On the Ingredients for Bubble Formation: Informed Traders and Communication *

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Abstract

Bubbles in asset markets have been documented in numerous experiments. Most experiments in which bubbles occur feature a declining fundamental value. This feature has been criticized for being atypical of real financial markets. Here, we experimentally study other ingredients for bubble formation that are common in such markets, namely the existence of inside information and communication among traders. We find that bubbles and mirages can occur if these additional ingredients are present. In particular, the mere possibility that some traders are better informed than others can create bubbles. Surprisingly, communication turns out to be counterproductive for bubble formation.

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). Following their design, most experiments in which bubbles frequently occur feature a declining fundamental value for the traded asset. This feature has been criticized as atypical for real financial markets. Furthermore, bubbles disappear if measures are taken that reduce the potential confusion of subjects about the fundamental value (see e.g. Kirchler, Huber, and Stöckl, 2010, and Cheung, Hedegaard, and Palan, 2010). In experimental markets with a perhaps more natural increasing or constant fundamental value, bubbles are rarely observed.[1]

Here, we propose an entirely different and complementary approach to the design of experimental asset markets. This approach includes multiple assets, so that it becomes possible to distinguish between bubbles in one asset and the market index. Moreover, it features elements of financial markets that have been linked to bubble formation[2] but so far not been examined experimentally. The main purpose of this paper is to investigate the effect of these new features with respect to their tendency to contribute to bubble formation in experimental asset markets. In particular, we are interested in the roles of inside information and communication amongst traders. More specifically, we ask: Are bubbles driven by the possibility (i) that some traders

[1]See e.g. Smith et al. (2000), Davies (2006), and Kirchler (2009).
[2]See for example, Robert Shiller (2005)'s book "Irrational excurberance".

may have inside information and (ii) that traders communicate with each other?

Both of these aspects are difficult to deal with in an empirical study. It is often not possible to observe whether there are informed traders and what information they have, and it is hard to monitor communication between traders.[3] Using experimental methods in the current study, we can control whether traders have inside information and we can monitor their communication.

We implement those two features in the following experimental design. We examine ten traders who can simultaneous trade in five assets. Assets pay only a final dividend and hence have a constant rather than a falling fundamental value. On top of the final dividend, supplements are paid to two of the five assets. The possibility of inside information is implemented by the fact that in two of our treatments (INF and INFCHAT), with a certain probability, one 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.

Our main result is that bubbles can occur in markets with constant fundamental values if these additional ingredients are present. Crucial for the formation of bubbles seems to be the *possibility* of the presence of informed traders. 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 our expectation, bubbles all but disappear again when we add the chat option (in our treatment INFCHAT). Apparently, chat is counterproductive for bubble formation. We

[3]There are, however, some interesting empirical studies showing that stock purchases are influenced by stock purchases of neighbors (Ivkovi and Weisbenner, 2007) or of colleagues (Harrison et al., 2005).

offer some suggestions why this may be the case.

We also report a measure of overconfidence and relate the degree of overconfidence to the probability of bubbles. In particular, median overconfidence in the group of traders seems to 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 prices at the end of the current trading day and final dividends for each asset. If subjects believe that current prices reflect the true value, they should report dividend estimates that equal the current price. If subjects are aware of mispricing and speculate, they should report dividend estimates equal to the fundamental value. We find support for the latter hypothesis and conclude that bubbles are driven mainly by speculation.

Our design also enables us to study the tactics of the one trader with inside information. A monopolistic informed trader is facing the dilemma that he wants to profit from his information, yet when he trades too aggressively, he will give away this 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 or both. 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 informed trader could make against totally naive traders, the insiders in our experiment extract on average about 30% of the gain they could make from the inside information.

The closest theoretical model to our experimental setting is a model with a monopolistic informed trader and continuous time trading as in Kyle (1985).[4] The Kyle model makes two predictions that can guide our analysis of the informed trader's behavior. First, at the end of the trading period, prices fully reveal the informed trader's private information. Second, the information is being gradually incorporated into prices at a constant rate. We find qualified support for both predictions in our data.

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

The literature on bubbles in experimental asset markets is based on the pioneering design by Smith et al. (1988). In their experiment, there are 15 trading "days" and 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. Our starting point here is an entirely different one. We examine multiple assets with flat fundamental values. Figure 1 depicts how our main design features (the lower triangle) relate to the canonical model by Smith et al. (1988). Starting from their design, the existing literature has been extended in two directions: by adding more assets (see e.g. Fisher and Kelly, 2000) which did not influence the occurrence of bubbles, and by eliminating intermittent dividends (i.e. by having a flat fundamental value as in Smith et al. 2000). The latter modification practically eliminated bubbles. Our NOINF treat-

[4]The other well known model by Kyle (1989) also can be applied to a monopolistic insider. However, given that this is a static model, it seems to miss one important feature of our markets with continuous trading. The model by Friedman and Aoki (1992) explains how inside information can give rise to bubbles. However, in their model, all traders can posses inside information.

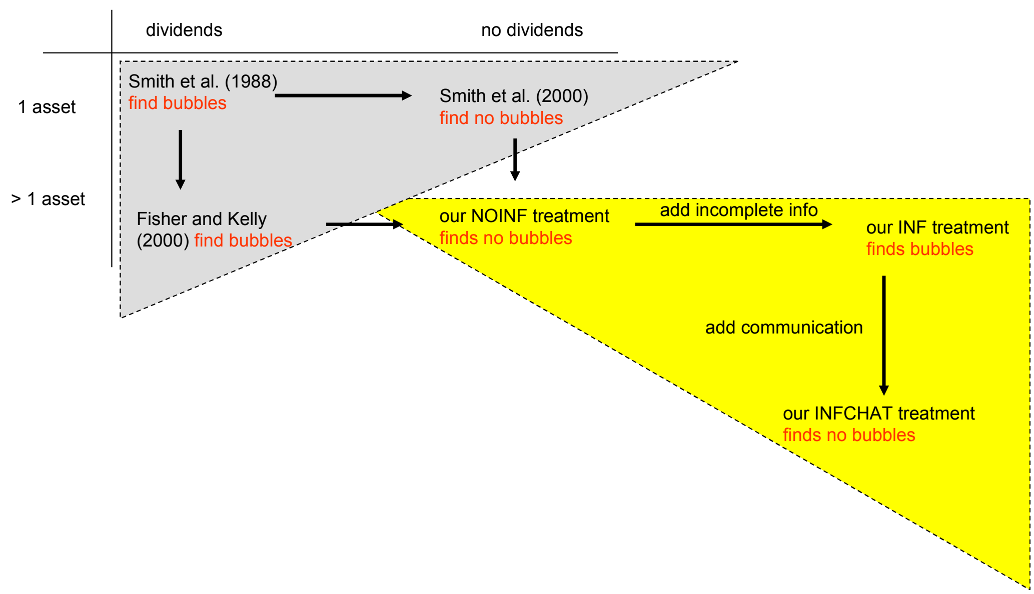

Figure 1: Our treatments in relation to the canonical design by Smith et al. (1988)

ment is exactly the combination of both of the above changes. The existing literature suggests and our experimental results confirm that one should not expect bubbles in NOINF. Thus, our NOINF treatment is anchored in the existing literature. By adding additional features like communication and inside information one at a time, we are able to isolate the effects of those features on the occurrence of bubbles.

Smith et al.'s finding (1988) that there are frequent bubbles with falling fundamental values 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) introduce short-selling and find that this generally reduces asset prices but does not induce prices to track fundamentals. Ackert et al. (2006) observe that short-selling moderates the extent of bubbles; they also 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. Therefore, 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, the fundamental value curve is flat. Smith et al. (2000) study markets with flat fundamentals and find hardly any bubbles.[5] 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.

It is also interesting to relate our paper to the literature on learning-to-forecast experiments (see Hommes, 2010, for a survey). In learning-to-forecast experiments, subjects are rewarded for correctly predicting the price in future periods but do not trade on a market. Rather, an algorithm trans-

[5] Simlarly, Hirota and Sunder (2007) use a setting with only a final dividend. They find that with long term investors there are rarely any bubbles.

[6] An 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. Finally, Noussair and Powell (2008) observe that prices track fundamentals better in a design with first increasing and then decreasing fundamentals rather than the opposite order.

lates subjects' predictions into new prices. This setting sheds light on the interesting question of what happens when forecasting and trading tasks are separated, e.g. because they are delegated to two different departments of a firm. Given that the forecasters do not carry the risk of trading losses in case of a crash, this setting can lead to pronounced momentum trading behavior. In fact, Hommes et al. (2008) find dramatic bubbles in a setting with constant fundamental values (see also Hommes, et al. 2005).

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 trader. The uncertainty as to whether there actually is inside information in the market creates interesting real world scenarios. When observing unusual price movements, traders have to figure out whether those 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 informed trader, 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. Schnitzlein (2002) allows for uncertainty about the presence and the number of insiders. However, his focus is not on the possible formation of bubbles. In a series of papers, Bloomfield et al. (2005, 2007) study the role of (several) informed traders on the provision of liquidity in experimental markets.

3 Experimental design

3.1 Market structure

In each session 10 subjects participate in a computerized experimental asset market, in which 5 different assets are traded simultaneously.[7] Allowing subjects to simultaneously trade in five assets has several advantages.[8] First, it enables us to distinguish between bubbles in single assets and bubbles in the whole market. Second, it reduces the probability that an uninformed trader bets on the right asset by chance.[9] Finally, chat becomes more interesting with many assets. For example, a trader can point out unusual price movements of one asset to other traders who have not so far been aware of it. To facilitate this, our computer interface imitates trading platforms in the field by displaying charts of asset prices after each trading day.

Trading is conducted in continuous time double auctions (one double auction for each asset).[10] All 10 traders start with the same endowment of 10 shares of each asset, 5000 units of cash (denoted in "Taler"), and 5000 Taler as a loan, which has to be repaid at the end of each trading round. We chose to give subjects sufficient cash such that the no-borrowing constraint is unlikely to be binding.[11] However, relative to the fundamental value of assets, the cash endowment is 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

[7]The five assets are labeled and represented by different colors on the computer screen.

[8]Most 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).

[9]In addition, the design raises some potentially interesting portfolio diversification issues, which however, are not the focus of the current study. We just note that in treatment NOINF all risk-averse traders should hold the market portfolio (i.e. an equal number of shares of each asset).

[10]The experiment was programmed with the software z-tree (Fischbacher, 2007). The program keeps track of a queue of offers (the order book) but only the standing offer is visible to subjects. Own offers can be seen in a separate window; they can be withdrawn if they are not the standing offers.

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

current experiment, we would expect to see even more bubbles with a higher cash endowment. Short–selling of assets and borrowing of extra cash is not possible.

Assets pay only a *final* dividend, which implies that fundamental values are flat. This dividend d is the sum of a *base value*, distributed uniformly between 50 and 90, and a *supplement*. It is common knowledge that in each round one of the 5 assets is endowed with a supplement of 80 and one with a supplement of 40. The remaining assets carry no supplement. All assets are equally likely to be selected for a supplement, and dividends are independent over rounds. Thus, ex ante without any further information about supplements, the expected value for each asset is given by

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

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.[12]

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 chat with other traders.

- Treatment **NOINF** is a control treatment 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 (with equal probability either

[12] Note 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 financial markets. 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

the 80 or the 40 supplement) 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.[13]

Table 1 summarizes the treatment properties.[14]

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 familiar-

[13]The 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.

[14]A 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.

izing subjects with the trading platform. Payoffs from the practice round are not counted towards the final earnings.

Figure 2 illustrates the sequence of events within each round. At the beginning of each round, subjects are asked to predict their payoff rank for this round among the 60 subjects facing the same situation. Then, dividends are determined randomly and independently of earlier rounds.[15] Subjects start with the same initial endowment for each round. In treatments INF and INFCHAT and 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 and 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. Furthermore, subjects see 5 charts with all transaction prices of the respective asset from day 1 up to the current day.

At the end of a round, subjects are informed about the dividends each asset paid out and about their total payoff for this round. At the end of the experiment, subjects are told their total payoff in the experiment. Subjects are asked to report their demographics and describe their trading strategy

[15]Random draws were determined beforehand in order to make sessions more comparable. In order to preempt information leakage, we changed the colors of the traded assets from session to session.

in words. We also ask subjects to answer 6 questions designed to test their knowledge about financial markets (see appendix).

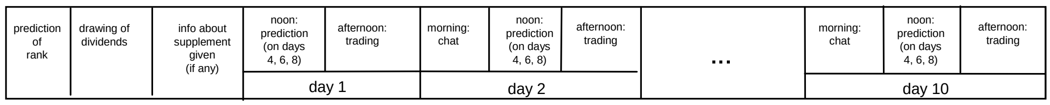

Figure 2: Sequence of events during one round; there are three rounds plus one practice round

3.4 Experimental procedures

Computerized experiments were conducted at the University of Mannheim. Subjects were recruited via an online recruiting system. They were mostly undergraduate students from business, economics, law, natural science, and other disciplines. About 60% were male. We oversubscribed sessions to make sure that exactly 10 traders participated in each session. We conducted six sessions per treatment. Each subject participated in only one session and hence only in one of the four treatments. 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 ensure 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 a certain asset receives a supplement of 40, the expected dividend for this asset is $70+40 = 110$ Taler and for each remaining asset 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).[16]

3.5 Hypotheses

Given our experimental design, we now derive a number of hypotheses. Being interested in the frequency of bubbles, we have to be more specific of what we mean by a bubble. 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. We use the following definitions as they allow a clear–cut classification of a price path as a bubble. Alternative measures for bubbles from the literature yield similar results (see Table 7 in the appendix).

- A *mirage* is said to occur if prices are substantially above the 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:[17]

    1. The median price is closer to 110 than to 94, where the former is the expected value of an asset given knowledge that it carries a supplement of 40 and the latter is the fundamental value without information.[18]

[16]Subjects who failed to answer the questions correctly were asked in private to go through the question, again. No subject finally failed the quiz.

[17]We calculated all measures also for "at least two consecutive" and "at least four consecutive" trading days. The results are qualitatively similar and are printed as Table 8 in the appendix. Considering even longer bubbles does not seem reasonable as a round lasts only for 10 trading days.

[18]Analogously, 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.

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 exceed the fundamental value substantially while this deviation cannot be justified by any possible information on supplements.[19] To be precise, we call a sequence of prices an asset bubble if the median daily price of an asset is above 150 for *at least three* consecutive trading days. The value 150 represents the highest expected dividend for an asset. This value is attained if the asset is known to have a supplement of 80.

Asset bubbles are unlikely to occur in our experiment as it is rare that an observed price cannot be justified by any information on supplements (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 is 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 overvaluation of the entire market.

- A *market bubble* is said to occur if the *prices index* of the whole market exceeds the 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 exceeds 94 by more than 10% for *at least three* consecutive trading days.

We now use these definitions to formulate various hypotheses.

[19] In Table 9 in the appendix, we also consider *negative* bubbles, which are defined as median prices below 80 for at least three trading days.

In all of our treatments, the sum of supplements across assets is equal to 120 and hence constant. As pointed out above, this implies that the expected value of the market index (measured as the average price of the 5 assets) amounts to 94 – irrespective of the treatment. If traders are risk–averse, the certainty equivalent lies below this expected value. These considerations lead to the following hypothesis.

Hypothesis (Price index) In all three treatments, the price of the market index does not exceed the value of 94.

In other words, according to this hypothesis, no bubbles occur in the price of the market index in any treatment. If we further assume that all traders have the same risk preferences (e.g. that all traders are risk neutral), then the initial distribution of shares is Pareto optimal and the usual No–Trade theorems (see e.g. Milgrom and Stokey, 1982) apply in the INF and INF-CHAT treatment. This is because uninformed traders know they may be trading with an insider against whom they will lose money.

Hypothesis (No trade) There is no trade in treatments INF and INF-CHAT.

The central idea of the INF treatment is not the introduction of additional information as such. If this had been the aim, we would have always informed one trader. Rather, the design aims to create uncertainty about whether information is present or not. Shiller (2005) argues that such uncertainty is a key ingredient to bubble formation: the possibility that someone might know more gives credibility to prices that would otherwise be deemed too extreme. This is why we did not always supply inside information but only with some probability. Prior experiments (Smith et al., 2000; Hirota and Sunder, 2007) suggest that if it is common knowledge that no one has any inside information (as in NOINF), one should not expect to see many bubbles. If Shiller is right, the introduction of uncertainty should lead to more bubbles. Whether and which type of bubble results depends on how much traders pay and for what. If traders pay too much for the wrong asset, this would lead to mirages, if traders pay prices that can no longer be justified by supplements the results are asset bubbles, and if the market as a whole overheats, this would yield a market bubble. Summarizing, we obtain the following more behavioral hypothesis.

Hypothesis (Potential Presence of Inside Information) There are more bubbles of all three types in INF than in NOINF.

Another ingredient for bubble formation suggested by Shiller (2005) is the opportunity to communicate. He argues that communication helps spread (false) "stories" amongst traders. According to this view, the probability of bubbles should increase further once traders can communicate.

Hypothesis (Chat) There are more bubbles of all three types in INFCHAT than in INF.

It has been argued that inside information makes markets more efficient by reducing mispricing (for a survey see Easterbrook and Fischel, 1991). In rounds, in which such information is available, we thus expect prices to be closer to the underlying fundamental values than when the information is unknown. Although Kyle's model (1985) does not fit our experiment perfectly,[20] it shares some important features, namely a monopolistic informed trader and continuous time trading. Based on his results, we can formulate a more specific hypothesis about the dynamics of how prices incorporate the inside information.

[20] For example, we do not have noise traders in the experiment. However, in each experiments there is naturally some noisy behavior by subjects, which can be seen as a substitute.

Hypothesis (Revelation of information) Information about supplements is being gradually incorporated into prices. At the end of the trading period, prices fully reveal the informed trader's private information

In the next section, we test these hypotheses.

4 Experimental results

The main question this paper is trying to answer is about the ingredients that make bubbles possible in markets with flat fundamentals. We study the role of two features that are present in real financial markets, namely the possibility of inside information and the possibility of communication. It turns out that only the former feature seems to foster bubbles. We shall elaborate on this in Section 4.1, where we also look at the influence of overconfidence on bubble formation. Section 4.2 presents some preliminary evidence as to why communication via chat may, contrary to our expectations, prevent bubble formation. Section 4.3 tries to distinguish whether traders in a bubble are actually believing that current prices reflect the value of assets or whether they are aware of overprincing but speculate. Section 4.4 analyzes how much of the information is revealed in prices. Finally, in Section 4.5 we take a look at the tactics of informed traders.

Figure 3 allows a first look at the data, where the price index is averaged over all rounds of a treatment. The average price index in treatment INF lies above those in INFCHAT and NOINF on all days, with particularly high prices on days 4 through 7. We find no support for the Price–Index–Hypothesis as the price indices for all treatments lie above 94. When we conservatively consider the average price index (over all days) of one session as one independent observation, the price indices in INF and NOINF are significantly above 94 at the 5% level of a two–sided Wilcoxon test (but not for INFCHAT).

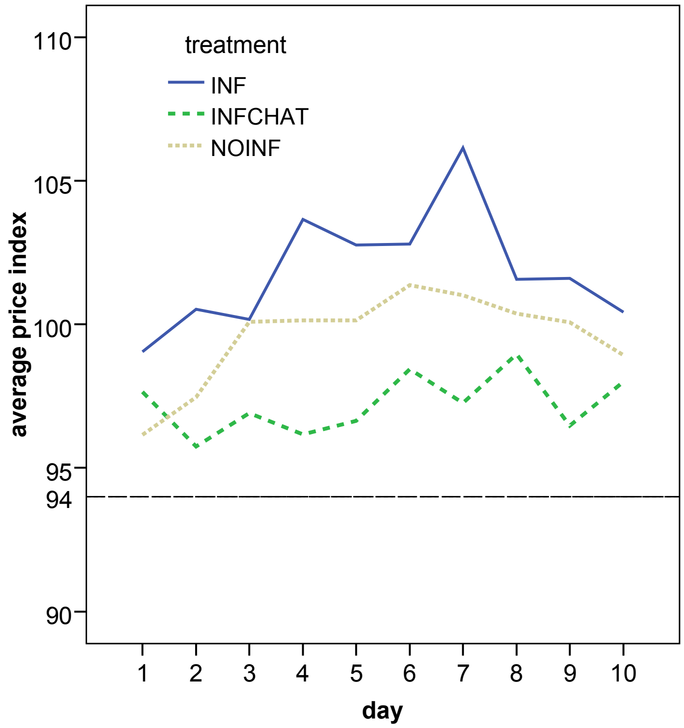

Figure 3: Price indices for treatments INF, INFCHAT and NOINF averaged over all rounds and sessions

The average number of trades per session is 1509.3 in treatment INF and 1244.7 in INFCHAT, which clearly contradicts the No–Trade–Hypothesis. The average number of trades in NOINF is slightly higher at 1585.7 but differences are not significant at any conventional level (based on a Mann-Whitney-U test).

4.1 Bubble count

In this section we analyze the frequency of bubbles in our experiment. Table 2 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.[21] Thus, our

[21]If 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

Table 2: Frequency of bubbles

number of bubbles			
bubble type	NOINF	INF	INFCHAT
mirages	n.a.	32	9
of which with insider	n.a.	18	6
market bubble	4	12	3
of which with insider	0	10	2
asset bubble	(0)	2	0
of which with insider	0	2	0
number of bubble rounds (out of 18)			
bubble type	NOINF	INF	INFCHAT
mirages	n.a.	12	5
of which with insider	n.a.	6	3
market bubble	4	10	3
of which with insider	0	8	2
asset bubble	(0)	2	0
of which with insider	0	2	0

Note: A mirage or bubble is counted as such if the respective price deviation is observed for at least 3 consecutive trading days. For a mirage, "with insider" means that there is inside information in the market but not with respect to the asset under consideration.

data supports the Potential–Presence–of–Inside–Information–Hypothesis.

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). Thus, we find no support for the Chat–Hypothesis. Just the opposite, chat seems to lower the number of bubbles.

As expected, asset bubbles are rare in all treatments. Two asset bubbles occur in treatment INF but none in treatments NOINF and INFCHAT.[22] Figure 4 shows an extreme case of an asset bubble in Session 4 of treatment INF. Recall that a risk neutral investor should never pay more than 150. Even the most optimistic investor should not pay more than 170 unless he

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 5% level.

[22]The 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.

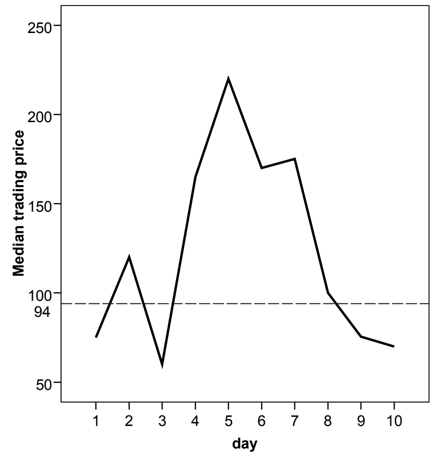

Figure 4: Example of an asset bubble (Session 4 of treatment INF)
The supplement of the asset was 80 but prices exceeded by far the fundamental value.

expects to sell before the bubble crashes.

To conduct a more disaggregated test for the determinants of bubbles, we run several random effect probit regressions. The variable to be explained is 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, the share of 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 3 shows the marginal effects of the respective variables for this base model. Both treatment dummies are significant and negative, which confirms the impression from the non-parametric tests above. The probability of a market bubble in NOINF is 31% lower than in INF. For INFCHAT it is 35% lower than in INF. Surprisingly, market bubbles, are more likely in rounds when the share of economics and law students is high.

Columns 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 almost 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 shortsale constraint was binding).[23] Table 3, column 2 shows that the shortsale constraint does not enter significantly. 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 a regression with a measure for (over)confidence. 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 (over)confidence 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

[23]The 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 3: Probit analysis: probability of a bubble round

Dependent variable: prob. of bubble round	Base model	with shortsale	with confidence
INFCHAT#	−0.354**	−0.292**	−0.332***
	(0.130)	(0.114)	(0.109)
NOINF#	−0.307**	−0.298**	−0.266**
	(0.136)	(0.130)	(0.106)
financial knowledge	−0.742	−0.692	−0.704*
	(0.510)	(0.398)	(0.334)
male	0.648	0.535	−0.066
	(1.060)	(0.838)	(0.691)
upper division	0.334	0.372	0.084
	(0.549)	(0.456)	(0.353)
economics	2.479**	2.622**	2.785***
	(1.043)	(0.913)	(0.826)
business	−0.226	0.124	−0.263
	(0.656)	(0.623)	(0.455)
law	4.736***	4.691***	4.834***
	(1.280)	(1.184)	(1.106)
sciences	1.758	1.776	2.065***
	(1.001)	(0.805)	(0.635)
shortsale		0.906	
		(0.581)	
median rank belief			−0.030**
			(0.014)
Observations	54	54	54
Log-Likelihood	−21.221	−19.259	−19.499
Pseudo R^2	0.369	0.427	0.420

Note: Reported are marginal effects at the mean, with the exception of dummy variables (#) where a discrete change from 0 to 1 is considered. *** 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.

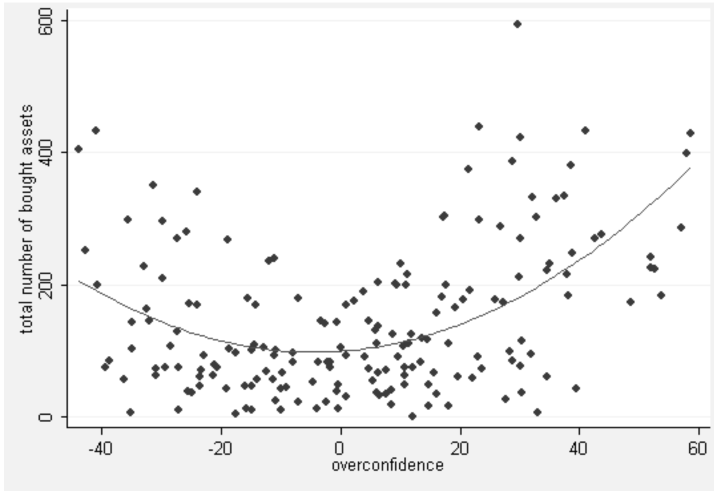

Figure 5: Confidence and Trades

Note: On the y-axis is the total number of assets bought during the whole session (that is of all 5 assets in all 10 trading days of all 3 rounds) and a quadratic least-square fit. Subjects who overestimate or underestimate their relative position tend to buy more assets than subjects who predict their relative position acurately.

in terms of payoffs for this round.[24]

For the regression, we capture confidence by the rank that the median trader believes to have attained ("median rank belief"). The lower this number, the more confident the group of 10 traders. The respective coefficient in column 3 indicates that the probability of a bubble in the subsequent round increases by 3% if the median person believes that he or she is one rank higher. Indeed confidence, measured by subtracting the actual rank from the predicted rank, affects trading trading behavior. The extreme groups according to this measure (very confident and very unconfident traders) seem to trade more often—see Figure 5.

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

[24]The men in our experiment believe that they are slightly better than they actually are (estimated median rank 30, actual median rank 33) while women underestimate their rank (estimated median rank 36, actual median rank 26.5); the difference in confidence between women and men is significant at any conventional level (a MWU-test rejects equality at $p = 0.0001$).

to repeated experience in the same market and with the same traders. When we aggregate over all treatments, we find that there are 2 market bubbles in the first round, 9 market bubbles in the second round, and 8 market bubbles in the 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 9 mirages in round 1, 12 in round 2, and 20 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 amongst 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 informed trader, in contrast, an informed trader can patiently wait to exploit his informational advantage (see Section 4.5).

4.2 Why is chat counterproductive for bubble formation?

The Chat–Hypothesis that communication should be conducive to bubble formation is clearly rejected by the data. What could account for this? There are at least two ways in which chat may prevent bubbles. Chatters may point out overvalued market situations to other traders. And chatters may explain

Table 4: 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.

the mechanics of the market to others. We find anecdotal evidence for both types of communication.[25]

Before analyzing the content of chat messages, we present in Table 4 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 bubble 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.

Market bubbles may occur if 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

[25]Chat may also prevent bubbles by giving subjects something to do rather than trading when they should not. However, we find no significant relationship between the number of chat messages a subjects sends and the number of his trades.

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 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 indeed happened 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 asset, 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 to this effect 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.

4.3 Confusion or speculation?

An important question with respect to 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 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 these predictions for all 5 assets at "noon" of days 4, 6, and 8. Thus, for each round we have

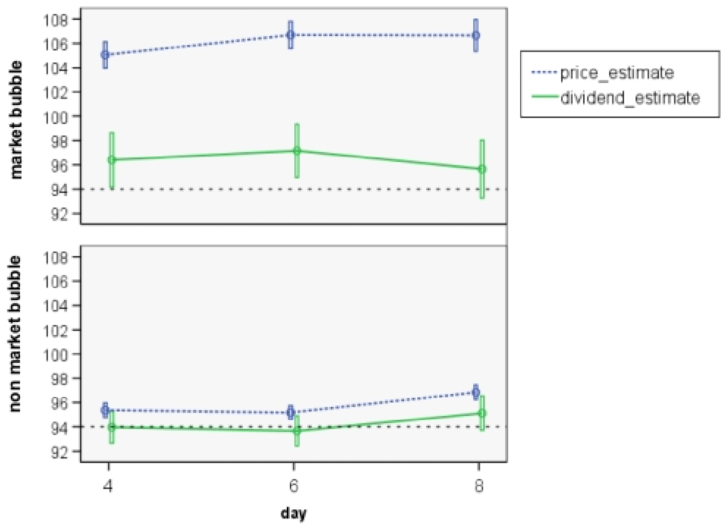

Figure 6: Predictions of prices and final dividends in market bubble and non-market bubble rounds

Note: Data is averaged over rounds, sessions, and treatments; vertical bars show 95% confidence intervals; the price prediction is for the end of the trading day.

up to three predictions per subject.[26]

Figure 6 shows the average predictions of subjects in all treatments separately for rounds in which a market bubble occurred and for rounds in which no 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 at the end of a round.[27]

[26]The 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.

[27]Bianchi and Jehiel (2007) provide a theoretical model in which bubbles occur although all traders are aware of being in a bubble. The reason is that traders differ in their ability to forecast the end of the bubble. In an experimental study, Haruvy et al. (2007) show that crashes are rarely anticipated correctly by subjects in early rounds.

4.4 Prices and the revelation of information

Does information eventually get revealed through prices? This question is at the heart of the literature on rational expectations and the informational role of prices. On the one hand, game–theoretical models would predict a No-Trade Theorem to hold. On the other hand, in a fully revealing rational expectations equilibrium (REE) all information in the market gets revealed through prices. Finally, market microstructure models with an informed trader (see, in particular, Kyle, 1985) predict that eventually, at the end of the trading period, information is fully revealed.[28] Over time, information is gradually being incorporated into prices at a constant rate.

In Table 5, 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 fact. The row "info about supplement" indicates whether information about supplements has been available in the respective round ($x \neq 0$) or not ($x = 0$). Positive numbers indicate that it has been known that the asset had the respective supplement. For example, the column with $x = 80$ contains predictions and actual prices about assets that were known to have a supplement of 80. Negative numbers indicate that it was known that the asset would not have the respective supplement. For example, the column with $x = -80$ contains predictions and actual prices about assets that were known not to have a supplement of 80. The REE predictions were explicitly explained to subjects through examples before the experiment (see appendix). Table 5 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. With a

[28]See however the static model of Kyle (1989) in which information is never fully revealed.

Table 5: 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

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

supplement of 40, final prices do not differ by much from the no-information expected value of 94 but the small number of observations does not allow definite conclusions. 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. The following is particularly noteworthy: if there is information that a specific asset has a supplement, the price of the remaining assets is not low enough. 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. Alternatively, he may trade first in other assets to draw the attention of traders away from the asset about which he is informed. In this section, we shall have a closer look at the tactics employed by informed traders.

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 the 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 7 shows the informed traders' portfolio for different trading dates. 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 7 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 7 shows that this indeed occurred when insiders knew that the four assets did not 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 above the value expected

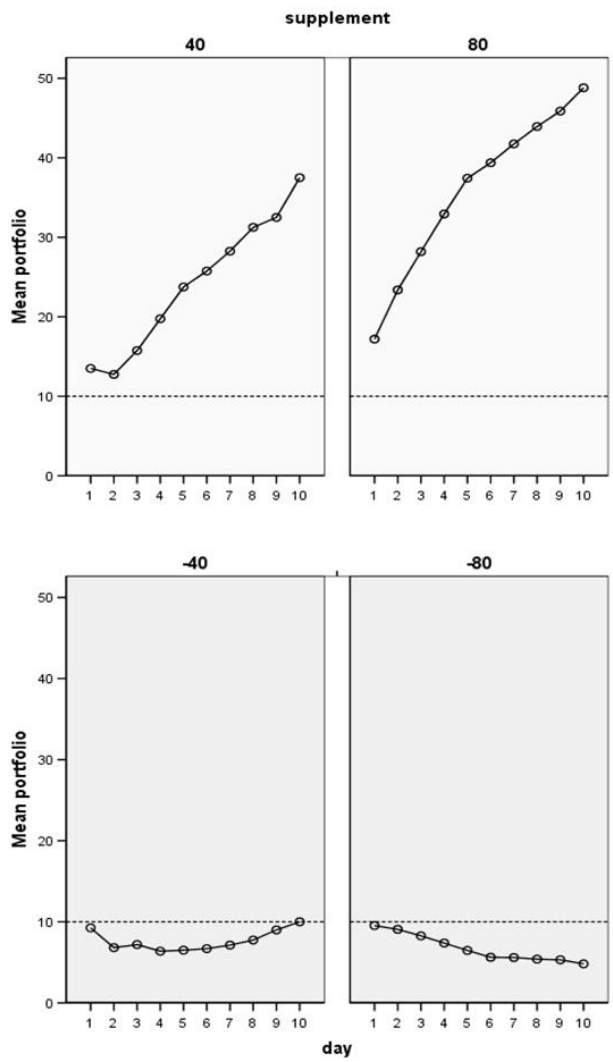

Figure 7: Evolution of average holdings by insiders of the asset insiders were informed about (upper two panels) and of the average holding of the remaining 4 assets (lower two panels)

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

by an insider (see Table 5).

Figure 8 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, they feel the need to place higher and higher bids. That is consistent with the Revelation–of–Information–Hypothesis and the Kyle (1985) model as prices seem to gradually incorporate the information.[29] 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 9 shows the average number of limit bids per day per asset. The right panel shows average number of bids by informed traders for the asset they are informed about ("insider assets"). The left panel shows the same for all other assets by all traders. 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 intuitively makes 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.

[29]In a slightly different experimental setting, this results is also described by Schnitzlein (1996).

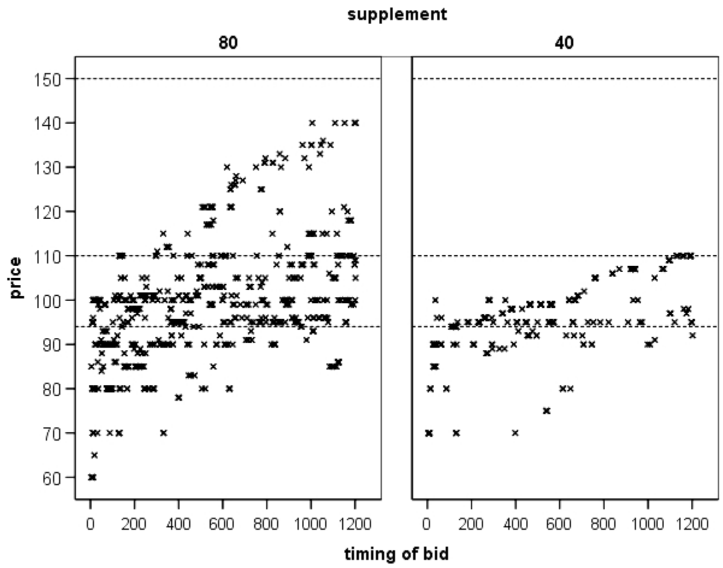

Figure 8: Timing (in seconds) and prices of limit bids by insiders to buy insider assets.

Data are averaged over rounds, sessions, and treatments; dotted lines denote fundamental values without information (94), with information about 40-supplement (110), and with information about 80-supplement (150), respectively.

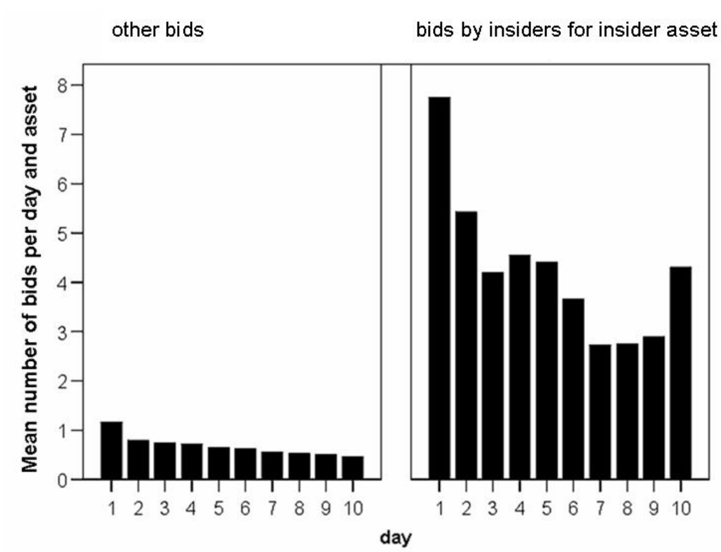

Figure 9: Number of limit bids per day per asset for insider assets by insiders (right panel) and for other assets by all traders (left panel).

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 informed trader 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 informed trader 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 Table 6 in the 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. The maximal possible informational rent amounts to 4,389 Taler of which insiders only capture 1,126 Taler or 31.3%.

5 Conclusion

In this paper, we report results on an experiment designed to test which ingredients drive bubbles in asset markets. Existing studies (following the design of Smith et al., 1988) find substantial bubbles but only in the presence of a declining fundamental value. Furthermore, these bubbles disappear when subjects have some experience. Our experiment extends this literature in a new direction. We examine here the ingredients that foster bubble formation when the fundamental value is constant. Consistent with the literature we find virtually no bubbles when additional ingredients are missing (NOINF treatment). From our results, we learn that the possible presence of inside information increases the likelihood of bubble formation. There are market bubbles and mirages in almost 2/3 of rounds when someone might be informed (INF treatment). An additional benefit compared to existing studies is that our multiple asset model makes it harder for subjects to learn: there is no indication that bubbles disappear with experience. Arguably, this is typical for real financial markets, where at one time a bubble occurs in internet stocks, at another time bubbles may occur in solar energy stocks or in the housing market. In line with most studies, we find a significant effect of overconfidence on the formation of bubbles: the higher median over in a group, 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 to the level of our treatment without inside information (NOINF). We suggest some hypotheses why this may the case, but clearly further research is needed to study this unexpected effect. In particular, it could be investigated whether chat that is addressed to some traders privately has a different effect from the public chat in the current experiment.

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 of 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. At the end of a round, prices reveal fairly well the identity of assets endowed with a supplement, which is consistent with the rational expectation equilibrium. On the other hand, prices insufficiently adjust downwards when it should be known that an asset does not carry a supplement.

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Appendix A: 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 quite 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 IN-

FCHAT 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 $70 + (80 + 0 + 0 + 0)/4 = 90$.

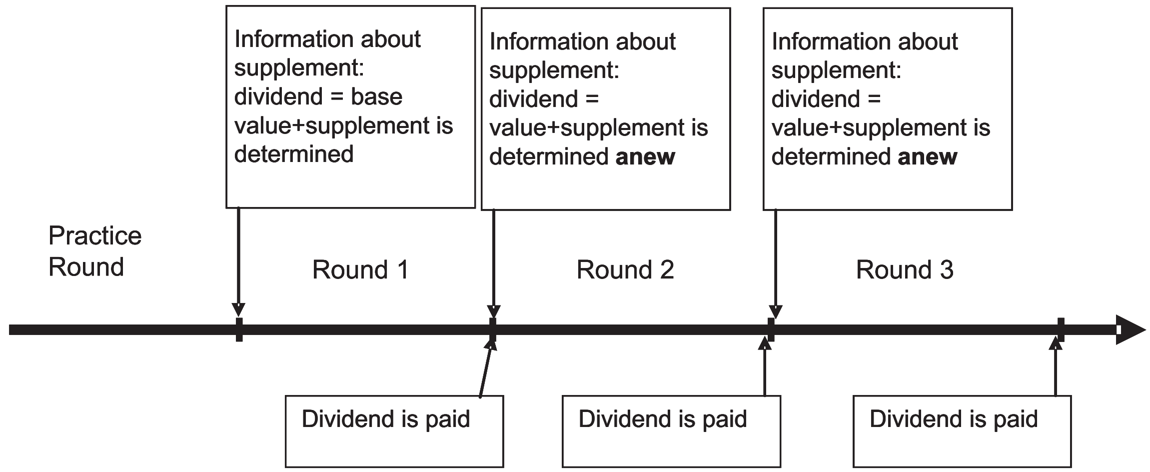
If you know that a given asset receives a supplement of 80 Taler but you don't know which asset gets a supplement of 40 Taler, then the expected dividend...

... 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:



[Information about supplements not for NOINF]

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.

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.

Appendix B: Additional tables

Table 6: 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.

There is a large number of alternative bubbles measures that have been used in the literature (see e.g. Dufwenberg et al., 2005; Haruvy et al., 2007; Van Boening et al., 1993). The following definitions were calculated for each round and then averaged over treatments, where $\bar{p}_t$ denotes the price index (= average of median daily prices), f the fundamental value (in our case 94 for the price index), and t the trading day.

- amplitude
$$\max_t \frac{\bar{p}_t - f}{f} - \min_t \frac{\bar{p}_t - f}{f}$$
- total dispersion: $\sum_t |\bar{p}_t - f|$
- quadratic deviation: $\sum_t (\bar{p}_t - f)^2$
- average bias: $\sum_t (\bar{p}_t - f) /(\#\text{ of periods})$
- turnover: # of trades per session / total number of stocks outstanding

- normalized deviation: $\sum_i |p_i - f| /$(total number of stocks outstanding), where the sum is taken over all transactions i at asset prices p_i. Here, f refers to the fundamental value of the respective asset.

Table 7: Other bubble measures

measure			
	NOINF	INF	INFCHAT
amplitude	0.10	0.18	0.13
total dispersion	62.4	92.4	58.0
quadratic deviation	734	1687	687
average bias	5.57	7.87	3.22
turnover	3.17	3.02	2.49
normalized deviation	27.12	59.43	44.87

Table 8: Frequency of bubbles depending on duration

# of bubbles	if lasting at least 2 days			if lasting at least 4 days		
bubble type	NOINF	INF	INFCHAT	NOINF	INF	INFCHAT
mirages	n.a.	33	15	n.a.	13	7
market bubble	5	15	3	4	7	3
asset bubble	(0)	4	0	(0)	1	0
# of bubble rounds						
bubble type	NOINF	INF	INFCHAT	NOINF	INF	INFCHAT
mirages	n.a.	14 / 18	8 / 18	n.a.	9 / 18	4 / 18
market bubble	3	10 / 18	2 / 18	2 / 18	4 / 18	2 / 18
asset bubble	(0 / 18)	3 / 18	0 / 18	(0 / 18)	1 / 18	0 / 18

A mirage or bubble is counted as such if the respective price deviation is observed for at least 2 or 4 consecutive trading days, respectively. Only positive bubbles counted.

Table 9: Frequency of positive and negative bubbles

# of bubbles			
bubble type	NOINF	INF	INFCHAT
mirages	n.a.	23	8
market bubble	4	14	3
asset bubble	(0)	5	0
# 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

Note: A mirage or bubble is counted as such if the respective price deviation is observed for at least 3 consecutive trading days. A negative bubble is defined as median prices below 80 (the fundamental value when it is known that the asset does not carry the 80 supplement).