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Asset Bubbles without Dividends - An Experiment

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Abstract

Bubbles in asset markets have been documented in numerous experimental studies. However, *all* experiments in which bubbles occur pay dividends after each trading day. In this paper we study whether bubbles can occur in markets without dividends. We investigate the role of two features that are present in real markets. (1) The mere possibility that some traders may have inside information, and (2) the option to communicate with other traders. We find that bubbles can indeed occur without dividends. Surprisingly, communication turns out to be counterproductive for bubble formation, whereas the possibility of inside information is, as expected, crucial.

JEL-classification numbers: C92, G12, D8.

Key words: asset markets, bubbles, experiment, mirages, dividends.

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1 Introduction

Bubbles in experimental asset markets have been documented in numerous experiments starting with the seminal paper by Smith et al. (1988). The standard definition of a bubble used in this literature describes bubbles simply as “persistent deviations of prices from fundamentals” at high volumes of trade (see e.g. Haruvy and Noussair, 2006).¹ Robert Shiller in his book “Irrational Exuberance” gives a much more colorful and descriptive definition by describing speculative bubbles as...

“...a situation in which news of price increases spurs investor enthusiasm, which spreads by psychological contagion from person to person, in the process amplifying stories that might justify the price increases and bringing in a larger and larger class of investors, who despite doubt about the real value of an investment, are drawn to it partly through envy of others’ successes and partly through a gambler’s excitement.” (Shiller, 2005, p.2)

According to this definition, several related aspects are ingredients for bubble formation. One crucial aspect seem to be “stories”. Those stories often involve inside information that may or may not be true but, if true, can justify a price change for the asset. Another aspect seems to be that those stories are spread from “person to person”, i.e. some form of communication is required.

In the typical asset market experiment, as pioneered by Smith et al. (1988), bubbles occur even in a very austere environment without any of the features mentioned by Shiller (2005). Usually one asset is traded for a finite (often 10 or 15) number of trading “days”. After each day a stochastic dividend is paid. Thus, the fundamental value of the asset is declining since it is given by the expected value of the dividend times the number of remaining periods. Nevertheless, Smith et al. observed constant or even increasing prices followed by crashes at the end of the experiment. Their

¹Similar definitions were used by Lei et al. (2001), King et al. (1993), and many others.

experiment has been replicated many times and with a large number of robustness checks.²

It is not easy to explain those results. A conspicuous feature of most experiments in this literature is that the fundamental value of the asset is declining throughout the experiment, a feature that is not typical for real financial markets. However, a few studies (see e.g. Noussair et al. 2001; Ball and Holt, 1998; Davies, 2006) find that bubbles may occur with constant or even increasing fundamental values. Nevertheless, *all* experiments in which bubbles occur pay dividends after each trading day. Thus, it seems that frequent dividend payments are crucial for the emergence of bubbles in the laboratory.

While dividend payments certainly are one possible factor to explain bubbles in some real financial markets, they cannot account for bubbles in many other markets. For example, many of the new economy stocks, which experienced a tremendous bubble in 2000, never paid dividends (e.g. Dell, Yahoo!, Oracle). Also, commodities do not pay dividends but experience bubbles nevertheless. Furthermore, for most stocks dividends are paid out only once per year, which could only explain a very slow formation of bubbles. Thus, it seems that dividend payments can only be a partial explanation for the formation of bubbles in real financial markets.

The purpose of the current paper is to check whether bubbles occur in experimental asset markets without dividend payments after each trading day. In particular, what does it take to produce bubbles with constant fundamental values and only a final dividend?³ Our conjecture is based on Robert Shiller's arguments. We propose that there are in particular two ingredients that might matter for bubble formation: (1) The possibility that some traders may have inside information, and (2) the possibility for traders to communicate with each other.

We shall implement those two features in the following way. In all treatments assets may pay supplements on top of the usual final dividends. The

²See Section 2.

³Prior experiments with only a final dividend suggest that in the usual austere experimental environment hardly any bubbles occur (see e.g. Smith et al. (2000) and Hirota and Sunder's (2005) long-horizon treatment).

possibility of inside information is implemented by the fact that in two of our treatments (INF and INFCHAT), with a certain probability a subject receives private information about those supplements. The second feature is implemented in our INFCHAT treatment by the opportunity to communicate with other traders through a computerized free-format chat platform.

In our experimental markets, five different assets are traded simultaneously.⁴ The purpose of this is to make the chat interesting and to give “stock pickers” a chance to actually select something. Furthermore, it allows to differentiate between a bubble in just one asset or a bubble involving the entire market. Our computer interface imitates real life trading platforms by displaying charts of asset prices after each trading day.

Our main result is that bubbles can indeed occur without intermittent dividend payments. Crucial for this result seems to be the possibility of inside information. Without this possibility (in our base treatment NOINF), we find very few bubbles. With this possibility (in our treatment INF), we find bubbles in more than half the rounds. Contrary to the intuition of Shiller’s description, bubbles all but disappear again when we add the chat option (in our treatment INFCHAT). Apparently, chat is counterproductive for bubble formation. We offer some suggestions why this may be the case.

We also report a measure of overconfidence and relate the degree of overconfidence in a group of subjects to the probability of bubbles. While average overconfidence in the group does not seem to matter much, the number of people, who believe that they are going to be the top-ranked traders in a treatment, increases the probability of bubble formation.

An important issue for theories about asset bubbles is whether traders are aware of overpricing but speculate on even higher prices to cash in or whether traders are simply unaware of the fact that prices deviate from fundamental values. To check this we asked subjects to predict both, prices at the end of the current trading day and final dividends for each asset. If subjects are aware of mispricing and speculate, they should report dividend estimates equal to the fundamental value. We find that in rounds

⁴Most of the previous experimental literature considers only trading in one asset (see Fisher and Kelly, 2000, and Ackert et al. (2006) for exceptions with two assets).

in which market bubbles occur, estimates for dividends significantly exceed fundamental values, whereas in rounds in which no bubbles occur, dividend estimates are fairly close to fundamentals.

Our design enables us to study the tactics of a trader with inside information (and possibly, of traders posing as such). A monopolistic insider is facing the dilemma that he wants to profit from his information, yet when he trades too aggressively, he will give away the information. Thus, an interesting question is whether insiders will try to delude other traders through their trading behaviors or by chatting on our chat platform. We observe, however, few such attempts. In general, insiders trade early and late in a round but not too aggressively. Insiders trade a lot more than non-informed traders. Compared to the – admittedly fairly extreme – benchmark of the maximal profit an insider could make against totally naive other traders, insiders extract on average less than 30% of the gain they could make from the inside information.

The remainder of this paper is organized as follows: Section 2 provides a selective summary of the experimental literature on asset bubbles. Section 3 introduces the experimental design of our experiment. Section 4 presents the experimental results and Section 5 concludes.

2 Related Literature

There is by now a large literature on bubbles in experimental asset market. The experiments differ along a number of dimensions. For our purposes the two most important dimensions are the frequency of dividend payments and the shape of the fundamental value curve over time. These two dimensions are interrelated since the fundamental value at each point in time is always the expected value of the remaining dividend payments.

The first paper that convincingly documents bubbles in the current setting is Smith et al. (1988). In their experiment there are 15 trading days and after each day a stochastic dividend is paid. Since the expected value of the dividend is positive, the fundamental value of the asset is declining.

Smith et al. (1988) find frequent bubbles and their finding has been

replicated many times with a large number of robustness checks (see e.g. King et al., 1993). Lei et al. (2001) replicate those findings even in a setting in which resale of assets is prohibited (which makes speculation impossible). They also reject the hypothesis that bubbles are created by subjects trading out of boredom by providing an alternative activity for traders to engage in. Haruvy and Noussair (2006) test and reject the hypothesis that shortsale constraints are responsible for bubbles. Ackert et al. (2006) let subjects trade simultaneously in two assets with the same expected payoff and find that bubbles occur more frequently in the lottery asset, i.e. the asset that promises a large but unlikely payoff.

There are two features that seem to prevent bubble formation. Noussair and Tucker (2006) introduce a future market into the canonical design in addition to the spot market and find hardly any bubbles in the spot market. More importantly for our purposes, sufficient experience *in the same market* (usually three or more rounds) reliably eliminates bubbles (see van Boening et al., 1993). Furthermore, Dufwenberg et al. (2005) find that it is sufficient to have a relatively small share of experienced traders (around 1/3) in the population of traders to prevent bubbles. For this reason, we let traders in our experiment gain experience by having three trading rounds.

All the aforementioned papers feature a falling fundamental value and dividend payments after each trading day. When there is only a final dividend at the end, the fundamental value curve is flat. Smith et al. (2000) study markets with flat fundamentals and find hardly any bubbles.⁵ The interesting question then is, whether frequent dividend payments or decreasing fundamental values are the driving force for bubbles. In order to separate out this issue, Noussair et al. (2001) employ an elegant trick by using dividends with an expected value of zero, which allows for flat fundamentals despite frequent dividend payments.⁶ They find that there are still bubbles although less frequent than with falling fundamentals. Thus, it seems that the main driving force for bubbles in the usual austere environment are the

⁵Similarly, Hirota and Sunder (2005) use a setting with only a final dividend. They find that with long term investors there are rarely any bubbles.

⁶An alternative to dividends with zero expected value is the design of Ball and Holt (1998) with discounting. See Davies (2006) for a design with *increasing* fundamentals.

frequent payments of dividends. For reasons stated above we do not believe that this gives a compelling explanation for bubbles in real financial markets and shall therefore consider a design without dividend payments (except a final payment).

Another strand of the literature that is related to our paper are experiments in which there is the possibility (with probability strictly less than one) of an informed insider. The uncertainty whether there actually is some inside information in the market creates the opportunity for real world scenarios in which traders have to guess whether price movements are driven by actual information or whether they are simply seeing a “mirage”. Camerer and Weigelt (1991) are the first authors to study this setting. They find some but not too many instances in which such mirages occur. In particular, there are no mirages in later rounds. In contrast to Camerer and Weigelt (1991) who consider the case of competition among insiders, Friedman and von Borries (1988) in an unpublished pilot study consider the case of a monopolistic insider, which is close to the setting that we use in the current paper. They find that insiders are able to earn substantially larger profits than uninformed traders.

Finally, note that our experimental design with 5 assets and 2 supplements, which give rise to a fixed expected value for the market index of all 5 assets, resembles a situation frequently encountered in prediction markets, e.g. when contracts drawn on the vote share of candidates for political office or the outcome of sport events are traded (see e.g. Plott and Sunder, 1988, Wolfers and Zitzewitz, 2004; and Berg et al., forthcoming).

3 Experimental design

3.1 Market structure

In each session 10 subjects participated in a computerized experimental asset market, in which 5 different assets were traded simultaneously.⁷ Trading was conducted in continuous time double auctions (one double auction for each

⁷The five assets were labeled and represented as different colors on the computer screen.

asset).⁸ All 10 traders started with the same endowment of 10 shares of each asset, 5000 units of cash (denoted in “Taler”), and 5000 Taler as a loan, which had to be repaid at the end of each trading round. We chose to give subjects sufficient cash such that the no-borrowing constraint was unlikely to be binding.⁹ However, relative to the fundamental value of assets, the cash endowment was still much lower than in some of the experiments in the literature (see e.g. Lei et al., 2001). Thus, if we observe bubbles in the current experiment, we would expect to see even more bubbles with a higher cash endowment. Short-selling of assets and borrowing of extra cash was not possible.

Assets paid only a *final* dividend, which implies that fundamental values were flat. This dividend d was the sum of a *base value*, distributed uniformly between 50 and 90, and a *supplement*. It was common knowledge that in each round one of the 5 assets was endowed with a supplement of 80 and one with a supplement of 40. The remaining assets carried no supplement. Thus, ex ante without any further information about supplements, the expected value for each asset was given as

$$E(d) = \text{expected base value} + \text{expected supplement} = 70 + \frac{40 + 80}{5} = 94.$$

Note that regardless of the information or beliefs about supplements, the expected value of the market *index*, which is defined as the average price of all 5 assets, is constant at 94.¹⁰

3.2 Treatments

There are three treatments which differ with respect to the information subjects receive about supplements and with respect to the opportunity to

⁸The experiment was programmed and conducted with the software z-tree (Fischbacher, forthcoming). The program kept track of a queue of offers (the order book) but only the standing offer was visible to subjects. Own offers could be seen in a separate window. They could be withdrawn if they were not the standing offers.

⁹In fact, in the experiment cash balances of subjects fell below 150 in only 0.13% of cases (subject-trading day combinations).

¹⁰Note that this implies that “good news” about one asset is always “bad news” for the remaining ones. This need not always be the case in reality. However, one can always interpret information about a supplement as *differential information*, i.e. by how much better the information is for asset x compared to those for asset y .

Table 1: **Treatments**

	NOINF	INF	INFCHAT
number of indep. sessions	6	6	6
number of rounds per session	3	3	3
traders per session	10	10	10
probability of inside information	0	0.5	0.5
opportunity to chat	no	no	yes

chat with other traders.

- Treatment **NOINF** is a control treatments in which subjects receive no private information about supplements. There is no opportunity to chat with other traders.
- In treatment **INF**, with probability $1/2$, *one* trader is informed about the amount of *one* of the supplements and the corresponding asset label. There is no opportunity to chat with other traders.
- In treatment **INFCHAT** the information structure with respect to supplements is the same as in INF. Additionally, subjects have the opportunity to chat with other subjects on a computer interface. The chat is free-format and visible to all subjects. Chatters' comments are identified only through a pseudonym. Additionally, they are marked by the chatter's current wealth, which is calculated as the value of the chatter's portfolio at the most recent prices plus cash.¹¹

Table 1 summarizes the treatment properties. Although our design introduces a number of innovations, it is easy to connect our NOINF treatment to earlier studies in a logical way. The main design differences between NOINF and earlier studies are the number of assets and the (recurrent) payment of dividends (see Table 2). Most earlier studies were conducted with one asset and recurrent dividend payments after each trading day. However, Fisher

¹¹The last feature was implemented to account for Shiller's (2005) idea that stock recommendations of a neighbor who drives up with his brand new Mercedes may carry more weight.

Table 2: **Placement of NOINF relativ to the literature**

	dividends	no dividends
1 asset	Smith et al. (1988) find bubbles	Smith et al. (2000) find no bubbles
> 1 asset	Fisher/Kelly (2000) find bubbles	NOINF

and Kelly (2000) also find bubbles when two assets are traded simultaneously. Thus, there is no evidence that bubbles are influenced by the number of assets. However, there is already evidence that dividends influence bubbles. Smith et al. (2000) and Hirota and Sunder (2005) find hardly any bubbles in markets with only a final dividend. Given this evidence, the hypothesis for our NOINF treatment, which combines more than one asset with no dividends, is that there are no bubbles. Taking this as our point of departure, we add further features that are omitted from the usual laboratory experiments but which are often present in real financial markets where bubbles are being observed. Those features are the possibility of inside information (in treatment INF) and, additionally, the possibility to communicate (INFCHAT).¹²

3.3 Timing

Each experimental session consists of three rounds plus one practice round. Prior research shows that bubbles tend to disappear with experience in the same market (see e.g. Dufwenberg et al., 2005). Thus, we chose three rounds in order to examine whether bubbles still appear in later rounds when subjects have more experience. The practice round has the purpose of familiarizing subjects with the trading platform. Payoffs from the practice round are not counted towards the final earnings.

Figure 1 illustrates the sequence of events for each round. At the be-

¹²A logical step might have been to complete a 2x2 design by having a treatment NOINF_CHAT. However, after observing the results from our first three treatments, we expect no interesting results since there are already very few bubbles in NOINF, and chat seems to be counterproductive for bubble formation.

prediction of rank	drawing of dividends	info about supplement given (if any)	noon: prediction (on days 4, 6, 8)	afternoon: trading	morning: chat	noon: prediction (on days 4, 6, 8)	afternoon: trading	...	morning: chat	noon: prediction (on days 4, 6, 8)	afternoon: trading
			day 1			day 2			day 10		

Figure 1: Sequence of events during one round

Note: There are three rounds plus one practice round.

gining of each round subjects are asked to rank themselves among the 60 subjects of a treatment in terms of payoffs for this round. Then, dividends are determined randomly and independently of earlier rounds.¹³ Subjects start with the same initial endowment for each round. In treatments INF and INFCHAT with probability 1/2 one subject is informed about one of the supplements.

The practice round consists of 3 trading “days” and no subject receives information in practice rounds. The actual three rounds consist of 10 trading days each. A “day” is divided into morning (only for treatment INFCHAT, not on day 1), noon (only on days 4, 6, and 8), afternoon, and evening. The morning lasts for 60 seconds, in which subjects can use the chat platform. At noon subjects are asked to give predictions for (1) prices of all assets at the end of this day and (2) the dividends of all assets at the end of the round. In the afternoon the double auction market opens for 120 seconds. In the evening each subject is informed about the number of shares he owns of each asset, the most recent price of each asset, the value of his portfolio at the most recent prices, and his available cash and credit. Also subjects see 5 charts with all transaction prices of the respective asset from day 1 up to the current day.

At the end of the experiment, subjects are asked to fill in a different questionnaire with some demographic data and questions with respect to their trading strategy. Finally, we ask subjects to answer 6 questions designed to test their knowledge about financial markets (see Appendix).

¹³The sequence of random draws was determined beforehand and was the same for each session in order to make sessions more comparable.

3.4 Experimental procedures

Experiments were conducted in the summer of 2006 in the experimental laboratory of the SFB 504 in Mannheim. In each session 10 traders, recruited via an online recruiting system, participated. Six sessions were conducted per treatment. Subjects were undergraduate students from business, economics, and social sciences. Sessions lasted for about 3 hours and average pay was about 30 Euros.

At the beginning of the experiments, printed instructions (see Appendix) were handed out. Special care was taken to insure that subjects understood the simple calculations for the expected final dividends. In fact, all possible cases (with or without private information) were explained to them by examples (“If you know that certain asset receives a supplement of 40, the expected dividend for this asset is $70 + 40 = 110$ Taler and for each remaining assets it is $70 + 80/4 = 90$ Taler.” etc.).

We used a powerpoint presentation to familiarize subjects with the trading screen. After subjects read the instructions, they had to pass several review questions in order to make sure that they had understood the market structure (see Appendix).

4 Experimental results

The main question this paper is trying to answer is whether bubbles can occur in asset markets when there are no recurring dividend payments but when instead we add two features that are present in real financial markets. The simple answer is “yes”. However, only one of the features suggested by Shiller (2005), namely the possibility of inside information or “stories”, seems to be responsible for bubbles. We shall elaborate on this in the next subsection.

Subsection 4.2 deals with the influence of overconfidence on bubble formation. Subsection 4.3 presents some preliminary evidence why communication via chat may, contrary to our expectations, prevent bubble formation. Finally, in Subsection 4.5 we take a look at the tactics of informed traders.

4.1 Bubble count

In this section we shall describe the frequency of bubbles in our experiment. For this we first need to specify a definition of bubbles. The usual definition of bubbles as “persistent deviation from fundamentals” is useful but needs to be operationalized. Also, given that in two of our treatments private information may be present, a distinction between bubbles and mirages (see Camerer and Weigelt, 1991) is necessary.

- A *mirage* is said to occur if prices are substantially above fundamental value, although they could be justified by information on a supplement but, in this case, are not. To be precise, we call a sequence of prices a mirage if the median daily price of an asset satisfies the following condition for *at least three* consecutive trading days:
 1. The median price is closer to 94, which is the fundamental value without information, than to 110, which is the expected value of an asset given knowledge that it carries a supplement of 40.¹⁴
 2. There is, in fact, no information about a supplement in the market (i.e. the fundamental value is 94).
- An *asset bubble* is said to occur if prices deviate substantially from fundamental value and this deviation cannot be justified by any possible information on supplements. To be precise, we call a sequence of prices an asset bubble if the median daily price of an asset is above 150 or below 80 for *at least three* consecutive trading days. Note that 150 is the expected dividend of an asset if it is known that the supplement is 80. If it is known that an asset carries no supplement, the expected dividend is 80.

Asset bubbles are unlikely to occur in our experiment as it will be rare that an observed price cannot be justified by any information on supplements

¹⁴Analogously, one can define an 80-mirage, if prices are closer to the expected value given an 80-supplement than to the expected value given a 40-supplement (or to 94). However, we did not find any instances of such mirages for at least 3 trading days.

(given that the supplements can be fairly large relative to the base value of an asset). But the same is, of course, true for real asset markets. It will be rare that an observed price movement cannot be justified by any plausible story.

Our design with 5 assets has the advantage that we can differentiate between bubbles for a single asset and *market bubbles* which describe an over- or undervaluation of the entire market.

- A *market bubble* is said to occur if the *prices index* of the whole market deviates substantially from fundamental value. Note that as pointed out above, the fundamental value for the market index is 94. Thus, we call a sequence of price index values a market bubble if the average of median prices for all 5 assets deviates from 94 by more than 10% for *at least three* consecutive trading days.

Table 3 reports the frequencies of bubbles according to the above definitions. We report the total number of bubbles and the number of rounds (out of 18 possible), in which at least one bubble occurred. A clear pattern emerges: In treatment INF, mirages and market bubbles are more frequent than in the other two treatments and occur in (almost) two thirds of the rounds.¹⁵ Surprisingly, mirages and market bubbles are as rare in INFCHAT as in NOINF (no significant differences according to Mann–Whitney U–Tests (MWU) for any bubble measure). As expected, asset bubbles are rare in all treatments. Nevertheless, 5 asset bubbles occur in treatment INF but none in treatments NOINF and INFCHAT.¹⁶ The total number of trades per session is highest on average in NOINF and lower in INF and INFCHAT. However, this difference is not significant according to a MWU test on the session level at any conventional significance level.

To conduct a more disaggregated test for the determinants of bubbles we ran several random effects probit regressions. The variable to be explained is

¹⁵If we conservatively consider entire sessions as units of independent observations, we get significant differences at the 5% level of a one-sided MWU tests for the differences between INF and INFCHAT for the number of mirages, number of market bubbles, and number of market bubbles rounds. Between INF and NOINF the difference is significant for number of market bubble rounds. All other pairwise tests are not significant at the

Table 3: **Frequency of bubbles**

number of bubbles			
bubble type	NOINF	INF	INFCHAT
mirages	n.a.	23	8
market bubble	4	14	3
asset bubble	(0)	5	0
number of bubble rounds			
bubble type	NOINF	INF	INFCHAT
mirages	n.a.	12 / 18	5 / 18
market bubble	4 / 18	11 / 18	3 / 18
asset bubble	(0 / 18)	3 / 18	0 / 18
avg. number of trades per session	1585.7	1509.3	1244.7

Note: A mirage or bubble is counted as such if the respective price deviation is observed for at least 3 consecutive trading days.

in all cases the probability that a given round is a round in which a market bubble occurs. The explanatory variables in all regressions are dummies for the treatments INFCHAT and NOINF (with INF being the default), a variable “financial knowledge”, which measures the average number of correct answers on a financial knowledge questionnaire given by the group of traders for the current session, a variable “male” which represents the share of males in the group, a dummy for students who are in the upper division of their undergraduate studies (last 2 years), and variables that represent the share of traders in the group who study one of the fields: economics, business, law, (natural) sciences. Since the three rounds of a session cannot be considered independent, we use standard errors that are clustered by session. Furthermore, we allow for heteroscedasticity in the error structure.

The first column of Table 4 shows the marginal effects of the respective variables for this base model. Both treatment dummies are significant

5% level.

¹⁶The definition of an asset bubble is not really applicable to NOINF. The frequency is reported here nevertheless to show that extreme price deviations were rare in this treatment.

and negative, which confirms the impression from the non-parametric tests above. The probability of a market bubble in NOINF is 35% lower than in INF. For INFCHAT it is 34% lower than in INF. Surprisingly, market bubbles, are more likely in rounds when the share of economics and law students is high.

Column 2 contains a further regression which enriches the base model by including a variable measuring how frequently the shortsale constraint was binding. Camerer et al. (1999) introduce the notion of an information trap. A market is in an information trap if traders cannot conduct arbitrage due to either (1) a lack of cash or (2) a lack of assets to sell in the presence of shortsale and no-borrowing-constraints. Since we provided subjects with sufficient cash (partly through a loan), the no-borrowing constraint was never binding for any of our subjects. To account for the shortsale constraint, we construct the variable “shortsale” by taking the average number of asset/day/subject combinations in which a trader had zero of an asset in his portfolio at the end of a day (i.e. when the short-sale constraint was binding).¹⁷ Table 4, column 2 shows that the shortsale constraint does not significantly increase the probability of bubbles. Apparently, the shortsale constraint is not responsible for bubble formation, which is consistent with the findings of Haruvy and Noussair (2006).

Finally, column 3 contains another regression including an (over)confidence indicator “top-rank belief” (to be explained below). This also does not affect the results substantially. However, (over)confidence seems to be a possible factor for bubble formation and we shall address this topic in the next section.

With respect to experience we find in contrast to most of the literature (e.g. Boening et al., 1993, or Dufwenberg et al., 2005) that bubbles are robust to repeated experience in the same market and with the same traders. When we aggregate over all treatments, we find that there are 4 market bubbles in first round, 7 market bubbles in second round, and 8 market bubbles

¹⁷The mean of the shortsale variable is 0.066. Note that the theoretical maximal value for this measure is 0.9 as at least one trader must hold assets.

Table 4: Probit analysis: probability of a bubble round

Explanatory variable: prob. of bubble round	Base model	with shortsale	with confidence
INFCHAT	-0.342** (0.130)	-0.288** (0.111)	-0.324** (0.130)
NOINF	-0.354** (0.137)	-0.335*** (0.137)	-0.351** (0.133)
financial knowledge	-0.791 (0.509)	-0.726* (0.400)	-0.727 (0.545)
male	0.053 (1.146)	0.012 (0.908)	0.003 (1.209)
upper division	0.154 (0.561)	0.201 (0.456)	0.314 (0.608)
economics	2.896** (1.096)	2.917** (0.999)	2.772** (1.089)
business	-0.477 (0.651)	-0.155 (0.618)	-0.299 (0.749)
law	4.778*** (1.291)	4.645*** (1.211)	4.678*** (1.321)
sciences	2.385* (1.091)	2.303* (0.900)	2.305 (1.144)
shortsale		0.725 (0.559)	
top-rank belief			0.171** (0.092)
Observations	54	54	54
Log-Likelihood	-20.519	-19.150	-19.945
Pseudo R^2	0.403	0.443	0.420

Note: Reported are marginal effects at the mean. *** significant at 1%-level; ** significant at 5%-level; * significant at 10%-level; Standard errors in parentheses are robust to heteroscedasticity and clustered by session; a constant is included in all regressions

in third round. One difference of our experiment to the aforementioned experiments, that could account for this observation, is that our markets are repeated with a slight variation in each round. The assets with supplements (and the information about these) change from round to round. We believe that this (probably realistic) feature may inhibit learning by subjects and makes them susceptible to bubble formation over and over again.

The number of mirages also does not decrease with experience. Aggregated over INF and INFCHAT we get 7 mirages in round 1, 10 in round 2, and 14 in round 3. If anything, the number of mirages seems to increase with experience. This is in clear contrast to the observation by Camerer and Weigelt (1991) who find hardly any mirages in later rounds. There is a simple explanation for this difference, though. In Camerer and Weigelt (1991) there is competition among insiders which forces them to trade early and aggressively lest their informational advantage is lost to the other insiders. This produces a particular trading pattern that became easy to notice by uninformed traders. In our design with a monopolistic insider, in contrast, an insider can patiently wait to exploit his informational advantage (see Section 4.5).

4.2 Overconfidence and bubble formation

Overconfidence of investors is widely believed to be a cause for irrational pricing patterns on financial markets (see e.g. Barber and Odean, 2001), although the exact mechanism by which it affects prices in markets is still under debate. To measure overconfidence in our experiment, we asked subjects before the start of each round (and before private information about supplements was given) to rank themselves among the 60 subjects of a treatment in terms of payoffs for this round. Overall, overconfidence in our experiment seems to be modest as 54 % of subjects thought to be better than the median, i.e. have rank 30 or better, which is significantly more than the expected 50% (at the 5% level of a one-sided binomial test) but not dramatically so. An interesting phenomenon, however, can be observed for subjects who believe that they are going to make the top-rank among 60 subjects. One out of 18 subjects thought that he is going to be top-ranked

although only one out of 60 can actually be top-ranked. The existence of traders who are particularly over-optimistic with respect to top-rank may be important as those subjects may be the most active traders,¹⁸ possibly causing bubbles.

To test this we constructed a variable “top-rank belief” which measures for each round the number of subjects who believed they would be top-ranked. Column 3 in Table 4 reports a regression that includes this top-rank belief variable and, indeed, it has a positive and significant effect on the probability of bubbles.

Figure 2 shows the top-rank belief variable aggregated over sessions for the different rounds and treatments. In contrast to the expected number of top-ranked traders, which is 1, the numbers are much higher in INF and they are increasing from round 1 to 3. Overconfidence is lower in NOINF but is also increasing with experience. All circled value are significantly above the theoretical value of 1 according to one-sided binomial tests with a p -value of 0.02 or better. In contrast, overconfidence is low (not significantly different from 1 at any conventional significance level) and does not increase in treatment INFCHAT. This points to an interesting and unexpected role chat may play in our experiment, namely to make traders more realistic with respect to their trading abilities.

4.3 Why is chat counterproductive for bubble formation?

Our original hypothesis that chat should be conducive to bubble formation is clearly rejected by the data. What could account for this? There may be several ways by which chat prevents bubbles from being formed. As we saw in Section 4.2, chat seems to reduce (or, at least, to prevent an increase in) overconfidence. We also found evidence that links overconfidence to bubble formation, which establishes one possible explanation for this counterintuitive result.

There are two further ways in which chat may prevent bubbles.¹⁹ Chat-

¹⁸In fact, traders who believed that they would be top-ranked made on average 2.41 trades per day and asset in contrast to 1.90 trades of those who did not believe this.

¹⁹Chat may also prevent bubbles by giving subjects something to do rather than trading

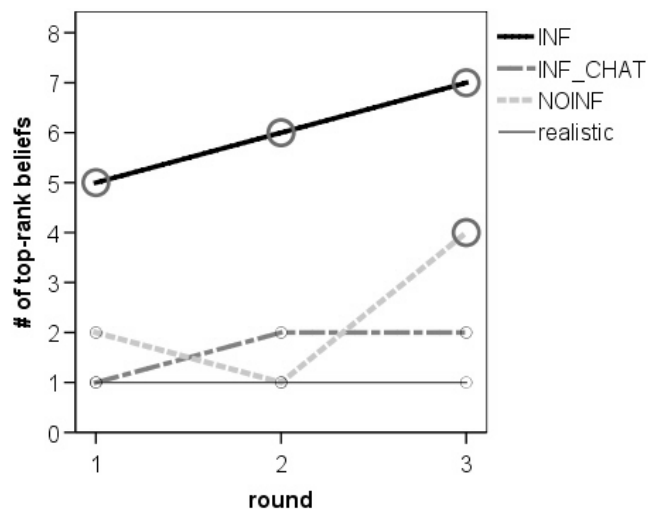


Figure 2: Overconfidence and experience: Number of traders who believe that they are going to make top-rank, aggregated over sessions.
 Note: Circles indicate significant differences to expected value according to one-sided binomial test with p-values < 0.02 .

Table 5: **Chatting in bubble and non-bubble rounds**

	bubble rounds		mirage rounds	
	yes	no	yes	no
average number of messages per round	53.7	108.3	65.2	115.3
average number of chatters	4.0	6.0	4.1	6.2
share of messages by insiders*	.20	.07	.15	.07
number of rounds	3	15	5	13

Note: Data from treatment INFCHAT. *Includes only rounds with insiders.

ters may point out overvalued market situations to other traders. And chatters may explain the mechanics of the market to others. We find anecdotal evidence for both types of communication.

Before analyzing the content of chat messages, we present in Table 5 a first quantitative view on the relation between chat behavior and the occurrence of bubbles. Simply counting the number of messages and number of chatters, one sees a clear difference between market bubble and non-market bubble rounds (respectively, mirage and non-mirage rounds). In bubbles rounds, only about half as many messages are exchanged and they are sent by fewer subjects than in non-bubble rounds. However, the share of messages sent by insiders is about twice as high in bubble rounds. Although it is impossible to infer from this a causal link between chatting behavior and bubbles, we see a correlation between fewer chat messages and more bubbles. When no chat messages are allowed, as in treatment INF, we find even more bubbles.

By definition market bubbles occur because some assets are traded above the expected value while the prices of others do not drop accordingly. If the price increase in one asset is backed by hard information (i.e. inside information), the market bubble must be driven by other assets not adjusting downwardly. Alternatively, the price increase is not backed by hard information. In this case, the bubble is driven by one or more asset bubbles. This second type of market bubble is more fragile in the sense that once the

when they shouldn't. However, we find no significant relationship between the number of chat messages a subjects sends and the number of his trades.

asset bubble bursts, the market bubble bursts, too. Which type of chat can eliminate which type of market bubble?

The first type can be eliminated if a chatter points out the inconsistency. This happened indeed in one round. The market correctly identified the asset with the supplement of 80. One chatter commented that this implies a lower value for the other assets and despite a high price for that one assets, no market bubble materialized. In fact, even in later rounds of the same session no market bubble occurred.

The second type of market bubble is less likely to occur if traders have doubts in the persistency of the asset bubble. Comments in this respect indicate that there is at least one trader who considers the asset to be overvalued which makes it more likely that the bubble may burst. A respective comment may act as an external trigger to burst the bubble. We find several instances in which chatters use the terms “overvaluation” or “overvalued”. However, there are not enough observations to warrant a statistical analysis.

4.4 Price predictions and revelation of information

An important question with respect of bubble formation is whether traders realize that assets are overpriced or not. If traders realize that current prices are far above fundamental values, they may still speculate on rising prices in the short run (“ride the bubble”). The alternative hypothesis is that traders simply do not recognize the mispricing. In order to separate out those two hypotheses we have asked our subjects to predict both, the price of an asset at the end of the current trading day and the final dividend after the last trading day (i.e. the fundamental value). Subjects were asked to make those predictions for all 5 assets at “noon” of days 4, 6, and 8. Thus, for each round we have up to three predictions per subject.²⁰

Figure 3 shows the average predictions of subjects in all treatments separately for rounds in which a positive market bubble occurred and for rounds

²⁰The predictions were voluntary and no monetary incentive was given. Subjects had up to 60 seconds for typing the predictions in. Some subjects provided nonsensical predictions in order to speed up the process (the most frequent nonsensical prediction was 0). Therefore, we eliminated all predictions below 50 and above 170 from the analysis.

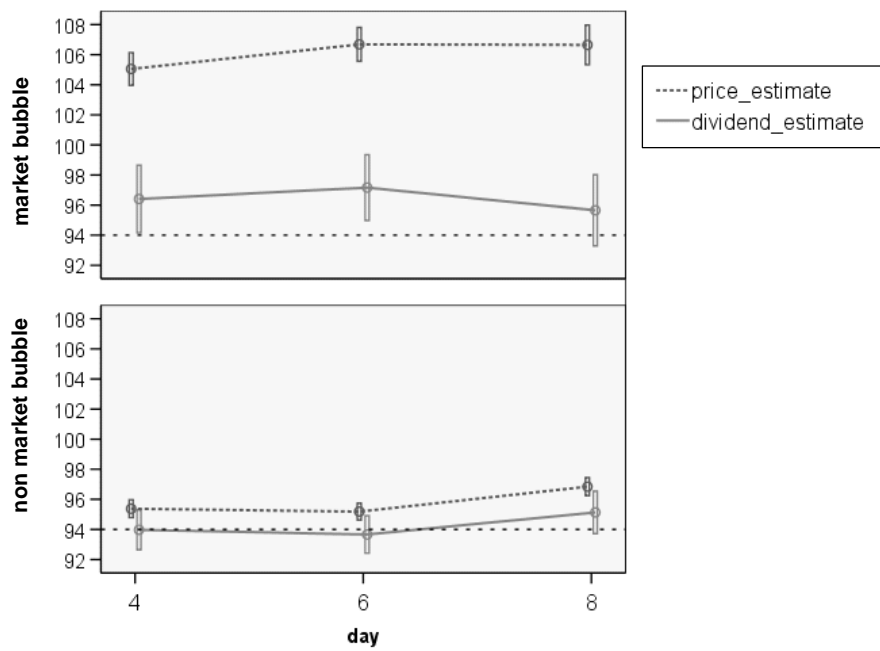


Figure 3: Average predictions of prices at the end of the current day and of final dividends in market bubble and non-market bubble rounds.
 Note: Aggregated over rounds, sessions, and treatments. Vertical bars show 95% confidence intervals.

in which no positive market bubble occurred. Interestingly, predictions for the final dividend are fairly close to the expected value of 94, which is the fundamental value for the market portfolio. In no-bubble rounds predictions for the price of assets at the end of the day are also close to 94. However, in bubble rounds, predictions for prices at the end of the day are substantially higher. This finding is more in line with the hypothesis that traders try to ride the bubble while being aware of the fact that a crash must occur in the end of a round.²¹

Does information eventually get revealed through prices? This question is at the heart of the literature on rational expectation and the informational role of prices. In a fully revealing rational expectations equilibrium (REE) all information in the market gets revealed through prices. On the other hand, game-theoretical models would predict a No-Trade Theorem. Finally, theories based on imperfect competition among informed traders (see e.g. Kyle, 1989) predict only a partial revelation of information. In our context, there is a monopolistic insider who clearly should be aware of the fact that his actions influence prices and may eventually reveal his information.

In Table 6 we list the fully revealing REE prices given that an asset is endowed with a supplement of 80 or 40 and one trader is informed about this. In the table “info about supplement” is denoted as 0 if no information about supplements is known in this round. Info about supplement is $-x$ if it known that another asset receives a supplement of x . Note that the REE predictions were explicitly explained to subjects through examples (see Appendix). Table 6 compares the REE predictions to the median of the final prices in all rounds with the respective supplement information.

Interestingly, the final prices on rounds in which an asset is known to have a supplement of 80 are fairly close to the fully revealing price of 150. However, with a supplement of 40, final price hardly differ from the no-information expected value of 94. Median final prices in rounds without any information are 98 and even exceed those with a supplement of 40. The possibility of mirages is probably responsible for this. Noteworthy is in

²¹However, traders may misjudge when exactly a crash will occur. Haruvy et al. (2006) show that beliefs are adaptive, and crashes are rarely anticipated correctly in early rounds.

Table 6: **Comparison of final prices to REE prices**

info about supplement	80	40	0	-40	-80
REE prediction	150	110	94	90	80
median of final prices in rounds	140	95	98	91.5	93.5
number of observations	16	4	170	16	64

Note: Info about supplement is 0 if no information about supplements is known in this round. Info about supplement is $-x$ if it known that another asset receives a supplement of x .

particular, that there is very little downward adjustment for asset without a supplement when there is information that another asset has a supplement. Median final prices are particularly far off from the REE prediction of 80 when the asset is known not to carry the 80 supplement.

4.5 Tactics of the informed trader

The decision problem of an informed trader is not simple. Clearly he wants to avoid revealing his information too early. He may even try to mislead other traders by first selling the asset he has positive information on. Or he may trade first in other assets to draw the attention of traders away from the asset he is informed about. In this section we shall have a closer look at the tactics our informed traders employed.

In their first trade of a round, none of the informed traders *sold* the asset which they knew carried a supplement of 40 or 80. Instead, 50% of informed traders placed a limit order to buy the asset with the supplement, 20% placed a market order to buy the asset with the supplement, and the remaining 30% traded in other assets in their first action of a round.

We are also interested in who placed the first limit order in a round for an asset, about which inside information was available. Plott and Sunder (1982) and Barner et al. (2005) find that inside information often gets revealed by insiders placing limit orders early in a round. Furthermore, in rounds in which bubbles or mirages happen, Barner et al. (2005) find that the uninformed were placing limit orders. In our data, in 5 of 20 cases the informed traders were the first traders to place a limit order for the

asset they were informed about, which amounts to only slightly more than their share among all traders. Interestingly, in 4 of those 5 rounds a market bubble occurred, which is not in line with Barner et al. (2005).

Figure 4 shows the evolution of the informed traders' portfolio. The upper two panels show the evolution of the insider asset (i.e. of the asset about which insiders had information), for a supplement of 40 and for a supplement of 80, respectively. The mean number of shares in the portfolio is slowly increasing over all 10 days starting from the endowment of 10 shares. In the end, informed traders held on average between 40 and 50% of the 100 outstanding shares. The lower panels of Figure 4 show the evolution of the insiders' portfolio with respect to the four assets, which they knew did not carry a supplement of 40 or 80, respectively. Given this knowledge, insiders should have sold those assets at any price above 80 or 90, respectively. Figure 4 shows that this indeed occurs when insiders knew that the four assets did carry the 80-supplement ($x = -80$) as average holdings are down to about 5 per asset. Surprisingly, average holding for the $x = -40$ case are U-shaped. At the end of the round, insiders are back to their initial endowment on average. Note that bargain prices for these assets cannot account for this behavior since prices are higher than the REE prediction (see Table 6).

Figure 5 shows the time and the price of limit order bids made by insiders for the asset they were informed about, separately for different supplements. While there are many bids just above 94, which shows that insiders try to carefully collect their portfolio without giving away their information, towards the end of the round, insiders feel the need to place higher and higher bids. In the case of the 40-supplement, some bids approach the fully revealing price 110. In the case of the 80-supplement all bids are below 150 but reach 140. Interestingly, there is a high frequency of prices at or slightly below 110, which hints at bids "masquerading" as bids for an asset with a 40-supplement.

The trading pattern of insiders and outsiders also differs substantially with respect to frequency and the distribution of trades over the 10 days of a round. Figure 6 shows the average number of limit bids per day per asset. The right panel shows average number of bids by informed traders for the

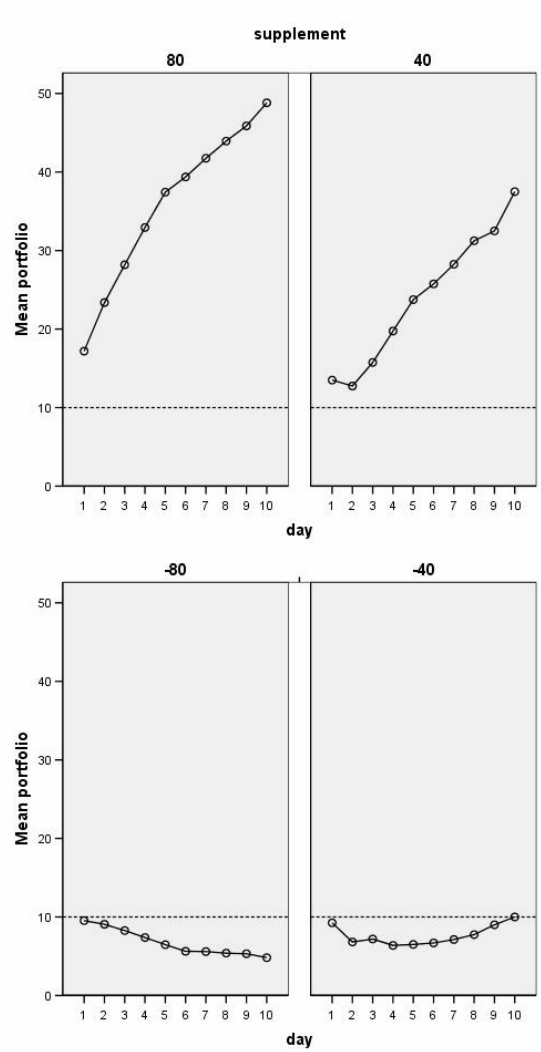


Figure 4: Evolution of average holdings by insiders of the asset insiders were informed about (upper two panels) and of the average holding of the remaining 4 assets (lower two panels)

Note: Dotted line at 10 denotes the initial endowment. A supplement of $-x$ means that these assets do *not* carry a supplement of x .

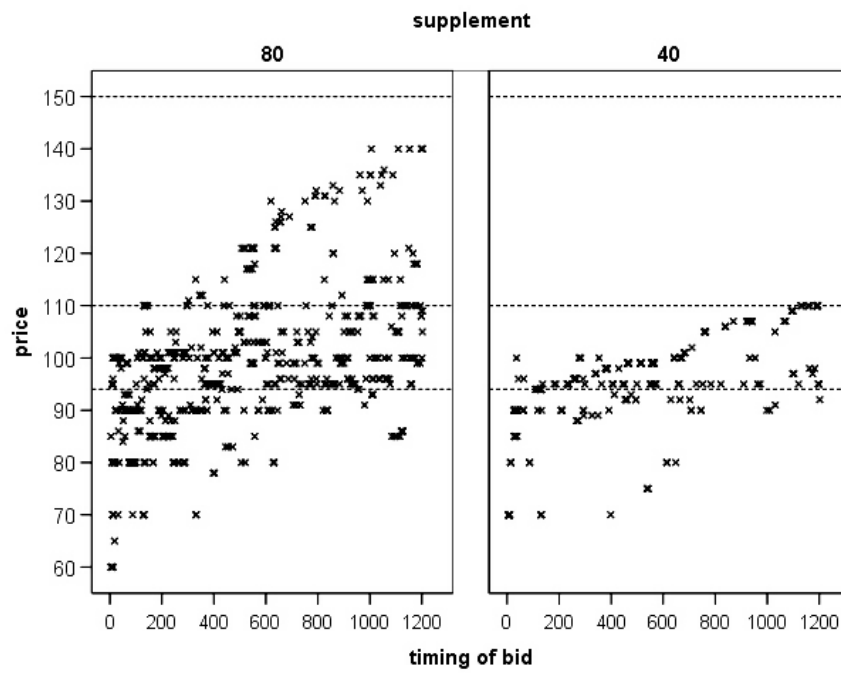


Figure 5: Timing (in seconds) and prices of limit bids by insiders to buy insider assets.

Note: Aggregated over rounds, sessions, and treatments. Dotted lines denote fundamentals values without information (94), with information about 40-supplement (110) and with information about 80-supplement (150).

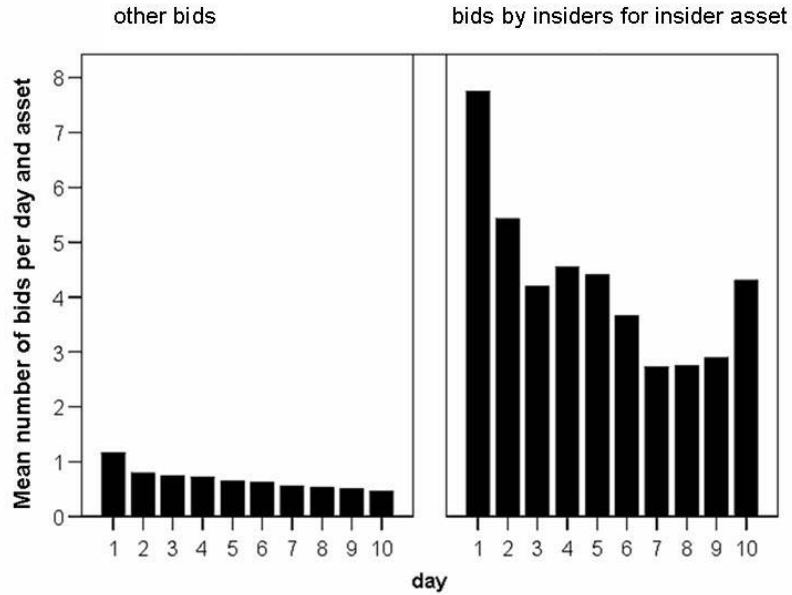


Figure 6: Number of limit bids per day per asset for insider assets by insiders (right panel) and for other assets by all traders (left panel).

asset they are informed about (“insider assets”). The left panel shows the same for all assets which are not known to carry a supplement. Overall there are a lot more bids placed for insider assets than for other assets. Insiders place bids with high frequency in the early days, slow down somewhat and then again place many bids on the final day. Uninformed traders on the other hand, show a declining activity with respect to bids throughout all 10 days. This trading pattern makes intuitively sense. Insiders try to profit from their private information by buying early but not too aggressively. Once prices start to rise, insiders and outsiders slow down. But insiders buy again on the last day in order to exploit any remaining profit opportunities.

Finally, we shall consider how insiders make use of their private information in terms of profits. Over all rounds and treatments, the median profit of insiders was 1,126 Taler per round. A fairly extreme benchmark is the profit an insider would make against totally naive, uninformed traders who believe that prices are uninformative and the fundamental value of each asset remains at 94 regardless of trading prices. Against naive traders, an insider would buy all outstanding shares of the asset with the supplement at a price of 94 and would sell all of his other assets at a price of 94. A simple calculation using the actual dividends paid in our experiment (see Appendix) shows that average profits of insiders would then be 14,274 Taler.

If there is no information about supplements in a given round, expected profits are equal to expected dividends of all assets plus cash, which amounts to 9,885 Taler, where we use the same dividend base values as above to make a fair comparison. Accordingly, insiders capture only 31.3% of their possible informational rent.

5 Conclusion

In this paper, we report results of an experiment designed to test whether bubbles in asset markets occur even when only a final dividend is being paid (and consequently, the fundamental value for each asset is flat). This question is motivated in part by the vivid description of bubbles in Shiller's book "Irrational Exuberance" which stands in marked contrast to the relatively austere environment which characterized prior experiments on asset bubbles.

All prior experiments in which bubbles were observed, paid out dividends after each trading day. In our base treatment NOINF, we confirm the implicit hypothesis derived from this observation, namely that frequent dividends are the driving force for bubble formation in experimental asset markets. Without them, hardly any bubbles can be observed.

However, bubbles undoubtedly do occur in real markets despite the absence of dividends, for example in stocks that never paid dividends or in commodities or currencies. To account for this fact we test in this exper-

iment Shiller's (2005) idea that bubbles may be driven by an interplay of inside information and communication among traders.

Our main result is that bubbles can frequently occur even in the absence of recurrent dividend payments. As hypothesized, the possible presence of inside information is crucial for bubble formation. In our treatment INF we observe market bubbles and mirages in almost 2/3 of rounds. Furthermore, there is no indication that bubbles disappear with experience. The latter result may be due to the fact that the labels of assets with supplements change from round to round. Arguably, this feature is typical for real financial markets. While at one time a bubble occurs in internet stocks, at another time bubbles may occur in solar energy stocks or in the housing market. We also find a significant effect of overconfidence on the formation of bubbles: the higher the number of traders in a group who believe that they are the best traders, the more likely it is that bubbles form.

In contrast to our expectations, the option to communicate via a chat platform has the effect of reducing the number of bubbles almost to the level of our NOINF treatment without inside information. We suggest some hypotheses why this may be the case, but clearly further research is needed to study this unexpected effect.

By collecting data on the beliefs of traders about future prices and dividends, we are able to distinguish between speculation and confusion, a distinction which has relevance for theories of rational vs. irrational bubbles. In particular, we find that most subjects are well aware of overpricing when it occurs.

Finally, our design makes it possible to study the intriguing question how traders with insider information behave. We find no evidence that insiders actively try to mislead other traders, either through chat or their trading behavior. However, they try to hide their information by not talking about it in the chat and by trading non-aggressively. Insiders have much higher trading volumes and slowly accumulate shares of the asset they are informed about such that in the end of the round they hold between 40 and 50% of the outstanding shares. However, they do not fully disinvest with respect to the remaining assets which may partly explain why they fall short of

achieving the maximal informational rent. In the end of a round, prices reveal fairly well the identity of assets endowed with a supplement, which supports the rational expectation equilibrium (REE) prediction. On the other hand, prices insufficiently adjust downwards when it should be known that an asset does not carry a supplement.

References

- [1] Ackert, Lucy F.; Charupat, Narat; Church, Bryan K.; and Deaves, Richard (2006), “Margin, Short Selling, and Lotteries in Experimental Asset Markets”, *Southern Economic Journal*, 73, 419-36.
- [2] Ball, S. and Holt, C. A. (1998), “Classroom Games: Bubbles in an Asset Market”, *Journal of Economic Perspectives*, 12, 207-218.
- [3] Barber, Brad, and Odean, Terrance (2001), “Boys will be Boys: Gender, Overconfidence, and Common Stock Investment”, *Quarterly Journal of Economics*, 116, 261-292.
- [4] Barber, Martin; Feri, Francesco and Plott, Charles (2005), “On the Microstructure of Price Determination and Information Aggregation with Sequential and Asymmetric Information Arrival in an Experimental Asset Market”, *Annals of Finance*, 1, 73-107.
- [5] Berg, J.; Forsythe, R.; Nelson, F.; and Rietz, T. (forthcoming), “Results from a Dozen Years of Election Futures Market Research”, in Plott, C. and Smith, V. (eds.), *Handbook of Experimental Economic Results*, Elsevier.
- [6] Caginalp, Gunduz; Porter, David; and Vernon L. Smith (1998), “Initial cash/asset ratio and asset prices: An experimental study”, *Proc. Natl. Acad. Sci. USA*, 95, 756-761.
- [7] Camerer, Colin and Weigelt, Keith (1991), “Information Mirages in Experimental Asset Markets”, *Journal of Business*, 64, 463-493.

- [8] Camerer, Colin F.; Nöth, M.; Plott, Charles R. and Weber, M. (1999), “Information Aggregation in Experimental Asset Markets: Traps and Misaligned Beliefs”, *Social Science Working Paper* no. 1060, California Institute of Technology.
- [9] Davies, Tim (2006), “Irrational Gloominess in the Laboratory”, mimeo, University of Arizona.
- [10] Dufwenberg, Martin; Lindqvist, Tobias and Moore, Evan (2005), “Bubbles and Experience: An Experiment”, *American Economic Review*, 95, 1731-37.
- [11] Fischbacher, Urs (forthcoming), “Zurich Toolbox for Research in Economic Experiments”, forthcoming *Experimental Economics*.
- [12] Fisher, Eric and Kelly, Frank (2000), “Experimental Foreign Exchange Markets”, *Pacific Economic Review*, 5, 365-387.
- [13] Friedman, Daniel and von Borries, Alexander (1988), “Monopolistic Insiders in Computerized Asset Markets: A Note on Some Experimental Results”, *Working Paper* no. 178, University of California, Santa Cruz.
- [14] Haruvy, Ernan; Lahav, Yaron, and Charles N. Noussair (2006), “Traders’ Expectations in Asset Markets: Experimental Evidence”, mimeo, University of Texas at Dallas.
- [15] Haruvy, Ernan and Charles N. Noussair (2006), “The Effect of Short Selling on Bubbles and Crashes in Experimental Spot Asset Markets”, *Journal of Finance*, 61, 1119-1157.
- [16] Hirota, Shinichi and Sunder, Shyam (2005), “Price Bubbles sans Dividend Anchors: Evidence from Laboratory Stock Markets”, mimeo, Yale University.
- [17] King, R.R.; Smith, V.L.; Williams, A.W.; and Van Boening, M. (1993), “The Robustness of Bubbles and Crashes in Experimental Stock Markets”, in: Priagogine, I.; Day, R.H. and Chen, P. (eds.) *Nonlinear Dy-*

namics and Evolutionary Economics, Oxford: Oxford University Press, 183-200.

- [18] Kyle, Albert S. (1989), “Informed Speculation with Imperfect Competition”, *Review of Economic Studies*, 56, 317-356.
- [19] Lei, Vivian; Noussair, Charles N. and Plott, Charles R. (2001), “Non-speculative Bubbles in Experimental Asset Markets: Lack of Common Knowledge of Rationality vs. Actual Irrationality”, *Econometrica*, 69, 831-859.
- [20] Noussair, Charles; Robin, Stephane and Ruffieux, Bernard (2001), “Price Bubbles in Laboratory Asset Markets with Constant Fundamental Values”, *Experimental Economics*, 4, 87-105.
- [21] Noussair, Charles and Tucker, Steven (2006), “Futures Markets and Bubble Formation in Experimental Asset Markets”, *Pacific Economic Review*, 11, 167-184.
- [22] Plott, Charles R. and Sunder, Shyam (1982), “Efficiency of Experimental Security Markets with Insider Information: An Application of Rational-Expectations Models”, *Journal of Political Economy*, 90, 663-98.
- [23] Plott, Charles R. and Sunder, Shyam (1988), “Rational Expectations and the Aggregation of Diverse Information in Laboratory Security Markets”, *Econometrica*, 56, 1085-1118.
- [24] Shiller, Robert (2005), *Irrational Exuberance*, Princeton: Princeton University Press, 2nd edition.
- [25] Smith, Vernon L.; van Boening, Mark and Wellford, Charissa P. (2000), “Dividend timing and behavior in laboratory asset markets”, *Economic Theory*, 16, 567-583.
- [26] Smith, Vernon L.; Suchanek, Garry L. and Williams, Arlington W. (1988), “Bubbles, Crashes, and Endogenous Expectations in Experimental Spot Asset Markets”, *Econometrica*, 56, 1119-1151.

- [27] Van Boening, Mark V., Williams, Arlington W. and LaMaster, Shawn (1993), "Price Bubbles and Crashes in Experimental Call Markets", *Economics Letters*, 41, 179-185.
- [28] Wolfers, Justin and Zitzewitz, Eric (2004), "Prediction Markets", *Journal of Economic Perspectives*, 18, 107-126.

Appendix: Translation of instructions

Welcome to our experiment. Please read these instructions carefully. They are the same for every participant. Please do not talk with other participants and remain quiet during the entire experiment. Please switch off your mobile phone and do not switch it back on until the end of the experiment. If you have any question, raise your arm and the experimenter will come to you.

The experiment is about trade in assets. Apart from you there are nine other traders in your group. The composition of the group does not change during the entire experiment. You can trade different assets with the other traders. All transactions will be in terms of "Taler". All Talers you earn are converted to Euros at a rate of 1,000 Talers = 1€ at the end of the experiment and paid out to you in cash.

The experiment consists of three rounds. At the beginning, there is a short practice round. During this practice round you can familiarize yourself with the situation and the program. All transactions during the practice round have no consequences on your payoffs. The experiment will last for approximately 3 hours, including time for instructions and the practice round.

Description of a round

There are five different assets, which can be traded. At the beginning of each round you receive 10 units of each of the five assets and 5,000 Taler in cash. Additionally you receive 5,000 Taler as a loan, which you have to pay back at the end of the round. At the end of each round, each asset pays a dividend. This dividend is paid to the trader who owns the asset at the end

of the round. How the dividend of an asset is determined will be explained below.

Your total payoff for each round consists of the dividends of your assets plus your cash holdings minus the loan of 5,000 Taler. Note that an asset is worth nothing after the dividend has been paid.

Each round consists of 10 “days”. In the “morning” of each day (except day 1) you have the opportunity to anonymously communicate with the other traders via computer (chat) [This sentence for INFCHAT only]. At “noon” you are sometimes asked to fill in a questionnaire in which you predict the asset prices and dividends that you expect. In the “afternoon” the market opens and you are able to start trading assets. In our experiment the “morning” is one minute long, “noon” lasts for up to 60 seconds and the “afternoon” for two minutes. In the “evening”, you see charts of the asset price developments from the first up to the present day. The round ends after the tenth day.

We will soon distribute an extra sheet, which will explain how to trade assets using the computer program.

Dividends

The dividend for a given asset consists of two components: the base value and a supplement:

$$\text{DIVIDEND} = \text{BASE VALUE} + \text{SUPPLEMENT}$$

The base value is chosen at random before each round and is an integer between 50 and 90 Taler. All integers are equally likely to occur. So, the expected base value amounts to 70 Talers. No trader knows the actual base value.

For the supplement, two of the assets are selected randomly at the beginning of each round. All assets have the same chance of being selected. One of the selected assets gets a supplement of 80 Talers, the other gets a supplement 40 Talers. All assets not selected receive a supplement of zero. So if you don't know which assets are selected [This clause for INF and INFCHAT only], the expected supplement will be $(80 + 40 + 0 + 0 + 0)/5 = 24$

Taler. The expected dividend is equal to the sum of the expected base value and the expected supplement: $70 + 24 = 94$ Taler.

Note that the actual dividend can lie anywhere between 50 and 170 Taler. No trader knows the actual dividend [This sentence for NOINF only].

With a probability of $1/2$, nobody will learn anything about the supplements. With the remaining probability of $1/2$, exactly one trader will get additional information. All ten traders have the same probability of being drawn. If you are drawn, you will learn one of the two selected assets and its supplement. No other trader has this information. However, you will not learn the base value of this asset or which other asset has been selected. This information is not known to any other trader, either. [This paragraph for INF and INFCHAT only]

Examples: [for INF and INFCHAT only]

If you know that a given asset receives a supplement of 40 Taler but you don't know which asset gets a supplement of 80 Taler, then the expected dividend...

... of the asset with the supplement of 40 Taler is: $70 + 40 = 110$.

... of each of the other assets is $70 + (80 + 0 + 0 + 0)/4 = 90$.

If you know that a given asset receives a supplement of 80 Taler but you don't know which asset gets a supplement of 40 Taler, then the expected dividend...

... of the asset with the supplement of 80 Taler is $70 + 80 = 150$.

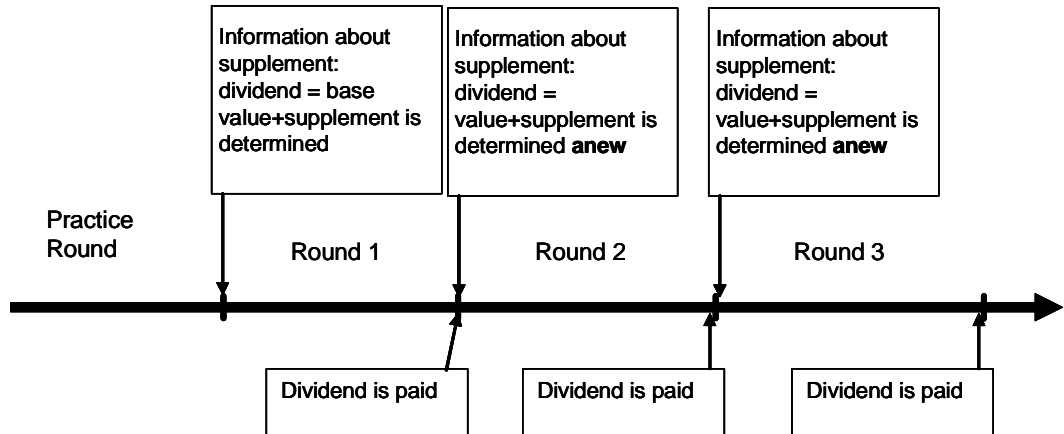
... of each of the other assets is $70 + (40 + 0 + 0 + 0)/4 = 80$.

Timing

Let's recall the timing of the experiment. At the beginning there is a practice round that lasts only three days. Then, the first round starts, which affects your payoff. Each round consists of 10 days and unfold as follows:

At the beginning of each round, dividends are determined randomly. These dividends are valid for the entire round but completely independent of the dividends paid in other rounds. There is a 50% chance that a randomly chosen trader is then informed about the supplement of one asset [This sentence for INF and INFCHAT only]. Then ten days follow, each of which

consists of a “morning” with communication [This clause for INFCHAT only], a “noon” at which you sometimes have to make forecasts, and an “afternoon” with trading.



[Figure: “information about supplements” not for NOINF]

Bankruptcy

Please be aware that you have to pay back your 5,000 Taler loan at the end of each round. If you are not able to pay your debts, your payment for the present round will be zero and you will have to quit the experiment.

Overall Payment

Your overall payoff from the experiment equals the sum of the payoffs from all three rounds.

Review questions

PLEASE ANSWER THE FOLLOWING QUESTIONS

1. Each of the three numbers 3, 6 and 9 is likely to occur with probability $1/3$. What is the expected value?
2. You bought an asset for 80 Taler, which receives a dividend of 90 Talers. Suppose you keep it until the end of the round, how much profit did you make by buying this asset?

3. Assume you have 1,000 Taler in cash at the end of the round and the dividend paid to your assets is 4,100 Taler. Are you bankrupt and do you have to quit the experiment? Yes _____ No _____

4. You have 100 units of one asset and 1,000 Taler in cash and you make no transactions until the end of the round. How large is your dividend at least? _____ Taler
Which payoff will you receive at least at the end of the round (note, that you still have to pay back the loan of 5,000 Taler)? _____ Taler

5. You are at the beginning of a round. How likely is it that one trader receives additional information about the supplement. _____ Percent [This question for INF and INFCHAT only]

6. You were informed which asset receives the 80 Taler supplement. Has any other trader been informed about supplements as well? _____
Yes _____ No _____
How high is the dividend for this asset?
At least _____ Taler and no more than _____ Taler. [This question for INF and INFCHAT only]

5. Can it happen that some other trader knows more than you about the base value or about the supplements at the beginning of a round?
_____ Yes _____ No [This question for NOINF only]

Financial market questionnaire

[The following 6 questions (true/false/uncertain) were asked at the end of the experiment to assess subjects' knowledge about financial markets]

1. I have already bought or sold stocks myself.

2. When buying shares of an American company, you bear the risk of a changing exchange rate.

3. To go short means to sell shares without holding them.

4. At a stock exchange each buyer has to deposit an agio to prove that he has enough liquidity.
5. Profit taking explains why stock prices tend to slightly decrease during an uptrend without any obvious reason.
6. IPO is an international authority monitoring the placement of new securities on the stock markets.

Table 7: Calculation of expected profits of insiders against naive traders

insider buys all 90 shares with known supplement at price of 94 from naive traders	-8460
insider sells all his 40 shares without known supplement at price of 94 to naive traders	3760
assets with known supplements paid on average a dividend of 139.74 in our exp., insider holds 100 shares	13974
sum	9274
plus cash	5000
total profit	14274

This needs to be contrasted with the profit when no trader is informed, which turns out to be 9885, when we use the same dividend base values as above to make a fair comparison. Thus, through their information, insiders could earn a rent of $14274 - 9885 = 4389$. However, they manage only to extract a gain of 1375 ($= 11260 - 9885$) or 31.3% of their informational rents.