenter read the instructions and trained the participants in the use of the market software. Earnings averaged 33 US dollars per subject.

Each of the nine participants possessed an initial endowment of 150 'francs' (the experimental currency) and six units of the asset at the beginning of period 1. Individual inventories of asset and cash balances carried over from one period to the next. That is, the quantities of cash and assets an individual had at the end of period *t* after the dividend had been paid equaled the same quantities of cash and asset the individual has at the beginning of period *t+1*. The exchange rate of experimental currency to US dollars was 10 francs of earnings in the market to 1 dollar of compensation to the participant. The market was computerized and used call market trading rules implemented using the *veconlab* software, developed by Charles Holt at the University of Virginia (http://veconlab.econ.virginia.edu/admin/login.htm).

At the end of each period, each unit of the asset paid a dividend of 0 or 0.30 francs, each with equal probability. The dividend was independently drawn for each period. The distribution of the dividends and the fact that the expected dividend was 0.15 francs per period were common knowledge among the participants.

A market for the asset operated each period. The market employed call market rules (as in Friedman, 1993; Van Boening et al., 1993; Cason and Friedman, 1997). In a call market, all submitted bids and asks in a period are aggregated into market demand and supply curves, and the market is cleared at a uniform price for all transactions of that period. The call market design is better suited for investigating price patterns in long horizon sessions, since each period is much shorter in a call market than in a continuous double auction[8].

In each period, each participant had an opportunity to submit one buy order and one sell order to the market. An individual's submitted buy order consisted of only one price and a maximum quantity the individual was willing to purchase at that price. Similarly, a sell order consisted of only one price and a maximum quantity the individual offered to sell at that price. Individuals did not observe any other traders' orders for the period when submitting their own orders. After all of the participants submitted their decisions, the computer calculated the *market* price, the median price in the intersection of the market demand and supply curves constructed from the traders buy and sell orders. If there was no intersection (all bids were lower than asks), no market price was generated, and the traders were informed that no trade was executed. Participants who submitted buy orders at prices above the market price made purchases, and those who submitted sell orders at or below the market price made sales. Any ties for last accepted buy or sell order were broken randomly. At the end of each period, after the market price was calculated and revealed, the submission of each trader was displayed on all monitors. Traders could not, however, identify the location of each trader in the room based on that information. Participants were not permitted to sell short or to borrow funds.

[8] Using a continuous double action design, and allowing four minutes of trade in each period (to be consistent with smith et al. 1988, King et al. 1993, Lei et al. 2001 and almost all others) means conducting an experiment that will last almost 14 hours. Such an experiment is not feasible. On the other hand, the price patterns generated by using the call market design is shown to be similar to the price patterns generated by the continuous double action design (see Van Boening et al. 1993).

4. Results

4.1 Description of the price patterns

The price patterns in all six sessions are shown in figure 1. The first thing that catches the eye is the lack of similarity in prices among sessions. It seems that each session has its own unique pattern. In sessions 1 and 3 prices are relatively close to fundamental values. However, even between these two sessions we can observe differences. While prices start low in session 1 (5 francs) and increase above fundamental values in period 7, session 3 starts with a price higher than the fundamental value (50 francs) and decreases in later periods. In both sessions, however, we observe prices higher than fundamental values for sustained intervals of time. More differences between these two sessions will be discussed later.

In sessions 2, 4, 5 and 6 we observe several bubbles and crashes. In session 2 we observe three bubbles. The first starts at the beginning of the session and ends around period 150[9]. The second bubble starts right after the first, and ends around period 175, where the third bubble starts. The end of the session is also the end of the last bubble. The first bubble in session 2 is the bubble that is the longest in duration observed in any session.

Session 4 exhibits at least two bubbles. The first starts right at the beginning and lasts for about 60 periods. The second bubble starts around period 160 and lasts 20 periods. Sessions 5 and 6 exhibit at least 3 bubbles in each session. In session 5, the first bubble starts around period 10 (unlike all the other sessions) and lasts until period 80,

[9] Unlike the bubbles in 15 period markets, and similarly to bubbles in field asset markets, it is difficult to determine when exactly the bubble starts and ends. One could decide that a bubble starts when prices exceed fundamental values. But sometimes the bubble starts after the crash of a previous bubble, and prices were never lower than fundamental values before the beginning of the bubble. The same apply when trying to decide about the end of the bubble (or the crash).

when the second bubble starts. The third bubble starts around period 125, where the second bubble bursts. In session 6, the first bubble starts at period 1 and lasts about 40 periods. The second bubble starts around period 65 and bursts at period 90, where the third bubble starts. This last bubble ends around period 140.

[Figure 1: around here]

4.2 Experience and bubble measures

Throughout the experimental asset markets literature, researchers used specific measures to estimate the size of a bubble, and to compare bubbles in different treatments. *Average Bias* is the difference between actual and fundamental prices, averaged over all trade periods. *Total Dispersion* is the sum of the absolute value of all differences between actual prices and fundamental values. *Turnover* measures trading volume. *Amplitude* is a measure of the magnitude of overall price changes relative to fundamental values. *Normalized Deviation* is the average of price differences, weighted by trade volume in each period. *Boom Duration* is a measure of the length (or duration) of a bubble. These measures are described and used, among others, in King et al. (1993), Van Boening et al. (1993), Dufwenberg et al. (2004), Haruvy and Noussair (2006) and Haruvy et al. (2007)[10].

Previous experiments show that the more experienced traders are, the lower the values of all the aforementioned measures. It implies that the more experienced traders are, the less the deviation of prices from fundamental values and as a result, the milder

[10] For readers who are unfamiliar with these measures, we recommend the description presented in Haruvy et. al. (2007) as the most relevant to this analysis.

the bubble is. In other words, the bubble diminishes with experience. Following these findings from previous research, we check the influence of experience on the value of the above measures. For that, we divide the 200-period interval into blocks and calculate the value of each bubble measure for every block. We do this twice: in one analysis we divide the 200-period horizon into five blocks of 40 periods in each, and in the second analysis we divide the horizon into ten blocks of 20 periods in each. When measuring Total Dispersion, Average Bias and Normalized Deviation, an adjustment must be made in order to compare the values of each block[11]. The results are shown in tables 1 and 2 for the first and second treatment respectively. Italicized letters represent an increase in the measure, which is a contradiction to previous findings regarding experience. As can be seen, an increase in the measures is not rare. We consider these results to be a significant departure from the findings in short horizon experiments. This means that within-market in long horizon markets affects behavior differently than the between-market experience of multiple shorter-horizon markets. In experiment 1, for example, five out of six bubble measures in the first analysis (Total Dispersion, Average Bias, Amplitude and Boom Duration) reach their maximum at the last block. In fact, in the first analysis (table 1) the maximum value of Amplitude is reached at the last block in five out of six experiments (experiments 1 – 5) and in all six of them in the second analysis (table 2).

The data show that experience with the asset market is not necessarily sufficient to reduce the severity of bubbles and crashes. The type of experience is important. It appears that individuals must experience the totality of the lifespan of an asset before they trade in a manner that leads to closer tracking of fundamental values. The entire

[11] The distance from fundamental value depends on the fundamental value itself. The fact that absolute deviation in the first block is greater than the absolute deviation in the second one does not imply much on the relative distances, given the fact that the fundamental values are smaller in later blocks.

sequence of feedback from a crash, followed by the disappearance of the asset at the end of the trading horizon, and a full accounting of profits from the entire market, which allows them to evaluate all of the consequences of earlier purchase and sale decisions, appears to be the crucial experience individuals require. This distinction between the value of experience with multiple markets and within the same market is important because asset markets in the field are typically not finitely-lived, and thus traders experience is best described as being analogous to that within the same market in the laboratory. The evidence here is that between-market experience from multiple short markets is more effective than within-market experience from one long market in promoting fundamental pricing.

[Tables 1 and 2: around here]

4.3 Is the crash an endgame effect or due to adaptive dynamics in traders' expectations (or neither)?

In section 2.3 we advanced two hypotheses to explain the bubble-crash pattern observed in experimental asset markets with short horizons, and argued that our experimental design can distinguish between them. If the limited ability to backward induct is the true reason for the location of the crash (close to the last period), then regardless of the length of the time horizon of trading, we should observe a bubble, stretched throughout the time horizon, and followed by a rapid convergence towards fundamental values around the last three periods of the trade. If, on the other hand, a delay in the realization that the deviation of prices from fundamental values is unsustainable is the true reason for the bubble-crash pattern, then using any time horizon higher than 15 periods, we should observe a bubble that lasts for about 12 periods (which is the time it takes traders to realize that prices consistent with adaptive expectation are not sustainable for the entire life of the asset) and followed by a convergence towards fundamental values thereafter. An observation of a price pattern which is different from the above should imply that market prices are driven by different causes.

Some of the bubble measures calculated in section 4.2 can be useful in determining the true reason for a crash. If a crash is caused by the application of backward induction near the end of the life of the asset, then the value of Total Dispersion, Average Bias, Amplitude and Boom Duration should show an increasing trend from one block to the next. If the crash is the realization of traders that their expectations are inconsistent with intrinsic values, then the values of the above bubble measures should be relatively high in the first block, followed by values very close to zero (which means convergence of price to fundamental values) in subsequent blocks. As can be seen in tables 1 and 2, there is no trend in the values of the bubble measures. The changes in the values of these bubble measures show no support to either conjecture about the origin of bubbles and crashes. It leaves us with the conclusion that prices are driven by a different reason (or reasons). The graphical depiction of prices in figure 1 supports this conclusion.

This conclusion should raise a question about the true reason for the timing of the crash in existing (15-period) asset markets. After all, if neither of the hypotheses are the reason, what is? Although answering this question is out of the scope of this research, by looking at the price patterns in figure 1 and by the fact that there is no consistent trend in the bubble measures presented in tables 1 and 2, it is possible that more than one reason exist. However, in light of the connection found by Haruvy et al. (2007) between the timing of the crash and traders' expectations, we believe that information about traders' expectations in asset markets with long horizons would provide some important information towards finding the true reason for the timing of the crash in real asset markets.

5. Conclusions

We consider the robustness of the bubble and crash phenomenon in experimental asset markets to a longer time horizon. Longer time horizons are a feature of field markets and in some cases, the similarities between field outcomes and experimental results are insufficient to conclude that the reasons for the experimental outcome are the same as those in the field. However, although we observe bubbles and crashes in many field asset markets, such as stocks and real estate, as well as in experimental asset markets, it does not mean that the reasons for this phenomenon are the same in both cases.

In this study, we took the structure of the experiment a bit closer to the field environments by extending the time horizon of the asset. Although we showed that the bubble and crash phenomenon still appears in this set up, we also showed that some explanations that are consistent with a bubble and a crash in the traditional design cannot explain the price dynamics in the long horizon environment. These findings question the connection between the traditional experimental results and outcomes in real asset markets. We began by showing that the quantitative price pattern does not remain the same as the length of the time horizon changes. We continued by showing that experience, which occurs across the lives of multiple assets as studied in Smith et al.

(1988) and Dufwenberg et al. (2005) has a different effect in our design. The same number of periods of prior experience is much more powerful in changing behavior if it spans the lifetime of a greater number of assets.

We also show that two reasonable hypotheses to explain the price pattern in the traditional 15 period design with inexperienced traders are inappropriate in explaining the price patterns in a long time horizon. We believe that the findings of this paper are to cast doubt on the robustness of previous findings to other experimental environments, and thus by extension, for explaining the behavior of field asset markets. It is important to state that we do not believe that the traditional findings are wrong, or do not hold. They do, and they are important. But their relevance may be specific to the environment where they were found. In the same way, since we do witness multiple bubbles and crashes in real asset markets, then the concept of experience as a device for convergence to fundamental pricing, as convincing as it is in the traditional set up, may not hold in field asset markets. Nevertheless, we do believe that findings like the 'endgame' effect, the role of experience and others are still relevant for the short time horizon set ups. That is, we do not doubt the internal validity of the traditional experimental asset paradigm, but our findings from long horizon markets cast their external validity in doubt.

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Table 1.a: Total dispersion

Session	1	2	3	4	5	6
Block 1	270	209	4	717	414	233
Block 2	231	429	116	712	744	632
Block 3	50	1,265	151	63	598	655
Block 4	135	939	77	157	600	78
Block 5	602	781	125	325	178	80

Table 1.b: Turnover

Session	1	2	3	4	5	6
Block 1	0.37	0.63	0.35	0.41	0.30	0.50
Block 2	0.24	0.20	0.11	0.11	0.20	0.19
Block 3	0.06	0.31	0.06	0.22	0.11	0.35
Block 4	0.17	0.17	0.22	0.22	0.11	0.17
Block 5	0.81	0.22	0.06	0.26	0.26	1.02

Table 1.c: Average bias

Session	1	2	3	4	5	6
Block 1	(6.76)	(5.21)	0.11	17.94	(10.36)	5.83
Block 2	(5.78)	10.73	2.89	17.80	18.60	15.81
Block 3	(1.25)	31.63	3.79	1.59	14.96	16.38
Block 4	3.39	23.47	1.94	(3.91)	14.99	1.96
Block 5	15.05	19.53	3.11	8.14	(4.45)	2.01

Table 1.d: Normalized deviation

Session	1	2	3	4	5	6
Block 1	10.68	8.24	4.86	16.66	9.24	20.58
Block 2	1.99	6.61	0.80	2.99	7.62	4.84
Block 3	0.51	18.69	0.53	1.28	2.89	15.23
Block 4	0.92	4.31	0.55	1.74	3.64	3.52
Block 5	4.40	6.91	0.16	2.77	2.54	3.37

Table 1.e: Amplitude

Session	1	2	3	4	5	6
Block 1	1.16	0.32	0.81	1.13	0.46	2.26
Block 2	0.48	0.94	0.40	0.50	1.81	1.32
Block 3	0.31	0.85	0.51	0.81	0.93	1.79
Block 4	0.61	2.26	0.75	0.39	1.21	1.44
Block 5	5.49	12.47	2.72	9.98	5.79	2.10

Table 1.f: Boom duration

Session	1	2	3	4	5	6
Block 1	3	-	6	40	-	18
Block 2	3	36	37	40	35	40
Block 3	13	40	33	20	40	27
Block 4	33	25	8	3	38	9
Block 5	34	26	30	23	4	21

Tables 1.a-1.f: bubble measures, calculated for five blocks of 40 periods, for each experiment. Values in italics imply an increase in the measure relative to the previous block.

Table 2.a: Total dispersion

Session	1	2	3	4	5	6
Block 1	104	149	13	208	260	277
Block 2	*185*	66	9	*566*	172	567
Block 3	149	*99*	*49*	406	158	410
Block 4	94	*377*	*76*	350	*670*	254
Block 5	61	*604*	32	122	196	208
Block 6	13	*793*	*143*	70	*483*	*537*
Block 7	*51*	*799*	99	*88*	361	154
Block 8	*112*	187	28	*91*	318	101
Block 9	*202*	143	*48*	27	104	71
Block 10	*799*	*1,278*	*154*	*705*	*149*	18

Table 2.b: Turnover

Session	1	2	3	4	5	6
Block 1	0.94	0.78	0.65	0.85	0.56	0.52
Block 2	0.37	0.63	0.35	0.41	0.30	0.50
Block 3	0.13	0.56	0.17	0.07	*0.35*	0.17
Block 4	*0.24*	0.20	0.11	*0.11*	0.20	*0.19*
Block 5	0.11	*0.28*	0.07	0.09	0.13	*0.41*
Block 6	0.06	*0.31*	0.06	*0.22*	0.11	0.35
Block 7	*0.13*	0.09	0.04	0.11	*0.15*	0.22
Block 8	*0.17*	*0.17*	*0.22*	*0.22*	0.11	0.17
Block 9	*0.33*	*0.37*	0.06	*0.31*	*0.19*	0.06
Block 10	*0.81*	0.22	0.06	0.26	*0.26*	*1.02*

Table 2.c: Average bias

Session	1	2	3	4	5	6
Block 1	(5.19)	(7.45)	0.63	10.41	(12.99)	(13.84)
Block 2	(9.25)	*(3.31)*	(0.46)	*28.29*	*(8.59)*	*28.33*
Block 3	*(7.47)*	*4.97*	*2.46*	20.28	*7.90*	20.52
Block 4	*(4.68)*	*18.86*	*3.79*	17.52	*33.50*	12.70
Block 5	*(3.04)*	*30.21*	1.62	6.10	9.79	10.38
Block 6	*0.65*	*39.65*	*7.15*	(3.51)	*24.15*	*26.85*
Block 7	*2.56*	*39.94*	4.93	(4.40)	18.06	7.69
Block 8	*5.61*	9.33	(1.42)	(4.57)	15.89	(5.04)
Block 9	*10.11*	7.13	*2.38*	*(1.36)*	(5.19)	*3.56*
Block 10	*39.97*	*63.88*	*7.70*	*35.27*	(7.43)	0.92

Table 2.d: Normalized deviation

Session	1	2	3	4	5	6
Block 1	7.41	6.41	4.64	6.72	7.20	8.30
Block 2	3.63	2.03	0.25	*11.04*	2.27	*13.65*
Block 3	0.90	*3.17*	*0.37*	1.52	*3.43*	2.39
Block 4	*1.25*	*3.93*	*0.48*	*1.68*	*4.79*	*2.80*
Block 5	0.46	*8.47*	0.21	0.28	0.81	*6.91*
Block 6	0.06	*12.27*	*0.38*	*1.20*	*2.51*	*9.99*
Block 7	*0.32*	3.45	0.07	0.72	*2.68*	2.49
Block 8	*0.80*	1.15	*0.64*	*1.36*	1.27	1.37
Block 9	*1.39*	*1.88*	0.06	*2.56*	*1.50*	0.06
Block 10	*6.02*	*10.05*	*0.20*	0.42	*2.08*	*6.61*

Table 2.e: Amplitude

Session	1	2	3	4	5	6
Block 1	1.16	0.16	0.81	0.80	0.19	0.58
Block 2	0.39	*0.17*	0.09	0.27	*0.37*	*1.67*
Block 3	0.20	*0.48*	0.09	*0.50*	*0.97*	1.27
Block 4	*0.48*	0.45	*0.40*	0.41	*1.63*	0.48
Block 5	0.30	*0.46*	0.39	*0.55*	0.54	*1.14*
Block 6	0.19	*0.63*	0.21	0.16	0.31	*1.32*
Block 7	*0.31*	*0.79*	*0.57*	*0.34*	*0.48*	0.90
Block 8	*0.47*	1.77	0.38	*0.39*	*1.21*	0.72
Block 9	*1.97*	*0.80*	0.30	*1.31*	0.84	0.61
Block 10	*5.49*	*11.58*	*2.72*	*9.98*	*5.79*	*2.10*

Table 2.f: Boom duration

Session	1	2	3	4	5	6
Block 1	3	-	4	20	-	-
Block 2	-	-	6	20	-	*18*
Block 3	-	16	20	20	*15*	*20*
Block 4	*3*	20	17	20	*20*	20
Block 5	1	20	13	20	20	10
Block 6	*13*	20	*20*	-	20	*20*
Block 7	13	20	8	*2*	20	9
Block 8	*20*	6	3	*3*	18	8
Block 9	20	11	*13*	*6*	3	*19*
Block 10	14	*20*	*17*	*17*	*4*	3

Tables 2.a-2.f: bubble measures, calculated for ten blocks of 20 periods, for each experiment. Values in italics imply an increase in the measure relative to the previous block.

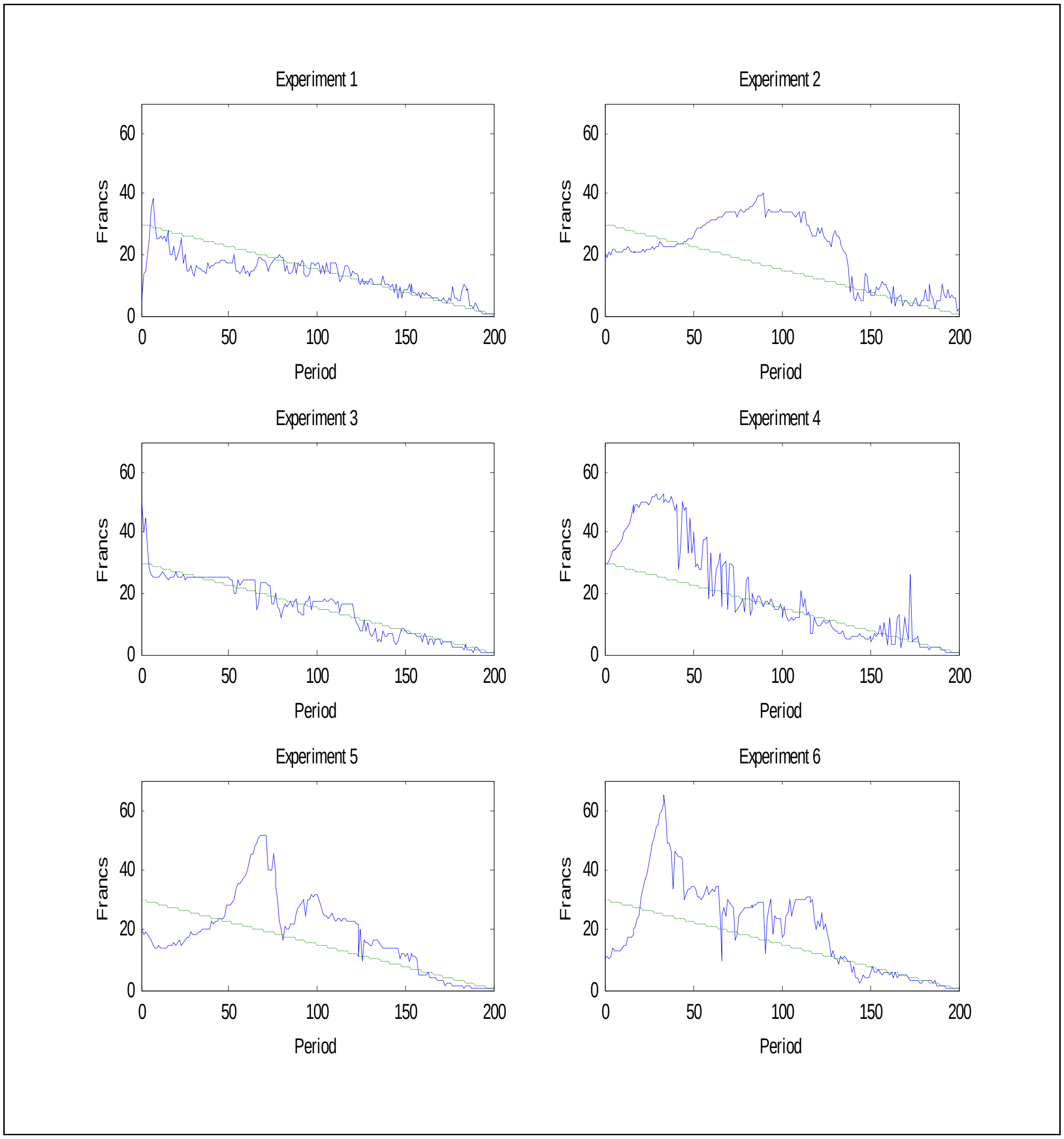

Figure 1: Market price patterns. When no trade occurred, market prices were calculated as the median of the lowest selling order and the highest purchasing order.