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Thar She Bursts – Reducing Confusion Reduces Bubbles.

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Abstract

To explore why bubbles frequently emerge in the experimental asset market model of Smith, Suchanek & Williams (1988), we vary the fundamental value process (constant or declining) and the cash-to-asset value-ratio (constant or increasing). We observe high mispricing in treatments with a declining fundamental value, while overvaluation emerges when coupled with an increasing C/A-ratio. A questionnaire reveals that the declining fundamental value process confuses subjects, as they expect the fundamental value to stay constant. Running the experiment with a different context ("stocks of a depletable gold mine" instead of "stocks") significantly reduces mispricing and overvaluation as it reduces confusion.

JEL: C92, D84, G10

Keywords: Experimental economics, asset market, bubble, market efficiency, confusion

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We explore possible causes for the emergence of "bubbles" in experimental asset markets replicating the seminal design introduced by Vernon L. Smith, Gerry L. Suchanek & Arlington W. Williams (1988, henceforth SSW). In particular, we separate the effect of a declining/constant fundamental value (FV) from the effect of an increasing/constant cash-to-asset-value-ratio (C/A-ratio).[1] We observe that confusion in treatments with declining fundamental value is the main driver for mispricing and leads to overvaluation when coupled with a high C/A-ratio.[2] This is supported by findings from a questionnaire and from two control treatments where the notion "stocks" is replaced by "stocks of a depletable gold mine". This change in context reduces subjects' confusion about the FV (elicited by a questionnaire) and leads to significantly smaller mispricing and overvaluation. The design is robust to treatment changes like a higher variance of the dividend process and a higher initial C/A-ratio that have rekindled bubbles in earlier experiments.

In 1988, Smith, Suchanek & Williams (1988) introduced a new and groundbreaking methodology to test the efficient market hypothesis (EMH) postulated by Eugene F. Fama (1970). While empirical studies testing the EMH suffer from the FV being unobservable, fundamentals become perfectly observable in laboratory asset markets. SSW define the FV as the expected value of a finite stream of stochastic dividend payments generating a FV that *declines deterministically.* The key finding of SSW is that market prices deviate strongly from the FV, with prices being mostly too high – the authors talk of bubbles. Over the past two decades numerous studies have replicated and modified this setting, exploring how parameter changes, such as short selling, experience, futures markets, constant fundamental value, etc. influence bubble formation.[3]

When investigating the properties of SSW-markets in more detail, one observes that the amount of cash grows due to dividend payments, while the FV of the asset declines to zero. Thus, the C/A-ratio in the market increases several fold over the course of the experiment.[4] Hence, SSW-markets are characterized by a declining FV combined with an increasing C/A-ratio over time.[5]

[1] The C/A-ratio is the ratio of all subjects' cash holdings and the total asset value, i.e. number of shares outstanding multiplied by FV.

[2] Overvaluation is present when average prices are above the respective fundamental value (FV). Mispricing measures deviations of prices from FVs, irrespective whether they are positive or negative. Here we follow Thomas Stöckl, Jürgen Huber & Michael Kirchler (2010) and measure mispricing by Relative Absolute Deviation (RAD) and overvaluation by Relative Deviation (RD).

[3] Ernan Haruvy & Charles N. Noussair (2006) investigate the impact of short-selling and buying on margin. Mark Van Boening, Arlington W. Williams & Shawn LaMaster (1993) use call markets instead of continuous double auction markets, while Vivian Lei, Charles N. Noussair & Charles R. Plott (2001) add a parallel market with a short-term asset that exists only for one period. Vernon Smith, Mark van Boening & Charissa P. Wellford (2000), Charles N. Noussair, Stephane Robin & Bernard Ruffieux (2001), and Jörg Oechssler, Carsten Schmidt & Wendelin Schnedler (2007) keep the FV constant over time. Lei, Noussair & Plott (2001) preclude speculation by prohibiting buyers to resell the asset and sellers to buy it. In most of the aforementioned studies, bubbles still emerge. Instead, bubbles are less pronounced with experienced subjects trading in the same setting, and when special emphasis is put on a thorough understanding of the dividend process. This is reported in Martin Dufwenberg, Tobias Lindqvist & Evan Moore (2005) and Vivian Lei & Filip Vesely (2009), respectively.

[4] In most settings the C/A-ratio increases by a factor of 15 to 50.

[5] Although unexplainable from a rational expectations perspective, Gunduz Caginalp, David Porter & Vernon Smith (1998), Gunduz Caginalp, David Porter & Vernon Smith (2001), and Haruvy & Noussair (2006) report that high initial C/A-ratios drive bubble formation in experimental asset markets. Given these behavioral findings and the dramatic increase in the

We separate the effect of a declining/constant FV from the effect of an increasing/constant C/A-ratio to provide explanations for the impact of each variable on mispricing and overvaluation. With a 2x2 design we test for each factor's impact, as, in addition to the replication of experiments with a declining FV and an increasing C/A-ratio and experiments with a constant FV and a constant C/A-ratio, we introduce one treatment with a declining FV and a constant C/A-ratio and one treatment with a constant FV and an increasing C/A-ratio. Table 1 provides an overview of the 2x2 design and related papers.

Table 1: Overview over the two treatment variables "C/A-ratio" and "Fundamental value" (FV) and related literature. For two of the four quadrants no experiments have been conducted before.

		Fundamental value (FV)	
		declining	constant
C/A-ratio	increasing	literature available[a]	no literature
	constant	no literature	literature available[b]

[a] See e.g. Gunduz Caginalp, David Porter & Vernon Smith (2000); Caginalp, Porter & Smith (2001); Dufwenberg, Lindqvist & Moore (2005); Haruvy & Noussair (2006); Ernan Haruvy, Yaron Lahav & Charles Noussair (2007); Reshmaan N. Hussam, David Porter & Vernon L. Smith (2008); Charles N. Noussair & Steven Tucker (2006); Smith, Suchanek & Williams (1988); Smith, van Boening & Wellford (2000), A2; Matthias Sutter, Jürgen Huber & Michael Kirchler (2010).

[b] See e.g. Caginalp, Porter & Smith (1998); Noussair, Robin & Ruffieux (2001); Oechssler, Schmidt & Schnedler (2007); Smith, van Boening & Wellford (2000), A1.

We observe (i) high mispricing in treatments with declining FVs and (ii) overvaluation when a declining FV is coupled with an increasing C/A-ratio. A questionnaire reveals that (iii) the concept of a declining fundamental value generates confusion among subjects, with most subjects believing the FV to either stay constant or increase. (iv) In two control treatments with the context "stocks of a depletable gold mine" we find significantly smaller mispricing and overvaluation than in the comparable treatment using the term "stocks". This holds even when the variance of the dividend process and the initial C/A-ratio are increased several fold. This points to the importance confusion about the FV plays in bubble formation.

The paper is structured as follows: Section 1 outlines the research questions and methodology, Section 2 provides details on market design, experimental treatments, and experimental implementation. Section 3 presents results from the experiments and Section 4 discusses the results and concludes.

C/A-ratio over time in markets with declining FVs the C/A-ratio was chosen as one of the two treatment variables in this study.

1 Research Questions and Methodology

1.1 Research Questions

Exploring possible causes of bubbles Smith, van Boening & Wellford (2000) investigate the impact of dividend timing on asset prices. In their Treatment A1 the asset pays a random dividend at the end of the experiment, while in A2 dividends are paid out each period. The former model leads to a constant FV with a constant C/A-ratio while the latter is the classic SSW-design with a declining FV and an increasing C/A-ratio. The authors conclude that frequent dividend payments in Treatment A2 induce bubble formation in comparison to A1 where no bubbles occur. These findings serve as starting point for Noussair, Robin & Ruffieux (2001) who conjecture that (i) frequent dividend payments increase the likelihood of bubbles and that (ii) changing (declining) FVs contribute to bubble formation, as prices need to adjust to the FV each period. They combine per period dividend payments (with an expected value of zero) with a constant FV (the asset is bought back at the end of the experiment at an ex-ante known terminal value). Reporting moderate bubbles, they argue that a constant FV cannot eliminate bubbles completely. Again, the authors name frequent dividend payments as the main driver of bubble formation.

However, comparing treatments A2 to A1 in Smith, van Boening & Wellford (2000), and the studies of Smith, Suchanek & Williams (1988) to Noussair, Robin & Ruffieux (2001) is problematic, since two parameters are changed simultaneously: The FV is constant, rather than declining and the C/A-ratio changes from increasing to constant. Consequently, it is impossible to exactly identify whether the larger bubbles in Smith, Suchanek & Williams (1988) and in A2 of Smith, van Boening & Wellford (2000) are due to a declining FV, an increasing C/A-ratio, or both. With a 2x2 design we examine changes in each factor (FV-process and C/A-ratio) separately. We formulate the following research questions:

- RQ1: Does an increasing C/A-ratio lead to mispricing and/or overvaluation?
- RQ2: Does a declining fundamental value lead to mispricing and/or overvaluation?

If the increasing C/A-ratio proved to be the main driver of mispricing and/or overvaluation, the results of Smith, van Boening & Wellford (2000) would be supported.

However, if the declining FV turned out to be the main driver, we focus on behavioral explanations, especially the influence of the experiment's context and potential confusion of experimental subjects. Two recent papers, Eileen Chou, Margaret McConnell, Rosemarie Nagel & Charles R. Plott (2009) and Vernon L. Smith (2010), stress the importance of context (the former talk of "recognition") in laboratory experiments. The latter argues that subjects interpret the task they face in an experiment against the background of their past experiences and personal knowledge. Summarizing his experiences with markets of the SSW-type, Smith outlines that subjects seem to be "*confused*", and that they "*do not get the message*" (p. 6 and 7, respectively, in Smith 2010). Following a similar line of reasoning, Jörg Oechssler (2010) argues that the SSW-design is very different from real markets and may therefore be difficult to understand for subjects. Consequently, we conjecture that the term "stock" used in the instructions confuses subjects as it is commonly associated with stable or upward trending prices (Smith 2010, p. 6, talks of a "*homegrown expectation of prices rising*"), in contrast to the deterministically declining FV-paths in the experiment.[6]

- RQ3: If a declining fundamental value significantly contributes to mispricing and/or overvaluation, is confusion, i.e. the lack of understanding the FV-concept, evident?

To test this research question, we run a questionnaire after each experiment on the understanding of the FV process and we conduct two control treatments where we change one paragraph in the instructions, talking of "stocks of a depletable gold mine" rather than "stocks" in general.

1.2 Measuring Mispricing and Overvaluation

Stöckl, Huber & Kirchler (2010) point out some weaknesses of previously used bubble measures. Following them, we apply one measure for "mispricing" and one for "overvaluation".

Table 2: Bubble measures: *RAD* (relative absolute deviation) and *RD* (relative deviation).

Measure	**calculation**
Relative absolute deviation	$RAD = \frac{1}{N}\sum_{p=1}^{N} \lvert\overline{P_p} - FV_p\rvert / \lvert\overline{FV}\rvert$
Relative deviation	$RD \;\; = \frac{1}{N}\sum_{p=1}^{N} (\overline{P_p} - FV_p) / \lvert\overline{FV}\rvert$

Notes: P_p = (volume-weighted) mean price in period p; FV_p = fundamental value in period p; $\overline{FV}$ = average fundamental value of the market.

Table 2 outlines details on the two measures we apply: RAD (relative absolute deviation) for mispricing and RD (relative deviation) for overvaluation. The resulting numbers of RAD and RD are easy to interpret − a RAD of 0.1 means that prices on average differ by 10 percent from the average fundamental value. RD provides additional information whether the asset is overvalued − e.g., with a RD of 0.1 (−0.1) prices are on average 10 percent higher (lower) than the average fundamental value. A combination of RAD=0.1 and RD=0 indicates that prices are on average 10 percent off the fundamental value, but phases of over- and undervaluation cancel out. In this case, mispricing would be present, but non-systematic as far as its direction is concerned.[7]

[6] Literature already provides hints that subjects may have difficulties in understanding the concept of a declining FV in the SSW-design: Lei & Vesely (2009) put special emphasis on the protocol of the experiment and report that no bubbles emerge when they introduce a pre-market phase to focus subjects' attention on the dividend structure. The results in Dufwenberg, Lindqvist & Moore (2005) can be interpreted in a similar way, since experience in repeated SSW-markets with identical settings, and thus a better understanding of the process governing the FV, eliminates bubbles. Note however, that experience only reduces bubbles when the setting remains unchanged. Hussam, Porter & Smith (2008) provide evidence that even among experienced subjects bubbles can be rekindled when the initial C/A-ratio and the variance of the dividend process are increased several fold.

[7] We additionally include results of some of the more familiar measures used in earlier

2 The Experiment

In each of our laboratory markets, ten subjects trade a dividend paying stock for experimental currency (Taler) in a sequence of ten periods. Dividends are paid out at the end of each period or are deferred and paid out at the end of the experiment. The realized dividend payments are not known in advance, but at the end of each period subjects learn the dividend of the respective period.

To determine the asset's FV, subjects know the possible dividend realizations, their probability of occurrence, the total number of trading periods, and the terminal value of the asset (if any).

$$FV_k = E(\text{dividend}) \cdot \text{remaining periods} + \text{terminal value}. \qquad (1)$$

Given this information set, the FV in period k is the product of the expected dividend payment per period and the number of periods remaining plus any terminal value (zero in SSW). This is public knowledge (see experimental instructions in Appendices D, E, and F).

2.1 Markets with a Declining Fundamental Value

In markets with a declining FV, the dividend is either 0 or 10 with equal probability. The FV in period 1 is therefore 50 and decreases by 5 Taler each period. After ten periods the asset expires worthless, no terminal value is paid to subjects.

2.2 Markets with a Constant Fundamental Value

In markets with a constant FV the dividend per period is either –5 or 5 with equal probability. Thus, dividends have an expected value of zero. In these treatments assets have a positive terminal value of 50. Hence, the FV is constant across periods with a value of 50.

2.3 Experimental Treatments

At the beginning of each experimental session half of the subjects is endowed with 60 shares and 1,000 Taler, while the other half is endowed with 20 shares and 3,000 Taler. Valued at the initial FV of 50, which is identical in all treatments, each subject starts with an initial wealth of 4,000 Taler. At the beginning of each market the total cash amount in the market (5·1,000 + 5·3,000 = 20,000 Taler) equals the value of all stocks in the market (5·20 + 5·60 = 400 stocks · 50 Taler = 20,000 Taler). Thus, the initial ratio between cash and asset value (the C/A-ratio) is 1.[8]

We implement a 2x2 design with the treatment variables FV (either constant or declining) and C/A-ratio (either constant or increasing). Table 3 presents an overview of the different treatment abbreviations and properties. The treatment abbreviations are to be read as follows: The symbols "╲" and "—" specify

studies on the SSW-model, like share turnover (ST), price amplitude (PA), total dispersion (TD), and average bias (AB) in Table A2 of the Appendix. See Table A1 for details on the formulae.

[8]Different values are used in round 2 of Treatment T6(╲$+_{\text{G\_re}}$).

whether the FV is declining or constant. "=" and "+" indicate whether the C/A-ratio is constant or increasing.[9]

Table 3: Treatment parameterization

	T1($\searrow$+)[a]	T2(—+)	T3($\searrow$ =)	T4(— =)	T6($\searrow$+$_{G\_re}$), R2
Exp. dividend	5	0	5	0	6
Periods	10	10	10	10	10
FV_0	50	50	50	50	60
FV_{10}	0	50	0	50	0
# Stocks	400	400	400	400	200
Total asset value$_0$	20,000	20,000	20,000	20,000	12,000
Initial cash	20,000	20,000	20,000	20,000	40,000
Cash in/outflow	2,000	+	-2,000	0	1,200
Dividend account	no	yes	yes	yes	no
Source of in/outflow	dividend	exogenous cash inflow	saving account	no cash inflow	dividend
FV process	$\searrow$	—	$\searrow$	—	$\searrow$
C/A-ratio	+ (1-19)	+ (1-19)	= (1)	= (1)	+ (3.33-42.33)

[a] The parametrization is identical in T5($\searrow$+$_G$) and in round 1 (R1) of T6($\searrow$+$_{G\_re}$).

The first treatment, T1($\searrow$+), replicates the classic experiment of the SSW–type with declining FV and increasing C/A-ratio. Dividend payments generate frequent inflows of cash into the market, which increases the available cash in the market on average by 2,000 (either 0 or 4,000 with equal probability) in each period.[10] Over the course of the experiment the "monetary basis" therefore doubles. This increase in cash is accompanied by a declining fundamental value, which falls by 90 percent from period 1 to the start of period 10. Thus, the C/A-ratio increases nineteenfold over the course of the experiment.[11]

Treatment two, T2(—+), is designed with a constant FV and an identical increase in the C/A-ratio as in T1($\searrow$+). Subjects receive increasing exogenous cash inflows in each period which mimic the development of the C/A-ratio in T1($\searrow$+). This requires quite substantial cash inflows in each period – e.g. the cash inflow into the market is 200,000 in the last period. Dividends are collected in a separate dividend account.

In the third treatment, T3($\searrow$ =), characterized by a declining FV and a constant C/A-ratio, dividend payments are displayed, but collected in a separate account and paid out at the end of the experiment. However, this would still lead to a tenfold increase in the C/A-ratio until period 10, as the FV falls by 90 percent. Consequently, we additionally reduce the monetary basis by deducting 200 Taler from each subject's cash account at the end of each period. If a subject has less than 200 Taler, her money holdings become negative and she is not

[9] Table A4 in Appendix C provides further details on each treatment.

[10] In SSW-markets dividend yields are extremely high, starting at 10 percent in the first period of a 10-period setting and reaching 33, 50, and 100 percent, respectively, in the last three periods. In real markets, however, dividend yields are very low – the dividend yield of stocks on the NYSE is currently around 2 percent, and even lower at 0.49 percent on NASDAQ, where 73 of the top-100 companies did not pay any dividend in 2007. Only one third of companies listed on NYSE pay dividends. Source: http://www.indexarb.com.

[11] Smith, Suchanek & Williams (1988) use different parameters. E.g. in their treatment "Design 1" (9 traders, 30 periods) they implement a C/A-ratio in period 1 of 1.2 which increases to 48.9 in period 30.

allowed to buy assets or post bids until her money holdings are positive again. Therefore, the C/A-ratio of 1 remains constant over time, as the "monetary basis" in the market is reduced by 90 percent from period 1 to period 10 as well.

Treatment four, T4(— =), features a constant FV and a constant C/A-ratio. Dividends are collected in a separate dividend account.

Treatment five, T5($\searrow +_{\mathrm{G}}$), is an exact replication of T1($\searrow +$). We only change one paragraph in the instructions, talking of "stocks of a depletable gold mine" rather than "stocks."

Treatment six, T6($\searrow +_{\mathrm{G\_re}}$), serves as a robustness check for T5($\searrow +_{\mathrm{G}}$) and is inspired by Hussam, Porter & Smith (2008) who rekindled bubbles with twice-experienced subjects by increasing the C/A-ratio and the variance of the dividend process. The treatment consists of two rounds (R1 and R2) of ten periods each. The first round is an exact replication of Treatment T5($\searrow +_{\mathrm{G}}$). In the second round the number of stocks is reduced, while both, cash holdings and the variance of the dividend process are increased.[12]

2.4 Market Architecture

Subjects trade in a continuous double auction with open order books with all orders executed according to price and then time priority. Market orders have priority over limit orders and are always executed instantaneously. Any order size and the partial execution of limit orders are possible. Shorting stocks and borrowing money is not allowed.

The trading screen provides subjects with current information on their stock and Taler holdings. All transaction prices with the corresponding trading time are shown in a real time chart on the left side of the screen.[13] Each market consists of 10 trading periods of 120 seconds each. Taler and stock holdings are carried over from one period to the next. No interest is paid on Taler holdings and there are no transaction costs.

2.5 Experimental Implementation

Six markets were run for each of the six treatments. All 36 experimental markets were conducted between December 2009 and October 2010 at the University of XY with a total of 360 students (bachelor and master students in business administration and economics). Most subjects already took part in other experiments in economics but each subject participated in only one market of this study. We especially took care that the subjects did not participate in earlier asset market experiments of comparable design. The markets were programmed and conducted with z-Tree 3.2.8. by Urs Fischbacher (2007). Subjects were recruited using ORSEE by Ben Greiner (2004).

At the beginning of each session subjects had 15 minutes to read the instructions on their own. This was done to eliminate any possible experimenter bias. We set up the instructions in an identical way to the papers of Dufwenberg, Lindqvist & Moore (2005) for markets with declining FVs, and Noussair, Robin & Ruffieux (2001) for markets with constant FVs to ensure comparability to

[12] Details on the parameters follow in Section 3.3.3.

[13] See Appendix D for a screenshot.

existing literature. Afterwards, the trading screen was explained in detail, followed by two trial periods to allow subjects to become familiar with the trading screen. After the main experiment, subjects had to complete a questionnaire testing their understanding of the FV-process and asking for demographic data.

In markets with a declining FV the traded asset is worthless after the last period. Thus, only Taler holdings are converted at a known exchange rate of 400 Taler = 1 Euro (The exchange rate is 520 in T6($\searrow +_{G\_re}$), R2). In markets with a constant fundamental value, the final wealth (units of the asset multiplied by FV of 50 plus Taler holdings) is converted at an exchange rate of 400 (4000) Taler = 1 Euro in T4(— =) (T2(—+)).

Each session lasted around 60 to 80 minutes and average earnings for treatments T1($\searrow$+) to T5($\searrow +_G$) were 10 Euro while average earnings in Treatment T6($\searrow +_{G\_re}$) were 20 Euro. Before the main experiment we ran a standard lottery experiment to measure risk-aversion similar to Charles A. Holt & Susan K. Laury (2002). Subjects earned on average 4 Euros from the lottery experiment in addition.

3 Results

3.1 Overview

Figure 1 provides an overview of average prices (bold lines with circles), price paths of individual markets (grey lines), and the FVs (bold lines) in treatments T1($\searrow$+) to T4(— =). One can see that treatments with declining FVs are characterized by a high variability of price paths in individual markets. On aggregate, average prices are well above the FV in T1($\searrow$+) while average prices track the fundamental value well in T3($\searrow$ =). In treatments with constant FVs, average prices track fundamentals quiet accurately.

Turning to mispricing (RAD) and overvaluation (RD) one can see patterns in Table 4. In T1($\searrow$+), in which the fundamental value declines and the C/A-ratio increases (top left panel of Figure 1), a RAD of 41.4 percent documents high mispricing and a RD of 29.7 percent marks strong overvaluation. This is in line with earlier literature on the SSW-design. Mispricing still remains high, but overvaluation is no longer present (on average) as soon as the C/A-ratio is kept constant over time in markets with declining fundamental value (bottom left panel of Figure 1, Treatment T3($\searrow$ =)). Due to the constant C/A-ratio of 1 in T3($\searrow$ =), individuals lack the buying power to bid prices up or keep them high when others want to sell. Prices decline along with overall money supply, but confusion about the declining FV-process is still evident in the huge dispersion of prices (measured by RAD).

Table 4: Treatment averages for RAD (relative absolute deviation) and RD (relative deviation).[14]

Treatment	RAD	RD
T1($\searrow$+)	0.414	0.297
T2(—+)	0.079	−0.060
T3($\searrow$ =)	0.306	−0.040
T4(— =)	0.027	−0.027

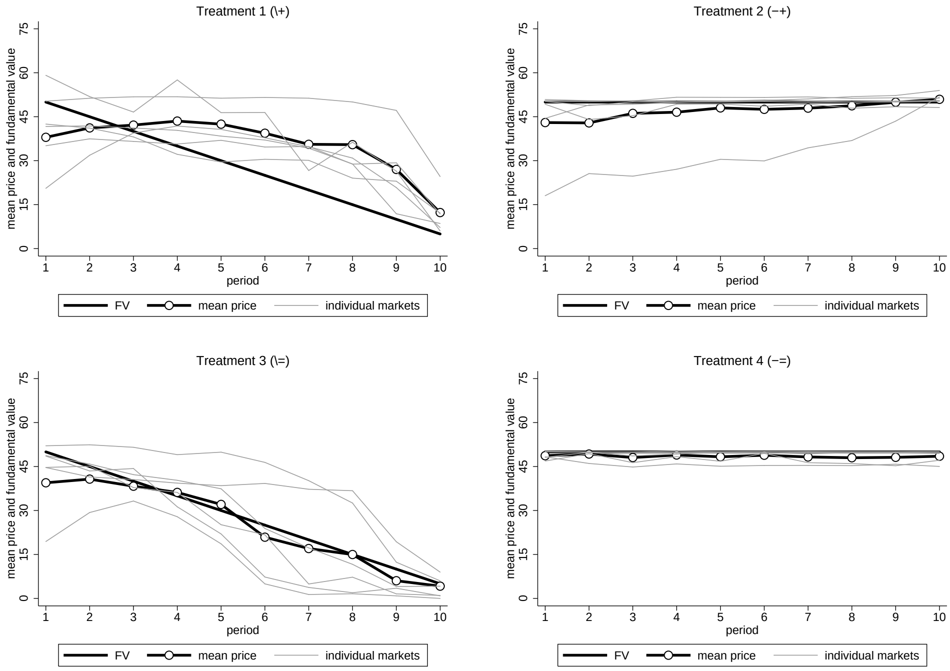

Figure 1: Fundamental value (FV, bold line), average treatment prices (bold line with circles) and volume-weighted mean prices of individual markets (grey lines) as a function of period. Left panels: treatments T1(╲+) and T3(╲ =) featuring declining FVs. Right panels: treatments T2(—+) and T4(— =) with constant FVs.

In contrast, both treatments with constant FVs (right panels in Figure 1) display very efficient prices.

3.2 Statistical Tests on Research Questions 1 and 2

To test for differences between treatments we conduct Mann-Whitney-U-tests. We consider markets with an increasing C/A-ratio (declining FV) and test them against markets with a constant C/A-ratio (constant FV) to answer RQ1 (RQ2). We run this analysis for the pooled data set and for pairwise comparison of treatments. Table 5 provides an overview of the pairwise treatment comparisons to answer the two research questions.

The results are presented in Table 6. It is evident that on aggregate markets with declining fundamental values are characterized by strong mispricing compared to markets with constant FVs as the Z-value of RAD is highly significant with a difference in means of 30.7 percentage points (see line 1 in the bottom

[14]Additionally, we provide, for each market, values of RAD and RD and values of some previously used bubble measures ST, PA, TD, AB in Table A2 in Appendix A.

[15]To test whether results are driven by outliers we run a robustness check by excluding the markets with the highest RAD in each treatment from the analysis. Results do not change (see Table A3 in the Appendix).

Table 5: Overview of the pairwise Mann-Whitney-U-Tests to answer RQ1 and RQ2.

	T1(╲+)	T4(— =)
T2(—+)	RQ2 (FV)	RQ1 (C/A)
T3(╲ =)	RQ1 (C/A)	RQ2 (FV)

Table 6: Tests on the research questions. The values represent the differences in means (Δ mean) of the treatments under investigation and Z-values from a Mann-Whitney-U-Test (Z).[15]

RQ1 (C/A-ratio)		RAD	RD
T1(╲+) & T2(—+) vs T3(╲ =) & T4(— =)	Δ mean	0.080	0.152*
N=24	Z	−0.751	−2.078
T1(╲+) vs T3(╲ =)	Δ mean	0.109	0.337
N=12	Z	−0.801	−1.601
T2(—+) vs T4(— =)	Δ mean	0.052	−0.033
N=12	Z	−0.641	−1.121

RQ2 (FV)		RAD	RD
T1(╲+) & T3(╲ =) vs T2(—+) & T4(— =)	Δ mean	0.307**	0.171*
N=24	Z	−3.753	−1.963
T1(╲+) vs T2(—+)	Δ mean	0.335*	0.357**
N=12	Z	−2.402	−2.882
T3(╲ =) vs T4(— =)	Δ mean	0.278**	−0.014
N=12	Z	−2.882	−0.160

Notes: * and ** represent the 5 percent and 1 percent significance levels.

panel of Table 6). While the results for overvaluation look similar on the aggregate level (with a significant difference of 17.1 percentage points), a closer inspection of Table 6 reveals that overvaluation is very strong in T1(╲+) compared to T2(—+) and T3(╲ =). Though not significant due to the small sample size and the high variance in individual market realizations when comparing T1(╲+) with T3(╲ =), an increasing C/A-ratio in markets with declining FVs seems to be necessary to lead to overvaluation as well.[16]

Summarizing our results so far, we find high mispricing in treatments with declining FV, while overvaluation only emerges when a declining FV is coupled

[16] Risk-averse subjects might act more cautiously in treatments with potentially negative dividend payments (those with a constant FV) compared to treatments with strictly non-negative dividends (those with a declining FV). This would result in less speculation and consequently in lower turnover. Therefore, we run the Mann-Whitney-U-Tests of Table 6 with share turnover (ST) as well as the variable of interest. We find no statistical difference in all specifications, i.e. trading volume is comparable across all treatments. We thank an anonymous referee for pointing us to this idea. See Table A3 in the Appendix for a related analysis.

with an increasing C/A-ratio. This is not in line with Smith, van Boening & Wellford (2000), as frequent dividend payments in treatments with flat FV do not lead to bubbles.

3.3 Research Question 3.: Behavioral Reasons for the Impact of the FV-Process

In a recent paper Vernon Smith states that subjects may be "*confused*" and "*do not get the message*" in SSW-type markets (Smith 2010, p. 6 and 7, respectively). Furthermore, Smith highlights the importance of the context an experiment is presented in. This might be an important factor here: the term "stock" in the instructions may call to subjects' minds associations of stable or upward trending FV-paths – this is supported by the fact that even professional traders produce similar price patterns compared to other subject pools: their daily experience is for stock prices to not fall deterministically and this pattern is called to their mind when they read "stocks" in the instructions (see Oechssler (2010) for a similar line of reasoning and Smith, Suchanek & Williams (1988) for experimental results with professional traders).

To test the impact of context and of subjects' confusion, we run a questionnaire and two control treatments with different context.

3.3.1 Questionnaire

After each experimental session, we ask the following question: "*The fundamental value in period p is 50. What will the fundamental value most likely be in the next period?*" Subjects were asked to choose among values of 40, 45, 50, 55 or 60.[17]

The right panel of Figure 2 provides the distribution of subjects' deviations from the correct forecast in both treatments with constant FVs. Nearly 70 percent estimate the FV correctly and the remaining 30 percent are symmetrically distributed around the correct estimation.

In contrast, in markets with declining FVs (left panel in Figure 2), around 57 percent of subjects expect the FV to remain constant or increase and less than 30 percent of all subjects forecast the FV correctly.[18]

Subjects obviously are confused by the concept of a declining FV, even after having traded in the market for 10 periods. As most subjects in SSW-style markets believe that the FV will stay constant, prices do not fall, producing a "bubble" as the FV declines. This holds especially when an increasing C/A-ratio provides enough liquidity to the market.

3.3.2 Control Treatment with Context "Gold Mine"

If subjects' confusion about the FV-process is the driver behind bubble formation in SSW-markets, a more intuitive context in the instructions should reduce confusion and abate bubbles. Our control treatment T5($\searrow +_G$) is an exact replication of T1($\searrow +$), i.e. the classic SSW-setting, but with a different context used

[17] The questionnaire was not incentivized.

[18] The deviations from the correct forecast of the FV are significantly different between markets with constant and markets with declining FVs, Mann-Whitney-U-test, p-value of 0.000.

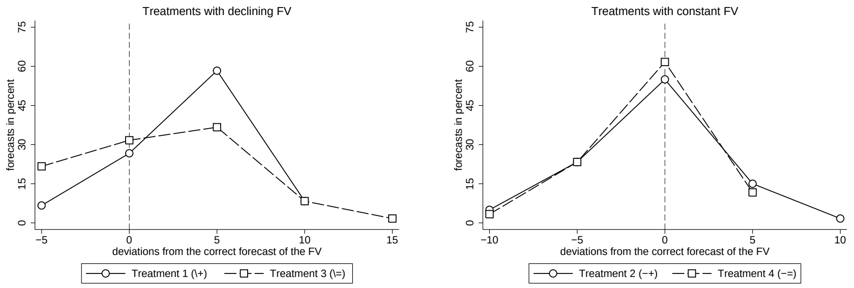

Figure 2: Errors in forecasting the FV in the questionnaire. Left panel: treatments T1($\diagdown$+) and T3($\diagdown$ =) with declining FV. Right panel: treatments T2(—+) and T4(— =) with constant FV.

in the instructions. Instead of "stocks" we label the assets as "stocks of a depletable gold mine". We do this, as we assume that subjects easily grasp that a gold mine can be exploited for a finite time span (e.g. 10 periods), sometimes gold is found (dividend = 10), while in some periods no gold is found (dividend = 0). Specifically, we replace the paragraph in the instructions that explains the FV-process (see Appendix D, fourth paragraph, starting with "At the end of each period...") by the following paragraph:

> *"The stocks are of a depletable gold mine, in which gold is mined for 10 periods. In each period the probability of finding (not finding) gold is 50%. If gold is found in period p, a dividend (profit) of 10 Taler for each unit of the stock will be paid. If no gold is found, the dividend will be zero. After 10 periods the gold mine is depleted and the value of the stock is zero."*

What might seem like a small change, provides subjects with a different context: instead of trading an abstract stock, calling to their minds stock prices following a random walk or trending upwards, they have an easy-to-grasp example of a depletable asset where declining prices supposedly become easier to imagine.

The results, presented in the right panel of Figure 3, show markedly smaller deviations of prices from FVs, compared to T1($\diagdown$+), which is shown in the left panel. RAD (0.16) and RD (-0.07) in T5($\diagdown +_{\mathrm{G}}$) are significantly smaller than the respective values in T1($\diagdown$+), demonstrating that the minor change in the instructions is sufficient to significantly reduce mispricing and overvaluation (Mann-Whitney-U-Test, p-values of 0.025 and 0.004 for RAD and RD, respectively). Further evidence that subjects' confusion about the declining FV is reduced in T5($\diagdown +_{\mathrm{G}}$) compared to T1($\diagdown$+) is given in the bottom right panel of Figure 3. In particular, 55 percent of subjects answered the questionnaire correctly, compared to 28 percent in T1($\diagdown$+) (bottom left panel).[19]

[19] The deviations from the correct forecast of the FV are significantly different between T1($\diagdown$+) and T5($\diagdown +_{\mathrm{G}}$), Mann-Whitney-U-test, p-value of 0.009.

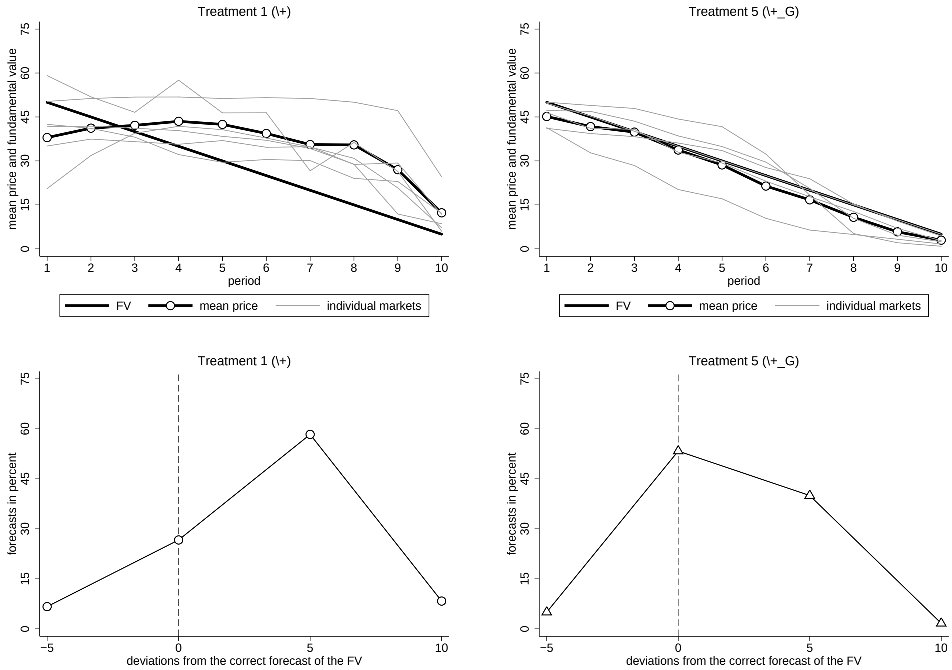

Figure 3: Fundamental value (FV, bold line), average treatment prices (bold line with circles) and volume-weighted mean prices for individual markets (grey lines) as a function of period (top panels). Errors in forecasting the FV in the questionnaire (bottom panels). Left panels: treatment T1($\diagdown+$). Right panels: treatment T5($\diagdown+_{\mathrm{G}}$).

3.3.3 Robustness Check: Rekindling Bubbles in the Control Treatment with Context "Gold Mine"

Treatment T6($\diagdown+_{\mathrm{G\_re}}$) serves as a robustness check for Treatment T5($\diagdown+_{\mathrm{G}}$). We increase both the C/A-ratio and the variance of the dividend process of T5($\diagdown+_{\mathrm{G}}$), as these changes in the parameters rekindled bubbles even among twice-experienced subjects in Hussam, Porter & Smith (2008).[20] In particular, the six markets of Treatment T6($\diagdown+_{\mathrm{G\_re}}$) consist of two rounds of ten periods each. The first round is an exact replication of Treatment T5($\diagdown+_{\mathrm{G}}$) with inexperienced subjects. In the second round these once-experienced subjects face a very different setting. They are randomly shuffled into new cohorts of ten traders each, the number of stocks in the market is reduced by 50%, the amount of cash is doubled and the variance of the dividend process is multiplied by a factor of 2.44. In particular, the dividend in each period is drawn from the realizations 0, 1, and 17 with equal probabilities, which increases the expected dividend from 5 to 6 and the variance from 25 to almost 61. Consequently, the FV declines from 60 to zero towards the end of round 2.

[20]We thank one referee for pointing us to this idea. We set up this robustness check in an almost identical way to the "rekindle" experiments in Hussam, Porter & Smith (2008).

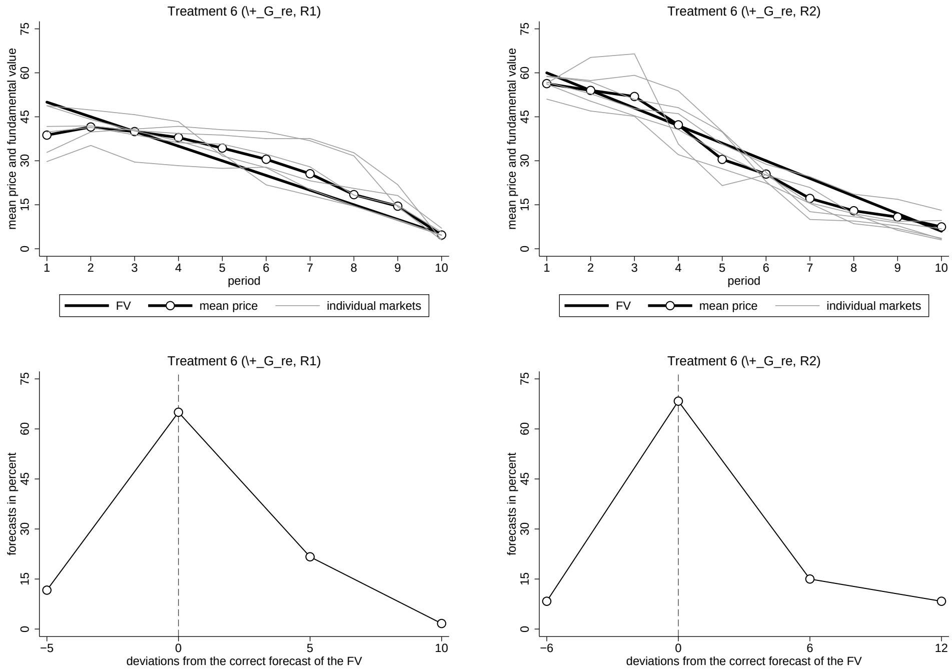

Figure 4: Fundamental value (FV, bold line), average treatment prices (bold line with circles) and volume-weighted mean prices for individual markets (grey lines) as a function of period (top panels) of the robustness check T6($\diagdown+_{\mathrm{G\_re}}$) (top panels). Errors in forecasting the FV in the questionnaire of T6($\diagdown+_{\mathrm{G\_re}}$) (bottom panels). The left plots present results for the first round (R1), the right ones those for the second round (R2).

The results of RAD and RD of both rounds (the respective individual and mean market prices are displayed in the upper panels of Figure 4), are perfectly in line with Treatment T5($\diagdown+_{\mathrm{G}}$) and do not exhibit increased mispricing or overvaluation in round 2. The respective values of RAD (R1: 0.20; R2: 0.16) and RD (R1: 0.07; R2: –0.06) are again significantly smaller than the respective values in T1($\diagdown+$) and are not significantly different to the respective values in T5($\diagdown+_{\mathrm{G}}$).[21] In fact, RAD and RD are even slightly lower in R2 than in R1 of Treatment T6($\diagdown+_{\mathrm{G\_re}}$), though not significantly.

Additional and more direct evidence that subjects' confusion about the declining FV in T6($\diagdown+_{\mathrm{G\_re}}$) remains low compared to T1($\diagdown+$) even in the "rekindle" setting of R2 is given in the lower panels of Figure 4. One can see that in both rounds 65 to 70 percent of subjects answered the questionnaire correctly.[22]

[21] T6($\diagdown+_{\mathrm{G\_re}}$) vs. T1($\diagdown+$), Mann-Whitney-U-Test, p-values of 0.037 (R1), 0.007 (R2) and 0.078 (R1), 0.004 (R2) for RAD and RD, respectively. T6($\diagdown+_{\mathrm{G\_re}}$) vs. T5($\diagdown+_{\mathrm{G}}$), Mann-Whitney-U-Test, P-values of 0.522 (R1), 0.631 (R2) and 0.150 (R1), 0.631 (R2) for RAD and RD, respectively.

[22] The percentage deviations from the correct forecast of the FV are significantly different between T1($\diagdown+$) and T6($\diagdown+_{\mathrm{G\_re}}$) (Mann-Whitney-U-test, p-values of 0.000 and 0.004 for R1 and R2, respectively) and insignificant between T5($\diagdown+_{\mathrm{G}}$) and round 1 of T6($\diagdown+_{\mathrm{G\_re}}$)

Following Hussam, Porter & Smith (2008), our markets with only once-experienced subjects should be even more prone to rekindled bubbles, but as the data shows, they are not, as the different context "gold mine" clearly reduces confusion about the FV-process.

4 Conclusion and Discussion

In this paper we explored reasons for the frequent emergence of "bubbles" in experiments replicating the market design first presented in Smith, Suchanek & Williams (1988). We observed (i) high mispricing in treatments with declining fundamental value, and (ii) overvaluation when the declining FV is coupled with an increasing C/A-ratio. By running a questionnaire after the experiments we found that (iii) subjects are confused by the concept of a declining fundamental value, since most believed that the FV would stay constant or increase. Finally, (iv) results from two control treatments with the different context "stocks of a depletable gold mine" showed significantly smaller mispricing and overvaluation than the comparable treatment with the term "stock". This finding is robust to treatment changes like increasing the initial C/A-ratio and the variance of the dividend process that had previously led to rekindling of bubbles even with experienced subjects.

Previous studies invariably report that only experience in the same setting (Dufwenberg, Lindqvist & Moore (2005)) and a very careful explanation and demonstration of the FV-process (Lei & Vesely (2009)) were able to eliminate bubbles in SSW-type markets. We have shown that a different context can achieve the same. In our view all three ways to abate bubbles have the same underlying origin: they all help to reduce or eliminate "confusion" about the FV-process among subjects that otherwise leads to bubbles. Following and adapting the argumentation of Chou et al. (2009), Oechssler (2010), and Smith (2010), the likely reason for the confusion is that a declining FV-process is not in line with subjects' past experiences and personal knowledge of real stock markets. We provide twofold evidence for this claim: (i) In the questionnaire conducted after the experiments the majority of subjects in markets with declining FVs expected the FV to stay constant or increase. (ii) We observed significantly smaller mispricing and overvaluation when the tradeable asset was labelled as "stocks of a depletable gold mine", since subjects' confusion about the underlying fundamental value process was reduced (two thirds answered the questionnaire correctly).

Putting historical pricing anomalies in context of these findings, we have to keep in mind that experimental markets are only a very simplified model of the real world. Still, our results can help to gain a better understanding of these bubbles. Two frequently discussed factors for bubble formation are: excess liquidity[23] and the impression that the "world had changed", that a paradigm shift, a "new economy"[24] had emerged. This impression of a "new world" (in the case of the South Sea bubble of the 1720ies) or "new economy" (dot-com bubble, railroad- and electricity-booms of the late 19th century) is a fitting de-

(Mann-Whitney-U-test, p-value of 0.2546).

[23]See e.g. the discussion in Nouriel Roubini (2006) and Adam S. Posen (2006).

[24]Dilip Abreu & Markus K. Brunnermeier (2003) talk of "productivity enhancing structural change".

scription for many of the famous historic bubbles. It seems that during such phases the fundamentally justified values of the traded assets became more uncertain and difficult to estimate, as new factors gave the impression to have "changed the game". E.g. during the South Sea bubble in the 1720ies, uncertainty about the unexplored Pacific Ocean offered the possibility of enormous riches. Unfortunately they never materialized. During the dot-com bubble at the turn of the millennium, prospects of enormous productivity gains due to the improvements in information technology meant that long-standing methods to calculate fundamental values seemed no longer appropriate, and investors were ready to provide billions of dollars to companies which had never produced any operating profit (many of them never did). While some sophisticated investors may have understood that the actual change to the economy might not be that large, the mass of less sophisticated investors believed in a "new economy" and drove prices up, especially when they had ample liquidity. Uncertainty or confusion about the fundamentally justified value combined with enough liquidity in the hands of investors seem to have been important drivers behind many famous historic bubbles.

Translated to our markets, confusion present in a market with declining fundamental value can lead to large mispricing (T1($\diagdown$+) and T3($\diagdown$ =)), unless abated by a reduced level of confusion about the FV (T5($\diagdown +_{\mathrm{G}}$) and T6($\diagdown +_{\mathrm{G\_re}}$)). When combined with ample liquidity (T1($\diagdown$+)) this leads to overvaluation as well. When the FV is easier to estimate (e.g. when it is flat in T2(—+) and T4(— =)) or more intuitively graspable in T5($\diagdown +_{\mathrm{G}}$) and T6($\diagdown +_{\mathrm{G\_re}}$), confusion is reduced, mispricing is small, and overvaluation usually nonexistent.

Concluding, our results demonstrate that (i) reducing liquidity in times of confusion sufficed to prevent strong overvaluation, but not mispricing, i.e. huge deviations from the fundamental value. (ii) Reducing confusion – in our case by an intuitive explanation of the FV-process – suffices to reduce mispricing and overvaluation, even when liquidity is high.

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Appendix

Appendix A: Individual market results including alternative measures

Table A1: Bubble measures and formulae for calculation

Measure	Formulae
Relative absolute deviation	$RAD = \frac{1}{N}\sum_{p=1}^{N} \left\|\overline{P_p} - FV_p\right\| / \left\|\overline{FV}\right\|$
Relative deviation	$RD = \frac{1}{N}\sum_{p=1}^{N} (\overline{P_p} - FV_p) / \left\|\overline{FV}\right\|$
Share turnover[a]	$ST = \sum_{p=1}^{N} VOL_p/TSO$
Price amplitude[b]	$PA = max(\overline{P_p} - FV_p)/FV_1 - min(\overline{P_p} - FV_p)/FV_1$
Total dispersion [c]	$TD = \sum_{p=1}^{N} \left\|MedianP_p - FV_p\right\|$
Average bias [c]	$AB = \frac{1}{N}\sum_{p=1}^{N}(MedianP_p - FV_p)$

Notes: $\overline{P_p}$ = volume-weighted mean price of period p; FV_p = fundamental value of period p; $\overline{FV}$ = mean fundamental value in the market; $MedianP_p$ = the median price in period p; N = total number of periods.

[a] Van Boening, Williams & LaMaster (1993).

[b] Hussam, Porter & Smith (2008), Lei & Vesely (2009), Noussair, Robin & Ruffieux (2001), David P. Porter & Vernon L. Smith (1995). Varying computation in Haruvy & Noussair (2006), Haruvy, Lahav & Noussair (2007), and Van Boening, Williams & LaMaster (1993).

[c] Haruvy & Noussair (2006), Haruvy, Lahav & Noussair (2007).

Table A2: Individual market results for RAD, RD, and alternative measures.

Treatment	Market	RAD	RD	ST	PA	TD	AB
T1($\diagdown$+)	1	0.223	0.103	1.498	0.410	54.00	2.90
	2	0.356	0.168	2.940	0.684	103.25	4.33
	3	0.467	0.467	1.843	0.431	130.21	13.02
	4	0.262	0.179	1.628	0.452	74.60	5.23
	5	0.426	0.112	2.115	0.906	139.25	2.36
	6[a]	0.750	0.750	2.340	0.737	206.67	20.67
Mean		0.414	0.296	2.060	0.603	118.00	8.08
T2(—+)	1	0.004	−0.001	2.790	0.029	1.44	−0.06
	2	0.007	0.007	1.425	0.014	6.39	0.64
	3	0.041	−0.041	2.528	0.106	10.90	−1.09
	4[a]	0.362	−0.355	1.925	0.673	187.00	−18.10
	5	0.025	0.025	3.415	0.027	11.90	1.19
	6	0.035	0.005	1.825	0.190	11.46	0.72
Mean		0.079	−0.060	2.318	0.173	38.18	−2.78
T3($\diagdown$ =)	1[a]	0.501	−0.501	2.275	0.512	181.76	−14.18
	2	0.190	−0.180	0.993	0.325	58.00	−5.80
	3	0.113	0.002	2.843	0.267	30.76	1.37
	4	0.279	−0.247	0.808	0.441	78.30	−5.63
	5	0.427	0.427	0.848	0.408	122.50	12.25
	6	0.323	0.258	0.845	0.542	86.80	6.88
Mean		0.305	−0.040	1.435	0.416	93.02	−0.85
T4(— =)	1	0.003	−0.003	3.518	0.008	0.60	−0.06
	2	0.009	−0.009	1.620	0.029	4.49	−0.45
	3	0.008	−0.008	1.118	0.035	2.53	−0.25
	4	0.002	0.002	1.113	0.006	1.30	0.13
	5[a]	0.086	−0.086	1.880	0.069	43.14	−4.31
	6	0.056	−0.056	3.315	0.084	25.50	−1.45
Mean		0.027	−0.027	2.094	0.039	12.93	−1.07
T5($\diagdown+_{\mathrm{G}}$)	1	0.232	0.061	1.768	0.429	69.45	2.01
	2	0.125	0.014	1.388	0.205	35.79	0.52
	3	0.082	−0.076	4.265	0.093	13.81	−1.38
	4	0.003	0.000	1.410	0.012	0.15	−0.01
	5	0.105	−0.021	1.605	0.256	28.80	−0.60
	6	0.394	−0.394	2.733	0.229	113.09	−11.31
Mean		0.157	−0.069	2.195	0.204	43.51	−1.80
T6($\diagdown+_{\mathrm{G\_re}}$), R1	1	0.166	0.058	2.640	0.362	43.95	2.20
	2	0.260	−0.101	2.128	0.568	73.55	−2.65
	3	0.085	0.068	2.255	0.191	25.27	1.84
	4	0.045	−0.013	2.543	0.111	7.98	−0.50
	5	0.346	0.170	1.670	0.679	81.65	5.89
	6	0.315	0.217	1.408	0.520	86.30	5.63
Mean		0.203	0.066	2.107	0.405	53.12	2.07
T6($\diagdown+_{\mathrm{G\_re}}$), R2	1	0.115	−0.115	1.690	0.079	42.16	−4.22
	2	0.241	−0.039	2.390	0.548	78.00	−2.20
	3	0.214	−0.214	1.640	0.125	68.76	−6.88
	4	0.071	0.034	3.485	0.173	20.57	1.65
	5	0.175	0.014	1.565	0.387	57.61	1.02
	6	0.162	−0.066	1.510	0.335	59.20	−1.92
Mean		0.163	−0.064	2.047	0.275	54.38	−2.09

[a] Market dropped in robustness check, see Appendix B.

Appendix B: Robustness check

Table A3: Robustness checks for research questions 1 and 2. Markets with the highest RAD in each treatment are dropped from the sample. The values represent the differences in means (Δ mean) of the treatments under investigation and Z-values from a Mann-Whitney-U-Test (Z).

RQ1 (C/A-ratio)		RAD	RD
T1(╲+) & T2(—+) vs T3(╲ =) & T4(— =)	Δ mean	0.043	0.084
N=20	Z	−0.605	−1.890
T1(╲+) vs T3(╲ =)	Δ mean	0.080	0.154
N=10	Z	−0.940	−0.940
T2(—+) vs T4(— =)	Δ mean	0.006	0.014
N=10	Z	−0.731	−1.567

RQ2 (FV)		RAD	RD
T1(╲+) & T3(╲ =) vs T2(—+) & T4(— =)	Δ mean	0.288**	0.137*
N=20	Z	−3.780	−1.965
T1(╲+) vs T2(—+)	Δ mean	0.324**	0.207**
N=10	Z	−2.611	−2.611
T3(╲ =) vs T4(— =)	Δ mean	0.251**	0.067
N=10	Z	−2.611	−0.313

Notes: * and ** represent the 5 percent and 1 percent significance levels.

Appendix C: Treatment Details

Table A4: Details of the treatments with declining FVs. “Div” is the expected dividend payment, “FV” denotes fundamental value, “Asset Value” is the number of stocks multiplied with the expected fundamental value (FV), and “C/A” stands for the C/A-ratio.

Treatments with declining FVs						
T1($\searrow$+), T5($\searrow$+$_{G}$), and T6($\searrow$+$_{G\_re}$), R1						
Period	No. assets	Div	FV	Asset Value	Cash	C/A
1	400	5	50	20000	20000	1.0
2	400	5	45	18000	22000	1.2
3	400	5	40	16000	24000	1.5
4	400	5	35	14000	26000	1.9
5	400	5	30	12000	28000	2.3
6	400	5	25	10000	30000	3.0
7	400	5	20	8000	32000	4.0
8	400	5	15	6000	34000	5.7
9	400	5	10	4000	36000	9.0
10	400	5	5	2000	38000	19.0
T3($\searrow$=)						
Period	No. assets	Div	FV	Asset Value	Cash	C/A
1	400	5	50	20000	20000	1.0
2	400	5	45	18000	18000	1.0
3	400	5	40	16000	16000	1.0
4	400	5	35	14000	14000	1.0
5	400	5	30	12000	12000	1.0
6	400	5	25	10000	10000	1.0
7	400	5	20	8000	8000	1.0
8	400	5	15	6000	6000	1.0
9	400	5	10	4000	4000	1.0
10	400	5	5	2000	2000	1.0
T6($\searrow$+$_{G\_re}$), R2						
Period	No. assets	Div	FV	Asset Value	Cash	C/A
1	200	6	60	12000	40000	3.33
2	200	6	54	10800	41200	3.81
3	200	6	48	9600	42400	4.42
4	200	6	42	8400	43600	5.19
5	200	6	36	7200	44800	6.22
6	200	6	30	6000	46000	7.67
7	200	6	24	4800	47200	9.83
8	200	6	18	3600	48400	13.44
9	200	6	12	2400	49600	20.67
10	200	6	6	1200	50800	42.33

Table A5: Details of the treatments with constant FVs. "Div" is the expected dividend payment, "FV" denotes fundamental value, "Asset Value" is the number of stocks multiplied with the expected fundamental value (FV), and "C/A" stands for the C/A-ratio.

Treatments with constant FVs						
T2(—+)						
Period	No. assets	Div	FV	Asset Value	Cash	C/A
1	400	0	50	20000	20000	1.0
2	400	0	50	20000	24444	1.2
3	400	0	50	20000	30000	1.5
4	400	0	50	20000	37143	1.9
5	400	0	50	20000	46667	2.3
6	400	0	50	20000	60000	3.0
7	400	0	50	20000	80000	4.0
8	400	0	50	20000	113333	5.7
9	400	0	50	20000	180000	9.0
10	400	0	50	20000	380000	19.0
T4(— =)						
Period	No. assets	Div	FV	Asset Value	Cash	C/A
1	400	0	50	20000	20000	1.0
2	400	0	50	20000	20000	1.0
3	400	0	50	20000	20000	1.0
4	400	0	50	20000	20000	1.0
5	400	0	50	20000	20000	1.0
6	400	0	50	20000	20000	1.0
7	400	0	50	20000	20000	1.0
8	400	0	50	20000	20000	1.0
9	400	0	50	20000	20000	1.0
10	400	0	50	20000	20000	1.0

Appendix D: Experimental instructions for treatments featuring a declining FV[25]

Dear Participant! We welcome you to this experimental session and kindly ask you to refrain from talking to each other for the duration of the experiment. If you face any difficulties, contact one of the supervisors.

General Information
This experiment is concerned with replicating an asset market where traders can trade the stocks of a fictitious company (*stocks of a depletable gold mine*) for 10 consecutive periods.

Market Description
The market consists of ten subjects. Five of the ten traders get an initial endowment of 20 assets and a working capital of 3000 Taler, another five are endowed with 60 assets and 1000 Taler at the outset. At the beginning of the experiment the asset has a fundamental value (FV) of 50. Evaluating the asset at its initial FV yields that each subjects' wealth adds up to 4000 Taler. In every period you can sell and/or buy assets, and your asset and Taler inventories are transferred to the next trading period, respectively. Each trading period automatically terminates after two minutes.
Trade is accomplished in form of a double auction, i.e., each trader can appear as buyer and seller at the same time. You can submit any quote of assets with prices ranging from 0 to a maximum of 999 Taler (with at most two decimal places). For every bid you make, you have to enter the number of assets you intend to trade as well. Note that your Taler and asset inventory cannot drop below zero.
At the end of each trading period, every asset pays a dividend (profit) which gets summed up to your Taler holding. The dividend (for one asset) amounts either 0 or 10 Taler, given equal probability. Thus, an asset's average dividend amounts 5 Taler for every period. Assets feature a life-span of 10 trading periods, i.e., after dividends are paid out at the end of period 10, assets are worthless. *(The stocks are for a depletable gold mine, in which gold is mined for 10 periods. In each period the probability of finding (not finding) gold is 50%. If gold is found in period p a dividend (profit) of 10 Taler for each unit of the stock will be paid. If no gold is found, the dividend will be zero. After 10 periods the gold mine is depleted and the fundamental value of the stocks is zero.)*
You do not get any information about the dividend realization of the current period, i.e. you do not know the dividend payment for the current or the coming periods. The only thing you know is that the dividend either takes the value of 10 or 0 (per asset) in each period. At the end of a period you will be informed about the dividend realization of the expired period.

Fundamental Value (FV)
The subsequent table might help you to make your decisions. The first column, labeled "Ending Period", indicates the last trading period of the market. The second column, labeled "Current Period", indicates the period during which the

[25] To mimic closely already existing SSW markets, we use almost identical instructions as Dufwenberg, Lindqvist & Moore (2005). Instructions and sceenshots are for T1($\searrow$+), text changes in T3($\searrow$ =) are in (**bold**), text changes in T5($\searrow +_{G}$) and in T6($\searrow +_{G\_re}$), R1 are in (*italic*).

FV is being calculated. The third column gives the number of holding periods from the period in the second column until the end of the market. The fourth column, labeled "Average Dividend Value Per Period", gives the average amount that the dividend will be in each period for each unit held in your inventory. The fifth column, labeled "Fundamental Value Per Unit of Inventory", gives the expected total dividend earnings (per asset) for the remainder of the experiment. That is, for each unit you hold in your inventory for the remainder of the market, you receive in expectation the amount listed in column 5, which is defined as the FV of the current period. The number in column 5 is calculated by multiplying the numbers in column 3 and 4.
Suppose for example that there are 4 periods remaining in a market. Since the dividend on a unit of asset has a 50% chance of being 0 and a 50% chance of being 10, the dividend is in expectation 5 Taler (per period for each asset). If you hold one asset for 4 periods, the total dividend paid on the unit over 4 periods is in expectation 4 * 5 = 20.

Ending period	Current period	Number of Holding Periods	x	Average Dividend Value per Period	=	Fundamental Value per Unit of Inventory
10	1	10		5		50
10	2	9		5		45
10	3	8		5		40
10	4	7		5		35
10	5	6		5		30
10	6	5		5		25
10	7	4		5		20
10	8	3		5		15
10	9	2		5		10
10	10	1		5		5

(Saving account
In addition to your Taler account you possess a saving account. Your dividend earnings during the course of the experiment are directly transferred to this account. In each period an amount of 200 Taler are added to the account to increase your savings. This procedure may result in a negative Taler account. As long as your Taler holding are below zero you are not allowed to post bids or to buy shares. At the end of the experiment your savings are added to your TOTAL EARNINGS.)

Asset trading
If you buy assets, your Taler holding is diminished by the respective expenditures (price * volume). Inversely, if you sell assets, your Taler holding will be increased by the respective revenues (price * volume).

Calculate Your Earnings
At the end of the market (after 10 periods), assets have a value of zero. Solely your Taler holdings (**and your balance on the saving account (dividend payments and savings)**) serve for the determination of your total earnings.

Your TOTAL EARNINGS at the end of the experiment =

Taler holdings (+ **balance on the saving account**).

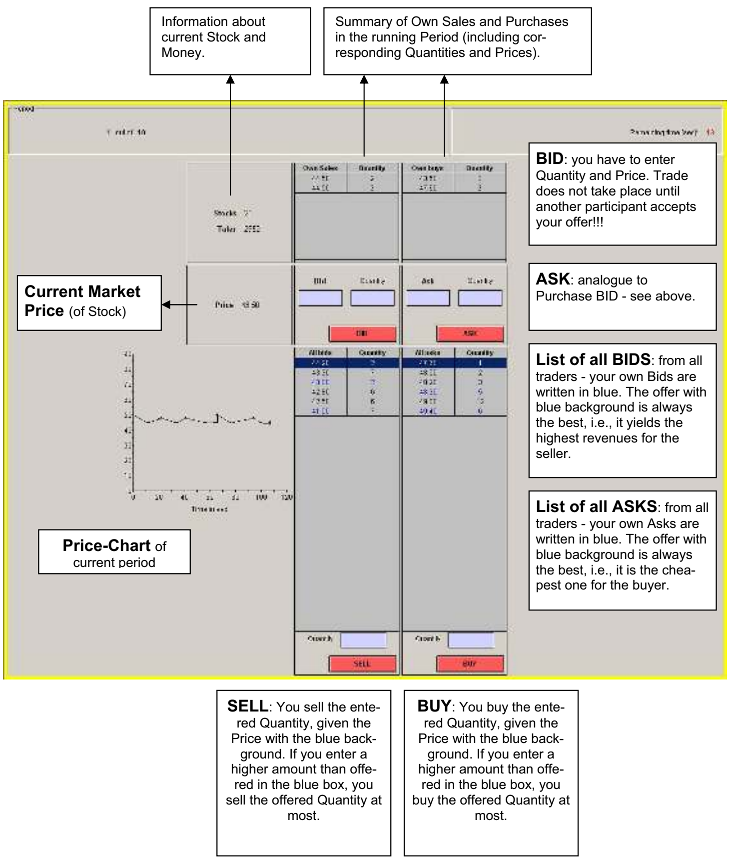
Your total earnings in this experiment are converted into Euro at a rate of

$$400 \text{ Taler} = 1 \text{ Euro}$$

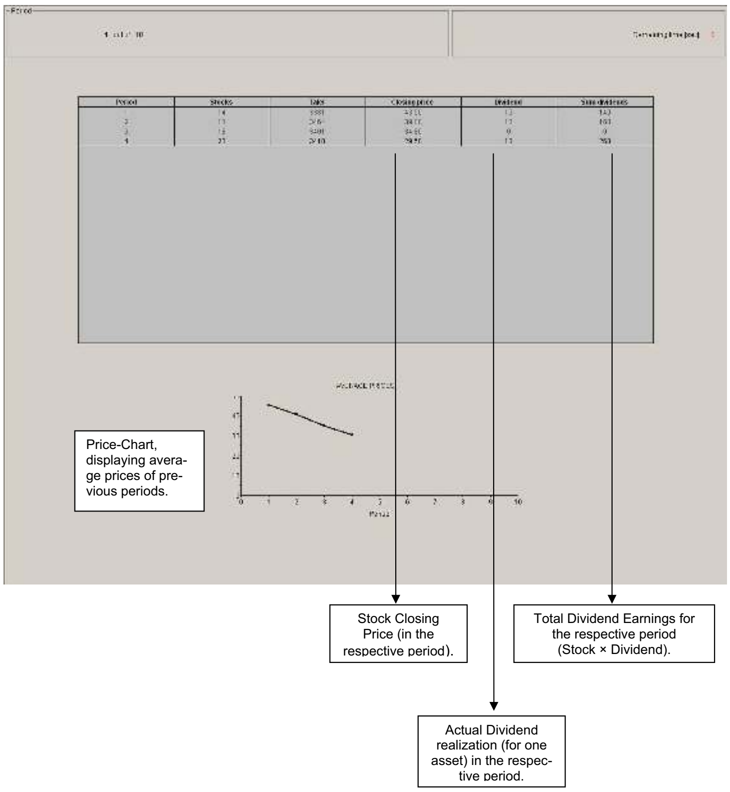
Important information

- No interest is payed for Taler holdings.
- **(Savings of 200 Taler each period.)**
- Each trading period lasts for 120 seconds.
- The experiment ends after 10 periods.
- Use the full stop (.) as decimal place.

Trading screen: By means of the following figure, the procedure of trading (buying and selling) will be illustrated.



History screen: appears after each trading period (for 10 seconds), providing you with information of past periods:



Appendix E: Experimental instructions for treatments featuring a constant FV[26]

Dear Participant! We welcome you to this experimental session and kindly ask you to refrain from talking to each other for the duration of the experiment. If you face any difficulties, contact one of the supervisors.

General Information
This experiment is concerned with replicating an asset market where traders can trade the stocks of a fictitious company for 10 consecutive periods.

Market Description
The market consists of ten subjects. Five of the ten traders get an initial endowment of 20 assets and a working capital of 3000 Taler, another five are endowed with 60 assets and 1000 Taler at the outset. At the beginning of the experiment the asset has a fundamental value (FV) of 50. Evaluating the asset at its initial FV yields that each subjects' wealth adds up to 4000 Taler. In every period you can sell and/or buy assets, and your asset and Taler inventories are transferred to the next trading period, respectively. Each trading period automatically terminates after two minutes.
Trade is accomplished in form of a double auction, i.e., each trader can appear as buyer and seller at the same time. You can submit any quote of assets with prices ranging from 0 to a maximum of 999 Taler (with at most two decimal places). For every bid you make, you have to enter the number of assets you intend to trade as well. Note that your Taler and asset inventory cannot drop below zero.
At the end of each trading period, every asset pays a dividend (profit) of 5 Taler or causes holding costs of -5 Taler with equal probability. Thus, an asset's average payout amounts 0 Taler at the end of each period. Dividends and holding costs are collected in a separate account. Assets feature a life-span of 10 trading periods. At the end of period 10 assets are bought back by the experimenter at a price of 50.
For the current period you do not get any information wether a dividend will be paid out or holding cost will accrue. The only thing you know is that the dividend payment and the holding cost either takes the value of +5 or −5 (per asset) in each period. At the end of a period you will be informed wether a dividend is paid out or holding costs accrued for the expired period.

Fundamental Value (FV)
The subsequent table might help you to make your decisions. The first column, labeled "Current Period", indicates the period during which the FV is being calculated. The second column, labeled "Average Payment Per Period", gives the average amount that the dividend/holding cost will be in each period for each unit held in your inventory. The third column, labeled "Fundamental Value Per Unit of Inventory", gives the average value for each unit held in your inventory from now until the end of the experiment. That is, for each unit you hold in your inventory for the remainder of the experiment, you will earn on average the amount listed in column 3.

[26] To mimic closely already existing SSW markets, we use almost identical instructions as Noussair, Robin & Ruffieux (2001). Instructions are for T4(— =), text changes in T2(—+) are in (**bold**).

Current period	Average Payment per Period (–5 or +5 with equal prob.)	Fundamental Value per Unit of Inventory
1	0	50
2	0	50
3	0	50
4	0	50
5	0	50
6	0	50
7	0	50
8	0	50
9	0	50
10	0	50

Saving account
Your dividend earnings (positive) and holding costs (negative) during the course of the experiment are directly transferred to a saving account. At the end of the experiment your cumulated earnings/losses are added to/substracted from your TOTAL EARNINGS.

Asset trading
If you buy assets, your Taler holding is diminished by the respective expenditures (price * volume). Inversely, if you sell assets, your Taler holding will be increased by the respective revenues (price * volume).

Calculate Your Earnings
At the end of each period earnings of external investments are added to your Taler holdings.

End of period	1	2	3	4	5	6	7	8	9	10
Earnings	444	556	714	953	1333	2000	3333	6667	20000	0

Your total earnings at the end of the market (after 10 periods) are your Taler holdings plus your balance on the saving account (dividend payments minus holding costs) plus the value of your asset holdings (number of assets * 50).

Your TOTAL EARNINGS at the end of the experiment =
Taler holdings + balance on the saving account + (# of assets * 50).

Your total earnings in this experiment are converted into Euro at a rate of

400 **(4000)** Taler = 1 Euro

Important information

- No interest is payed for Taler holdings.
- Each trading period lasts for 120 seconds.
- The experiment ends after 10 periods.

- Use the full stop (.) as decimal place.

Trading and history screen are identical to treatments with declining FV *and therefore omitted.*

Appendix F: Experimental instructions for round 2 of Treatment T6($\searrow +_{G\_re}$)

Market Description
The market consists of ten subjects, which are randomly reassigned to the market. Five of the ten traders get an initial endowment of 10 assets and a working capital of 4600 Taler, another five are endowed with 30 assets and 3400 Taler at the outset. At the beginning of the experiment the asset has a fundamental value (FV) of 60. Evaluating the asset at its initial FV yields that each subjects' wealth adds up to 5200 Taler.

The stocks are for a depletable gold mine, in which gold is mined for 10 periods. In each period there is an equal probability of finding plenty of gold, little gold or no gold. If plenty of gold is found in period p a dividend (profit) of 17 Taler for each unit of the stock is paid. If little gold is found, the dividend is 1. If no gold is found, the dividend is zero. After 10 periods the gold mine is depleted and the fundamental value of the stocks is zero.

Fundamental Value
Since the dividend on a unit of asset has a 33.33% chance of being 17, 1 or 0, the dividend is on average 6 Taler (per period for each asset). If you hold one asset for 4 periods, the total dividend paid on the unit over 4 periods is on average 4 * 6 = 24.

Ending period	Current period	Number of Holding Periods	x	Average Dividend Value per Period	=	Fundamental Value per Unit of Inventory
10	1	10		6		60
10	2	9		6		54
10	3	8		6		48
10	4	7		6		42
10	5	6		6		36
10	6	5		6		30
10	7	4		6		24
10	8	3		6		18
10	9	2		6		12
10	10	1		6		6

Calculate Your Earnings
At the end of the market (after 10 periods), assets have a value of zero. Solely your Taler holdings serve the determination of your total earnings.

Your TOTAL EARNINGS in this experiment are converted into Euro at a rate of

$$520 \text{ Taler} = 1 \text{ Euro}$$

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Michael Kirchler, Jürgen Huber, Thomas Stöckl

Thar she bursts - Reducing confusion reduces bubbles

Abstract
To explore why bubbles frequently emerge in the experimental asset market model of Smith, Suchanek and Williams (1988), we vary the fundamental value process (constant or declining) and the cash-to-asset value-ratio (constant or increasing). We observe high mispricing in treatments with a declining fundamental value, while overvaluation emerges when coupled with an increasing C/A-ratio. A questionnaire reveals that the declining fundamental value process confuses subjects, as they expect the fundamental value to stay constant. Running the experiment with a different context ("stocks of a depletable gold mine" instead of "stocks") significantly reduces mispricing and overvaluation as it reduces confusion.

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