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The “Inflow-Effect” – Trader Inflow and Bubble Formation in Asset Markets

Michael Kirchler, Caroline Bonn, Jürgen Huber and Michael Razen*

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Abstract

We investigate the impact of trader and cash inflow on bubble formation in asset markets with a novel design featuring heterogeneous information and a constant fundamental value. Implementing seven treatments we find that (i) only the joint inflow of traders and cash triggers bubbles (“inflow-effect”). (ii) In treatments with trader and cash inflow only in the first half of the market, prices converge to fundamentals towards maturity of the asset. This inflow-effect is very robust as we observe bubbles in almost all of the 24 markets with trader inflow. The analysis of traders’ beliefs reveals that (iii) despite fundamentals staying constant, beliefs about fundamentals co-move with upwardly trending prices. Finally, we report

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a speculative motive only among the optimists in treatments where we observe bubbles.

JEL: C92, D84, G10

Keywords: Experimental finance, inflow-effect, trader inflow, asset market, bubble, market efficiency.

1 Literature and Research Questions

In this paper we analyze the impact of trader and cash inflow on bubble formation with a novel experimental asset market setting. We find an "inflow-effect" as only the joint inflow of new traders and cash triggers strong price bubbles.[1] We elicit subjects' beliefs and observe that bubbles are driven by a speculative motive among optimists and are accompanied by a strong upward adaption of beliefs about fundamentals.

History reports numerous cases of financial euphoria and price bubbles. The Dutch Tulipmania in the 1630ies and the South-Sea Bubble in 1720/21 were two spectacular examples centuries ago. In more recent times financial euphoria in the second half of the 1920ies which preceded the Great Depression, the Dot-com Bubble at the end of the 1990ies, and the US real estate bubble 2000-2006 are three outstanding bubble episodes among many. Besides their fascinating nature, these market failures to price assets correctly triggered severe consequences: For instance, the stock market crash of 1929 led to a global recession and political turmoil and the bursting of the US real estate bubble paved the way for the financial crises erupting in 2007. The price of bubbles has usually been bankruptcy, recession and increased unemployment after the crash. A better understanding of why, when and how bubbles emerge is crucial for efforts to abate future bubbles and to dampen their destructive impact on the entire economy.

[1] An exact definition of a bubble is elusive as a definition has to include (1) a reference variable (e.g., fundamental value or past prices) and (2) a threshold deviation from this reference variable to call it a bubble (see Garber (2000) and Kindleberger (2000) for definitions). We use the percentage price difference from the beginning to the time when all traders have entered the market as main measure of price dynamics. If this is significantly different from zero we talk of a bubble.

Research on the origins of bubbles has seen great progress during the last two decades. In two surveys Brunnermeier (2008) and Brunnermeier and Oehmke (2012) give a comprehensive picture and outline various reasons such as rational bubbles, limits of arbitrage and heterogeneous information. Allen and Gorton (1993) show information asymmetries between investors and portfolio managers as reason for bubbles, while Benabou (2013) points to wishful thinking and delusion of the whole market. A seminal study that is particularly instructive to our paper is the one of Miller (1977) introducing traders with heterogeneous beliefs about the asset´s fundamental value. As short selling is prohibited all units of the asset are held by the investors with the most optimistic estimates of returns of the asset. Consequently, the market price equals the beliefs of the most optimistic traders. Moreover, as soon as some traders adjust their beliefs upward – either because they become more optimistic or because they consider more optimistic traders in the future – Harrison and Kreps (1978) and Ofek and Richardson (2003) show that prices can rise above the beliefs of the most optimistic traders. The latter relate this argument to the formation of the Dot-com Bubble at the end of the 1990ies.

In recent years especially experimental asset market research has made important contributions to bubble research. Its major advantage is that behavioral factors such as human emotions, over-optimism, miscalibrations of fundamentals and speculation can be explored. In the seminal design of Smith et al. (1988) – SSW henceforth – bubbles emerge because of speculation (Smith et al., 1988; Lei et al., 2001), inexperience (Dufwenberg et al., 2005), confusion about fundamentals (Huber and Kirchler, 2012; Kirchler et al., 2012) and lack of information asymmetries (Sutter et al., 2012). However, the most prominent reason for strong bubbles in this setting appears to be "excess cash", i.e., high cash to asset-value ratios (CA-Ratios) in the market. The CA-Ratio is defined as the total amount of cash divided by the product of outstanding shares and fundamental value of the asset. Among others, Caginalp et al. (1998, 2001) and Haruvy and Noussair (2006) report strong bubbles in markets of SSW-type with high initial CA-Ratios.[2]

Bubble phenomena have been investigated in different fields other than economics including history, psychology and sociology. Across fields it is evident that, among the above outlined reasons, one of the most important ingredients of historic bubbles is the "inflow" of new liquidity by new traders (see the narratives of Galbraith (1994) and Kindleberger (2000) on various historic bubble episodes). Xiong and Yu (2011) hypothesize that this effect has strongly contributed to the Chinese Warrants Bubble from 2005-2008 as well. In arguably one of the clearest bubble episodes in history, Put-warrants of 18 Chinese companies have been traded at highly inflated prices although the warrants were essentially worthless. The study of Xiong and Yu (2011) is one of the rare examples in which fundamentals are empirically observable because the fundamental values, derived by Black-Scholes, were almost zero. As theoretical explanation Xiong and Yu (2011) put forward the resale option theory that builds on the joint effects of heterogeneous beliefs and short-sale constraints (Harrison and Kreps, 1978; Morris, 1996; Scheinkman and Xiong, 2003). A drawback is that they cannot test their other hypothesized effect, namely the inflow of new traders contributing to the Chinese Warrants Bubble.

By using laboratory experiments we overcome shortcomings of empirical studies in measuring this inflow-conjecture. Usually, fundamental values are very difficult to measure and the extent of trader inflow is usually not quantifiable in empirical studies. Even if fundamental values and trader inflow could somehow be analyzed, the problem of not knowing the ceteris paribus outcome without trader inflow in the same environment at the same time arises. Laboratory experiments bypass these difficulties as fundamentals and trader/cash inflow can be controlled. With a specific treatment design the "inflow-effect" can be isolated by comparing its results to those of other treatments without inflow of new traders. In two studies with settings different to ours Hirota

[2]However, it appears that high CA-Ratios must already be present in the beginning of the market for bubbles to form. In markets with constant fundamental value and symmetric information Kirchler et al. (2012) report that increasing CA-Ratios over time when starting from a low level, do not yield bubbles. It is also shown in this framework that asset repurchases increase and share issues decrease prices (Haruvy et al., 2014).

and Sunder (2007) and Deck et al. (2014) investigate the effects of overlapping generations in laboratory asset markets. Hirota and Sunder (2007) find strong bubbles only in markets with short-term investors, i.e., investors that do not stay in the market until maturity. Using the SSW-model, Deck et al. (2014) report bubbles when new traders enter and crashes at the time when a subset of traders exit. However, both studies do not separate the effect of new traders entering from the effect of increasing CA-Ratios in the market.

We disentangle the effect of new trader inflow from the effect of an increasing CA-Ratio. We develop a novel market model in which information about the constant fundamental value of the asset is distributed heterogeneously, leaving each trader with incomplete information. In four basic treatments, outlined in Table 1, we implement a 2x2 design with the treatment variables "Trader Inflow" and "Cash-Asset-Ratio". We formulate the following research questions:

- RQ1: Does the inflow of new inexperienced traders yield increasing prices?
- RQ2: Does the inflow of cash yield increasing prices?
- RQ3: Does the joint inflow of new inexperienced traders with cash yield increasing prices?

Table 1: Basic treatments.

		Trader Inflow (T)	
		no	yes
Cash-Asset Ratio (CA)	constant	BASE	TRADERS
	increasing	CASH	CAT

Building on the results of the four basic treatments we run three treatments as robustness checks. The treatments are identical to Treatment CAT but with an extended trading horizon and they serve two purposes. First, we test the "inflow-effect" of Treatment CAT for robustness in a longer setting. Second, we investigate the price dynamics after all traders have entered the market (in one treatment) and whether two prominent crash drivers (Galbraith, 1994;

Kindleberger, 2000), i.e., the revelation of "new events/new information" and the enforcement of liquidity constraints trigger different price dynamics in the second half of the market.

We find (i) strong price bubbles only with joint inflow of new inexperienced traders and cash – we term this finding "inflow-effect". This effect is very robust, as it is present in almost all of the 24 markets with trader inflow. We do not observe price rallies in any other treatment. We also show that (ii) in treatments with trader and cash inflow only in the first half of the market, prices converge to fundamentals towards maturity of the asset. By eliciting traders' beliefs about fundamentals and about future prices we find that (iii) beliefs about fundamentals co-move with the bubble/crash price patterns in treatments where bubbles occur. This adaption is remarkable because fundamentals are constant over time. Finally, we report a speculative motive only among the optimists in treatments where bubbles are observed. In these treatments future market prices converge to or even exceed the beliefs of the most optimistic traders.

The observed "inflow-effect" is extraordinary because we neither apply the bubble-prone setting of Smith et al. (1988) nor do we set up the markets with high initial CA-Ratios that also reliably produce bubbles (Caginalp et al., 1998, 2001; Haruvy and Noussair, 2006). Hence we see clear and strong bubbles (prices markedly above fundamental values) in a novel setting that combines a constant fundamental value with heterogeneous information and the inflow of traders and cash. According to our experimental results, the latter two ingredients are major drivers of bubbles as hypothesized by Galbraith (1994), Kindleberger (2000) and Xiong and Yu (2011).

2 The Experiment

2.1 Market and Information Structure

In each market subjects trade assets of a fictive company for experimental currency (Taler) in a sequence of 8 or 14 periods of 180 seconds each. No interest is paid on Taler holdings. The asset does not pay dividends and there are no transaction costs. At the end of the experiment each unit of the common value asset pays either 30 or 80 Taler with equal probability.

Inspired by the work on heterogeneous beliefs by Miller (1977), Harrison and Kreps (1978), and Ofek and Richardson (2003) information about the company's fundamentals is distributed heterogeneously. Half of the subjects are informed about the probability and the value of the low buyback price (30), while the other half is informed about the probability and the value of the high buyback price (80). Both groups only know about the existence of a second buyback price, but know nothing about its value.

We are primarily interested in treatment comparisons of price dynamics. Therefore, the determination of a strict theoretical benchmark for overpricing is not a major concern.

2.2 Treatments

The first treatment, BASE, is designed with no trader inflow and no increase in the CA-Ratio. Each market is populated by eight subjects who are initially endowed with 20 units of the asset and 3,300 Taler. Subjects trade for eight periods. Valued at the expected value of the buyback price of 55 the total cash amount in the market ($8 \cdot 3{,}300 = 26{,}400$ Taler) is three times the value of all units of the asset in the market ($8 \cdot 20 = 160$ units $\cdot$ 55 Taler = 8,800 Taler). Thus, the CA-Ratio is constant at 3 over time.

Treatment CASH is identical to Treatment BASE except that the CA-Ratio is increasing over time. All subjects start with an initial endowment of 20 units of the asset and 3,300 Taler cash and receive exogenous cash inflows of 4,400 Taler each in periods three, five, and seven. No new shares are issued at any time. This is announced in the instructions and common knowledge. The inflow of 4,400 Taler is equal to each subject's Taler value of its initial endowment (20 units $\cdot$ 55 Taler = 1,100 plus 3,300 Taler in cash). Therefore, the CA-Ratio increases from initially 3 to 15 in period 7.

In the third treatment, TRADERS, four traders (generation 1, GEN1) trade in the first two periods with an initial endowment of 40 units of the asset and

6,600 Taler each.[3] In each of periods 3, 5, and 7 four new traders (GEN2 to GEN4) enter the market, each with the same initial endowment of cash and assets as traders of GEN1. This ensures a constant CA-Ratio of 3 throughout the experiment. Importantly, the distribution of fundamental information is balanced such that two traders are informed about the low and two are informed about the high buyback price in each generation. Before entering the market subjects of GEN2 to GEN4 earn Euros in several calculation tasks to keep them busy. These tasks are taken from Niederle and Vesterlund (2007) and Gill and Prowse (2012). Once traders of a new generation enter they receive the last trading price of the preceding period as additional information. The inflow procedure is common knowledge among all subjects.[4]

Treatment CAT features the same inflow structure as Treatment TRADERS except that new traders enter the market with cash only (no assets). At the beginning of periods 3, 5 and 7 four new traders enter with 8,800 Taler each (identical to Treatment TRADERS: 6,600 Taler + $40 \cdot 55 =$ 8,800 Taler) which increases the CA-Ratio from initially 3 to 15 in period seven.[5]

[3] Giving traders 40 units of the asset instead of 20 in treatments BASE and CASH is necessary to ensure an initial total number of outstanding shares of 160 in each treatment. The same holds for the initial cash endowment of 26,400.

[4] I.e., all subjects know when and how many subjects enter the market. They also know that heterogeneous information is balanced among all generations. Furthermore, we consciously refrain from endogenizing trader in- and outflows. Of course, this feature would be more realistic but lacks controllability.

[5] Clearly, one could argue that the different number of subjects might have an influence on the markets. However, this is an inherent feature of the “inflow-effect” and therefore a necessary condition to answer our research questions.

Table 2: Treatment parameterization.

Basic Treatments	BASE	CASH	TRADERS	CAT
Number of periods	8	8	8	8
Buyback prices	30; 80	30; 80	30; 80	30; 80
Probabilities of the buyback prices	50%; 50%	50%; 50%	50%; 50%	50%; 50%
Information structure	heterogeneous	heterogeneous	heterogeneous	heterogeneous
Number of traders	8	8	4-16	4-16
Trader inflow every 2nd period (Traders/assets (market)/cash (market))	-/-/-	-/-/-	4/160/26,400	4/0/35,200
Units of the asset in the market	160	160	160-640	160
Total cash in the market (Period 1/period 8)	26,400/26,400	26,400/132,000	26,400/105,600	26,400/132,000
CA-Ratio (Period 1/period 8)	3/3	3/15	3/3	3/15

Robustness Check Treatments	CAT^{14}	CAT$^{\mathrm{INFO}}$	CAT$^{\mathrm{OUTFLOW}}$
Number of periods	14	14	14
Buyback prices	30; 80	30; 80	30; 80
Probabilities of the buyback prices	50%; 50%	50%; 50%	50%; 50%
Information structure	heterogeneous	heterogeneous; changing to complete information for some traders beginning in period 9	heterogeneous
Number of traders	4-16	4-16	4-16
Trader inflow every 2nd period (Traders/assets (market)/cash (market))	4/0/35,200	4/0/35,200	4/0/35,200
Units of the asset in the market	160	160	160
Total cash in the market (Period 1/period 8/period 14)	26,400/132,000/132,000	26,400/132,000/132,000	26,400/132,000/26,400
CA-Ratio (Period 1/period 8/period 14)	3/15/15	3/15/15	3/15/3

In addition to the four basic treatments, we run three additional robustness check treatments. Markets of all three treatments replicate Treatment CAT, except for the extension to 14 periods and for applying crash scenarios in two treatments starting in period 9. Treatment CAT^{14} serves as baseline. Here, markets are identical to CAT except for the number of periods. In Treatment CAT$^{\mathrm{INFO}}$ we reduce uncertainty sequentially by providing four traders each in periods 9, 11 and 13 also with the second buyback price, i.e., providing them with complete information. In Treatment CAT$^{\mathrm{OUTFLOW}}$ we reduce free cash – again every two periods and beginning in period 9 – of four subjects each by 8,800 Taler.[6] Deducted cash is returned at the end of the experiment for calculation of subjects' final wealth.

Table 2 summarizes the treatments and the most important variables.

2.3 Elicitation of Beliefs

To provide explanations on the formation of market prices it is important to elicit subjects' beliefs. Because of our design with heterogeneous information we are able to elicit subjects' beliefs about fundamentals in addition to measuring beliefs about future market prices. With this approach we are the first to analyze whether bubbles can be explained by a speculative motive or by overoptimism about fundamentals.

Each period subjects answer an incentivized questionnaire before trading starts. First, at the beginning of period t and after the final period subject i has to guess the unknown second buyback price (BP^i_t).[7]

Second, similar to Haruvy et al. (2007) subjects are asked to predict average period prices for each future period in period t. $\mathrm{P}^i_{t,t+k}$ indicates subject i's beliefs in period t of each average period price from period t to the end of the experiment, indicated by $t+k$.[8]

[6] Consequently, negative cash holdings are possible which prevents traders from posting bids and market buy orders until cash holdings are positive again.

[7] At the end of the experiment one BP^i_t of subject i is drawn randomly. If the selected BP^i_t is within the range of ±10 percent of the corresponding unknown second buyback price, the subject receives EUR 2.25. For guesses of BP^i_t within the ranges of ±20 percent and ±40 percent, EUR 1.50 and EUR 0.50, respectively, are paid out.

[8] Again, in the end of the experiment one $\mathrm{P}^i_{t,t+k}$ of subject i is drawn randomly. If the

Only beliefs of subjects who have already entered the market are elicited. In Treatment CAT$^{\text{INFO}}$ we no longer elicit beliefs of a trader that has received complete information.

2.4 Market Architecture

When the asset market is open, subjects trade in a continuous double auction with open order books (see the Appendix for a screenshot and a detailed explanation of the trading screen). All orders are executed according to price and then time priority. Market orders have priority over limit orders and are always executed instantaneously. When posting limit orders traders specify price and quantity they want to trade for – with the risk of non-acceptance by another trader. When posting market orders traders only specify the quantity they want to trade and the order is executed immediately at the price of the currently best limit order. Any order size, the partial execution of limit orders, and deleting already posted limit orders are possible. Shorting assets and borrowing money is not allowed.

2.5 Experimental Implementation

Six markets were run for each treatment. All 42 markets were conducted at Innsbruck ECONLAB at the University of Innsbruck with a total of 576 students (bachelor and master students in business administration and economics). Each subject participated in only one market and we made sure that subjects did not participate in earlier asset market experiments of comparable design. The markets were programmed and conducted with z-Tree 3.3.6. by Fischbacher (2007). Subjects were recruited using ORSEE by Greiner (2004). In total, each experimental session lasted between 90 and 120 minutes, including 20 minutes to study the written instructions, five minutes to answer written comprehension questions, one trial period of five minutes, and the market experiment. Average earnings in the four basic treatments were EUR 17.2 and in the three additional

selected $\mathrm{P}^i_{t,t+k}$ is within the range of ± 10 percent around the realized average market price of period $t+k$, the subject receives EUR 2.25. The corresponding payouts for guesses of $\mathrm{P}^i_{t,t+k}$ within the ranges of ± 20 percent and ± 40 percent are EUR 1.50 and EUR 0.50, respectively.

treatments EUR 26.5 because of longer duration. Earnings are composed of earnings from the calculation tasks or slider tasks (if applicable), earnings from the elicitation of beliefs (see above), and earnings from the asset market. For the latter, the randomly drawn buyback price was multiplied by a subject's units of the asset held in the end of the experiment and added to the end holdings in Taler. Finally, this end wealth in Taler was exchanged into EUR at a specific conversion rate, which was conditional to the generation a subject was assigned to.[9]

3 Results

3.1 Basic Treatments – Research Questions 1, 2, and 3

The four panels of Figure 1 outline the development of prices in the four basic treatments. Grey lines show volume-weighted period prices of individual markets, while the bold lines with circles represent the treatment averages. Note that the vertical axis has a logarithmic scale. It is evident that prices in Treatment BASE, the static environment where no new traders or cash enter the market, are stable and mostly within the range of the two buyback prices (30 and 80). The average price increases from 70 in period 2 to 73 in period 8. The results of treatments CASH and TRADERS look similar, as again prices mostly stay in the range 30 to 80 (with one outlier in Treatment TRADERS). While the average price in Treatment CASH remains flat between 61 and 64 throughout the experiment it increases from 77 to 87 in Treatment TRADERS.

Hence, the inflow of cash only (in Treatment CASH) or inexperienced subjects only (in Treatment TRADERS) is insufficient to trigger bubbles. Combining these two factors in Treatment CAT, however, causes what we call the "inflow-effect". The effect leads to markedly increasing prices in all six markets and triggers strong bubbles in two of them. The average price increases each period, from 53 in period 2 to 183 in period 8. Importantly, prices of the four

[9]The exchange rates varied from 1 Euro=360 Taler in Treatment BASE to 1 Euro=3000 Taler for GEN4 in Treatment CAT to ensure comparable payouts across generations and treatments.

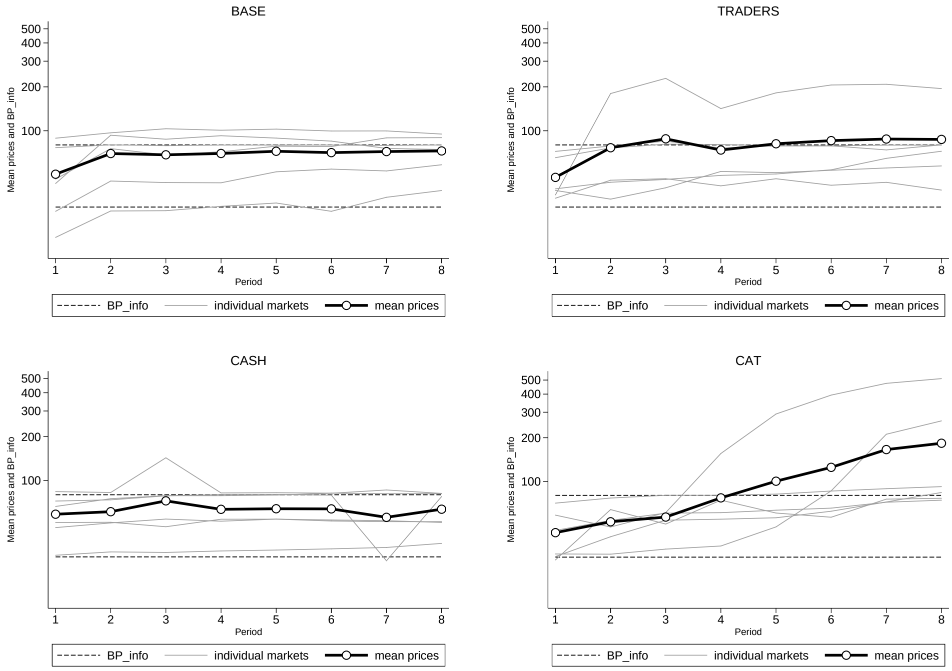

Figure 1: Average prices (bold line with circles) and volume-weighted mean prices for individual markets (grey lines) as a function of period for BASE (top left), CASH (bottom left), TRADERS (top right) and CAT (bottom right). The dashed lines show the two possible buyback prices (BP) of 30 and 80.

non-extreme markets also show much stronger price increases than markets of the other treatments. Prices in these four markets increase between 19.7 percent and 102.0 percent from period 2 to period 8.

As a measure of price dynamics we calculate the percentage difference of mean market prices P from period 2 (before new traders enter for the first time) to period 8 (after all traders have entered): $\Delta \mathrm{P}_{2\_8} = \frac{(P_8 - P_2)}{P_2}$. Table 3 shows results of statistical tests. We apply Wilcoxon signed-ranks tests for testing each treatment against zero (top panel) and pairwise Mann-Whitney U-tests for tests on differences between treatments (middle and bottom panels). The percentage price increase from period 2 to period 8 of 311 percent ($\Delta \mathrm{P}_{2\_8}$) in Treatment CAT is significantly different from zero and significantly higher than in any of the other three treatments. Importantly, significance levels of all tests remain almost identical even if the two extreme markets M3 and M5

Table 3: Top panel: Treatment averages of the price change from period 2 to period 8 (ΔP_{2_8}) in percent. Z-values of a Wilcoxon signed-ranks test are provided in parentheses (the null hypotheses test whether observations are different from zero). Bottom panel: Pairwise Mann-Whitney U-tests for ΔP_{2_8} (z-values and p-values in parenthesis are provided). Sample size N of each test equals 6 (signed-ranks test) or 12 (U-test).

Treatment	ΔP_{2_8}		
BASE	10.7		
	(0.734)		
CASH	4.7		
	(1.572)		
TRADERS	22.0		
	(1.363)		
CAT	311.1**		
	(2.201)		

ΔP_{2_8}	CASH	TRADERS	BASE
TRADERS			0.641
			(0.5218)
CASH		−0.480	−0.320
		(0.6310)	(0.7488)
CAT	2.882***	1.922*	2.082**
	(0.0039)	(0.0547)	(0.0374)

*, ** and *** represent the 10%, 5%, and 1% significance levels of a double-sided test.

of Treatment CAT are excluded. ΔP_{2_8} is not different from zero in any other treatment and there are no significant differences between the other treatments.

So far, we have established that bubbles emerge only with joint inflow of inexperienced new traders and cash. When these conditions are present we invariably observe increasing prices, up to nine times the actual average buyback price. Therefore, only research question 3 can be answered affirmatively as both conditions – new traders enter with cash – must be fulfilled at the same time.

3.2 Robustness Check Treatments

With treatments CAT^{14}, CAT^{INFO} and $\text{CAT}^{\text{OUTFLOW}}$ we follow two main objectives. First, we test the "inflow-effect" of Treatment CAT for robustness in a longer setting. Second, we investigate the price dynamics after all traders have entered the market (in Treatment CAT^{14}) and whether two prominent crash drivers (Galbraith, 1994; Kindleberger, 2000), the revelation of "new events"/"new information" (CAT$^{\text{INFO}}$) and the enforcement of liquidity constraints (CAT$^{\text{OUTFLOW}}$), trigger different price dynamics in the second half of the market. Figure 2 outlines average period prices of individual markets and treatment averages of treatments CAT^{14}, CAT$^{\text{INFO}}$ and CAT$^{\text{OUTFLOW}}$. It also shows the aggregate picture of all 18 markets of the three treatments. One can see that the "inflow-effect" is very pronounced in all three treatments, as bubbles emerge in almost every single market. The observed bubbles are very strong as prices increase on average by 294, 725 and 359 percent from period 2 to period 8 in treatments CAT^{14}, CAT$^{\text{INFO}}$ and CAT$^{\text{OUTFLOW}}$, respectively.[10]

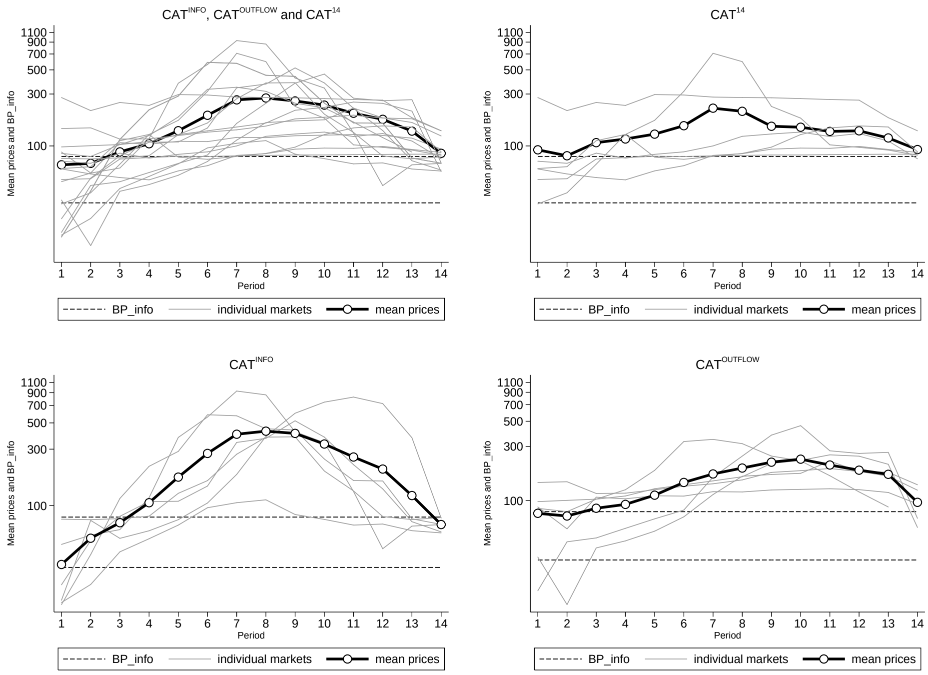

Figure 2: Average prices (bold line with circles) and volume-weighted mean prices for individual markets (grey lines) as a function of period for all 18 markets of all three robustness check treatments (top left), Treatment CAT^{14} (top right), Treatment CAT$^{\text{INFO}}$ (bottom) and Treatment CAT$^{\text{OUTFLOW}}$ (bottom right). The dashed lines show the two possible buyback prices (BP) of 30 and 80.

One can also see from Figure 2 that prices seem to drop towards 80 at the end of each treatment. The percentage price change from period 9 to period

[10]In market 6 of Treatment CAT$^{\text{OUTFLOW}}$ we exclude the last period price, because one subject mistakenly entered several buy limit orders of 999 with a quantity of one.

14 (ΔP_{9_14}) shows price drops with magnitudes of –29, –75 and –49 percent in treatments CAT^{14}, CAT^{INFO} and CAT^{OUTFLOW}, respectively. These numbers, however, are difficult to compare. At the end of the inflow phase in period 8, prices in CAT^{INFO} are markedly higher compared to the other treatments and so higher percentage price declines towards 80 are possible. However, it is evident that Treatment CAT^{INFO} exhibits different price dynamics in the second half of the experiment. Here prices in each market fall below 80 at the end of the experiment. This pattern is different in the two other treatments as mean prices ever fall below 80.

Table 4: Treatment averages of ΔP_{2_8} and ΔP_{9_14} in the first two columns. Z-values of a Wilcoxon signed-ranks test are provided in parentheses (the null hypotheses test whether observations are different from zero). The third column indicates the volume-weighted average market price in period 14 and the Wilcoxon signed-ranks statistic tests for differences from the upper buyback price of 80 (Z-values are provided in parentheses). Sample size N of each test equals 6. The last line indicates the results of all 18 markets of the three robustness check treatments (it is only possible to calculate the average for ΔP_{2_8} as treatments were identical up to this point).

Treatment	ΔP_{2_8}	ΔP_{9_14}	P_{14}
CAT^{14}	293.7**	−28.8**	92.6*
	(2.201)	(−1.992)	(1.780)
CAT^{INFO}	725.2**	−75.4**	69.2**
	(2.201)	(−2.201)	(−2.201)
CAT^{OUTFLOW}	358.6**	−48.8**	95.1
	(2.201)	(−2.201)	(0.946)
Aggregate	459.2***		
	(3.724)		

*, ** and *** represent the 10%, 5%, and 1% significance levels of a double-sided test.

Table 4 reports the related tests on significance. We find that the average price increase over all 18 markets of 459 percent (measured by ΔP_{2_8}) is highly significant at the 0.1 percent level. Again, all treatments impressively show the impact of the joint entry of new traders with cash on bubble formation. Tests for treatment differences of ΔP_{9_14} are not very meaningful because of the different price levels in period 9 between the treatments. To investigate differences in price dynamics towards the end of the experiment it is more reasonable to test whether prices return to the range of 30 to 80. P_{14} stands for the volume-weighted market price in period 14 and we test for differences from 80 with Wilcoxon signed-ranks tests. We observe that average final prices of 69 in $\mathrm{CAT}^{\mathrm{INFO}}$ are significantly below 80 which contrasts results of the other two treatments. Here prices stay above 90 and the price level is significantly higher than 80 for Treatment CAT^{14}.

We conclude that the "inflow-effect" is very pronounced in all 14-period settings, as bubbles emerge in almost every single market. The average price increase of 459 percent from period 2 to period 8 across all 18 markets is remarkable. We further conclude that as soon as the inflow of new traders stops prices start to decline until maturity of the asset (in Treatment CAT^{14}). This effect has its analogy in the Chinese Warrants Bubble, because Put options have a finite horizon. Like in our experiment the fundamental value will be revealed at maturity (i.e., the option will be executed or not) which stops irrational price behavior. The crash scenario of enforcing liquidity constraints shows similar results compared to CAT^{14} and only the revelation of complete information to a subset of traders leads to different (stronger) crash dynamics. Only when a majority has complete information prices become more efficient and therefore lie within the boundaries of 30 and 80.

3.3 Belief Elicitation

We have elicited subjects' beliefs about fundamentals and about future prices in each period. This allows us to gain insights into the bubble patterns in the treatments with trader inflow. As will be shown on the the next pages we find that subjects' beliefs about fundamentals and future prices only increase in markets with a steady inflow of new traders. Here, prices increase for two prominent reasons: (i) subjects (especially optimists) adapt their beliefs about fundamentals, i.e., buyback prices, upward and (ii) they speculate on ever higher prices in the hope to resell the asset later at an even higher price.

3.3.1 Beliefs about Fundamentals

Figure 3 presents subjects' beliefs about fundamentals. We calculate the average estimate of the unknown buyback price in each period of each market ($\overline{\text{BP}}_{m,t}$) and aggregate across markets to arrive at treatment means. To gain insights into the beliefs of the most optimistic traders we calculate the 85-percentile ($\text{OPT}(\text{BP}_{m,t})$) accordingly.[11] Table 5 presents the numbers for periods 2, 8, and 14 and further shows volume-weighted mean market prices.

One can see that average prices as well as average and optimists' beliefs about fundamentals are very stable over time in treatments BASE, CASH, and TRADERS. Again, all other treatments with a steady inflow of new traders with cash differ as the mean beliefs about fundamentals co-move with prices over time. It is evident that prices in these treatments converge to the optimists' beliefs about fundamentals at the end of the inflow phase in period 8. In particular, optimists are overly optimistic in period 2 as their beliefs exceed prices between 21 (CAT^{14}) and 89 percent (CAT^{INFO}). In period 8 their beliefs are less over-optimistic and fairly well calibrated with differences to prices ranging from –16 to 11 percent. In the robustness check treatments beliefs either decrease after period 8 (in CAT^{14} and CAT^{INFO}) or remain constant (in $\text{CAT}^{\text{OUTFLOW}}$). In Treatment CAT^{INFO} – the treatment with the strongest price crash – average beliefs even drop below the upper boundary of buyback prices towards 69. In the other two robustness check treatments optimists' beliefs either stay relatively high (32 percent above prices in CAT^{14}) or do not decrease at all (132 percent above prices in $\text{CAT}^{\text{OUTFLOW}}$).[12]

[11] We have consciously chosen the 85-percentile to be less prone to outliers and at the same time proxy optimists' beliefs more accurately. We obtain similar results with percentiles between 75 and 90.

[12] It is important to mention that mean prices in Treatment $\text{CAT}^{\text{OUTFLOW}}$ do not differ between periods 8 and 13 which is in line with the constant beliefs in the end of the experiment. Prices, however, drop strongly in the final period to values below average and optimists' beliefs.

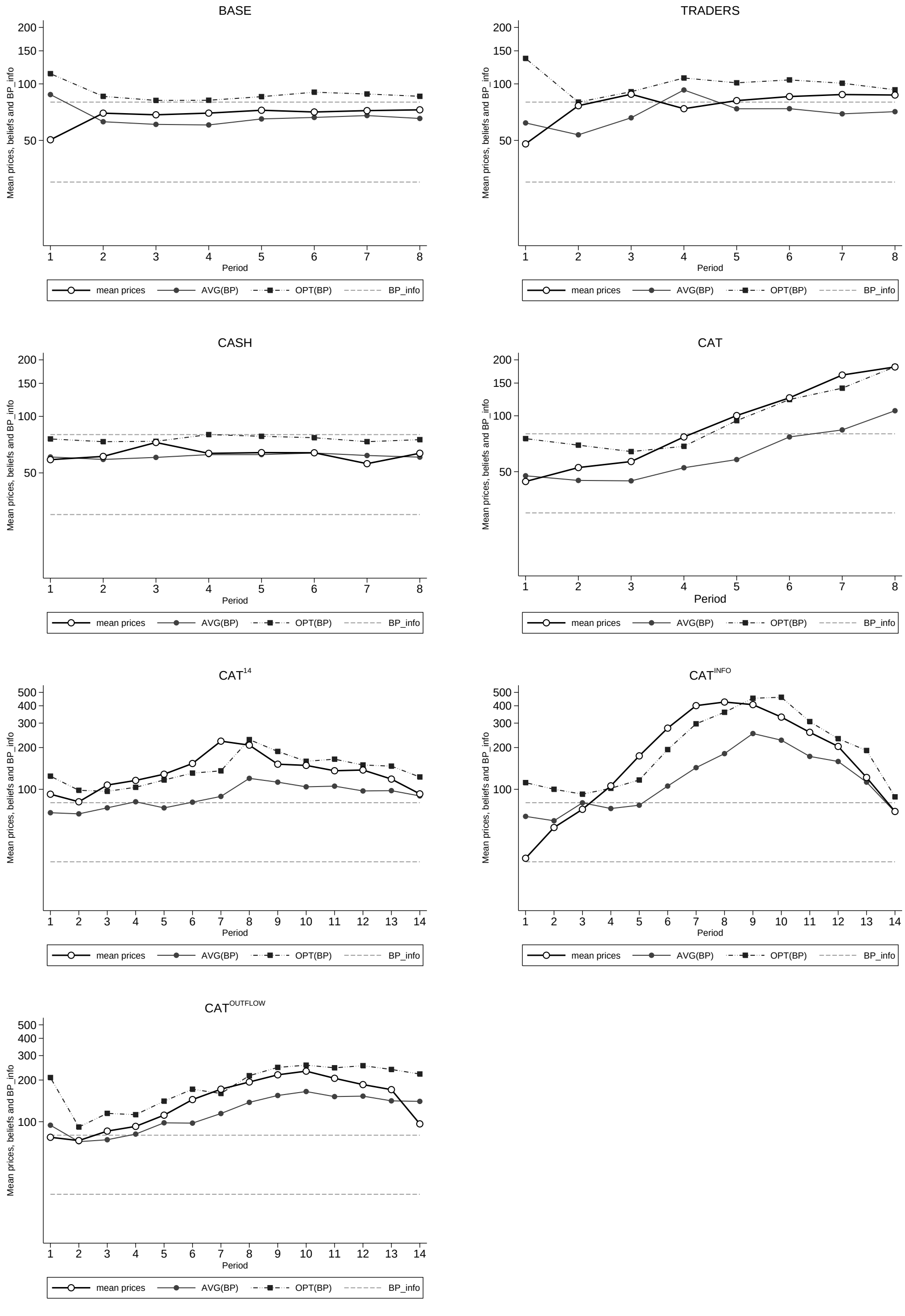

Figure 3: Volume-weighted average market prices (bold line with circles), average beliefs for the unknown buyback price ($\overline{\text{BP}}$ – black line with dark circles), optimists' beliefs for the unknown buyback price measured by the 85-percentile (OPT(BP) – dashed-dotted line with squares) of the individual treatments. Note the different scaling for treatments CAT^{14}, CAT$^{\text{INFO}}$ and CAT$^{\text{OUTFLOW}}$ in the bottom.

Table 5: Top panel: Volume-weighted average market prices and average ($\overline{\text{BP}}_t$) and optimists' beliefs about fundamentals ($\text{OPT}(\text{BP}_t)$) in periods 2, 8, and 14. Bottom panel: Treatment means of the average and optimists' percentage change in beliefs about fundamentals from period 2 to period 8, $\Delta\overline{\text{BP}}_{2\_8}$ and $\Delta\text{OPT}(\text{BP}_{2\_8})$, respectively. $\Delta\overline{\text{BP}}_{9\_14}$ and $\Delta\text{OPT}(\text{BP}_{9\_14})$ show the percentage change from period 9 to 14.

	P_2	$\overline{\text{BP}}_2$	$\text{OPT}(\text{BP}_2)$	P_8	$\overline{\text{BP}}_8$	$\text{OPT}(\text{BP}_8)$	P_{14}	$\overline{\text{BP}}_{14}$	$\text{OPT}(\text{BP}_{14})$
CASH	69.8	62.9	85.8	72.8	65.4	86.9			
TRADERS	61.2	59.0	73.3	63.6	60.7	75.2			
BASE	76.5	53.5	80.0	87.2	71.1	93.0			
CAT	52.6	44.9	69.5	183.3	106.5	183.7			
CAT^{14}	81.3	66.5	98.3	208.1	119.9	228.2	92.7	89.5	122.7
CAT^{INFO}	53.0	59.3	100.0	425.8	180.8	359.2	69.2	68.6	88.2
$\text{CAT}^{\text{OUTFLOW}}$	73.2	71.9	91.7	193.6	138.1	215.0	95.1	140.3	221.0

	$\Delta\overline{\text{BP}}_{2\_8}$	$\Delta\text{OPT}(\text{BP}_{2\_8})$	$\Delta\overline{\text{BP}}_{9\_14}$	$\Delta\text{OPT}(\text{BP}_{9\_14})$
CASH	7.7	3.0		
TRADERS	4.3	9.3		
BASE	30.5**	15.7		
CAT	139.0**	172.5*		
CAT^{14}	131.2**	217.5*	−9.6	−14.8
CAT^{INFO}	202.5**	288.3**	−66.0**	−73.3**
$\text{CAT}^{\text{OUTFLOW}}$	121.5**	183.3**	1.1	−0.5

*, ** and *** represent the 10%, 5%, and 1%
significance levels of a double-sided Wilcoxon signed-ranks test for differences against zero.
Sample size N for each test is 6.

As a measure whether beliefs of fundamentals are updated over time we calculate the percentage change of average and optimists' beliefs of the unknown buyback price from period 2 to period 8. $\Delta\overline{\mathrm{BP}}_{2\_8} = \frac{(\overline{\mathrm{BP}}_8 - \overline{\mathrm{BP}}_2)}{\overline{\mathrm{BP}}_2}$ stands for the average beliefs and $\Delta\mathrm{OPT}(\mathrm{BP}_{2\_8})$ measures the optimists' beliefs accordingly. Like in our analyses on price dynamics we apply the same procedure for periods 9 to 14 in the three robustness check treatments.

One can see in the bottom panel of Table 5 that beliefs do not change over time in treatments BASE and CASH as the numbers are not different from zero. Treatment TRADERS shows the same pattern for optimists but a significant increase in average beliefs of 31 percent. Although the trend of average beliefs is stable over time, beliefs are lowest in period 2 which leads to this significant result. In the inflow treatments CAT, CAT^{14}, CAT$^{\mathrm{INFO}}$, and CAT$^{\mathrm{OUTFLOW}}$ all changes in average and in optimists' beliefs are significantly different from zero and high in magnitude.[13] Similarly, beliefs are revised downward towards the end of the experiment in the robustness check treatments CAT^{14} and CAT$^{\mathrm{INFO}}$ with the latter showing significant results.

We consider these findings to be remarkable as fundamentals do not change during the experiment. To the best of our knowledge we are the first to show that subjects collectively become overly optimistic by updating their *beliefs about fundamentals* upward.

3.3.2 Beliefs about Prices

The data on price beliefs presented in Figure 4 for two representative markets of CAT$^{\mathrm{INFO}}$ shows a clear picture. Average beliefs about all future market prices $t+k$, elicited in period t, $(\overline{\mathrm{P}}_{t,t+k})$ adapt upward after prices increase, but they are rarely higher than last period's average price. In contrast, optimists' beliefs (the 85-percentile of price beliefs) for period $t+k$, elicited in period t, $(\mathrm{OPT}(\mathrm{P}_{t,t+k}))$ are often higher than the average market price of period $t-1$

[13] Note that the percentage changes are lower compared to the changes in prices, particularly for the optimists. As mentioned, this effect is explained by the overly optimistic beliefs of the optimists in period 2 which increases the denominator of the variable. Like in the analyses of the price dynamics, changes in beliefs in Treatment CAT are significantly different compared to the other treatments for average and optimists' beliefs (an exception is the comparison of optimists' beliefs to Treatment TRADERS where differences are marginally insignificant).

and increase with prediction horizon (see right panel of Figure 4). This means that prices adjust towards the price beliefs of the most optimistic traders rather than to the average estimate.[14]

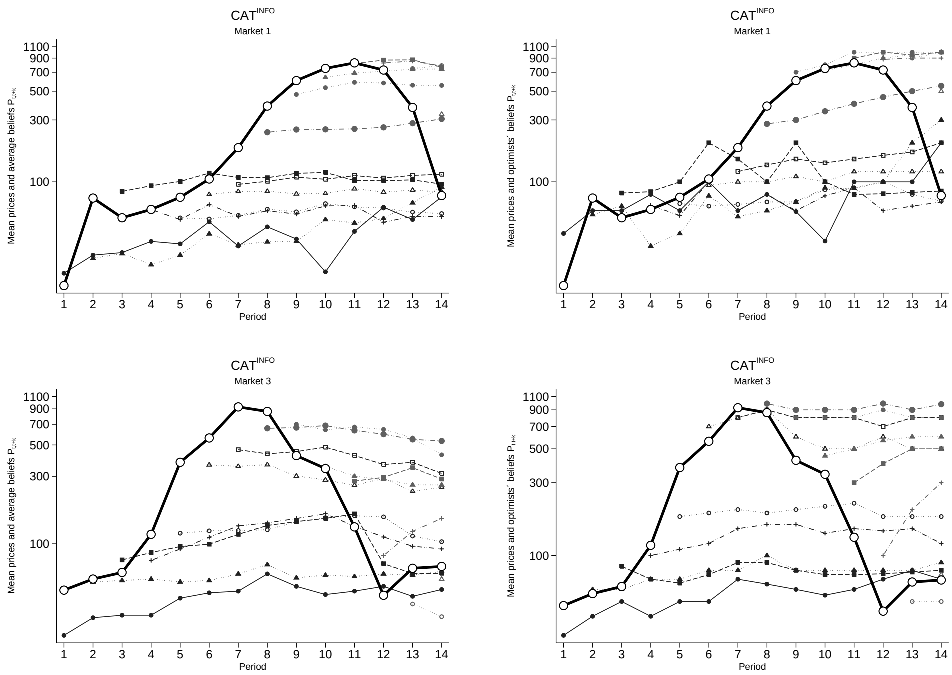

Figure 4: Left: volume-weighted average market prices (bold solid line with circles) and average price guesses for all future periods ($\overline{\mathrm{P}}_{t,t+k}$) of individual markets of Treatment CAT$^{\mathrm{INFO}}$. Right: volume-weighted average market prices (bold solid line with circles) and optimists' price guesses measured by the 85-percentile (OPT(P)) for all future periods ($\overline{\mathrm{P}}_{t,t+k}$) of selected markets of Treatment CAT$^{\mathrm{INFO}}$. The dashed and dotted lines label period 1 to period 14.

To detect belief dynamics we run panel-regressions. We calculate the differences between subjects' price beliefs and past period prices ($\overline{P}_{m,t-1}$) according to the following equations:

[14] Note that very similar patterns emerge in treatments CAT, CAT^{14} and CAT$^{\mathrm{OUTFLOW}}$ compared to Treatment CAT$^{\mathrm{INFO}}$. In line with the price developments in treatments CASH, TRADERS, and BASE beliefs about future market prices mainly remain within the boundaries of 30 to 80. Details on beliefs in each market can be provided upon request.

$$\overline{BeP}_{m,t,t+k} = \overline{\mathrm{P}}_{m,t,t+k} - \overline{P}_{m,t-1};\ k \in \{0,...,2\}, \tag{1}$$

$$BeP^{\mathrm{OPT}}_{m,t,t+k} = \mathrm{OPT}(\mathrm{P}_{m,t,t+k}) - \overline{P}_{m,t-1}. \tag{2}$$

$\overline{\mathrm{P}}_{m,t,t+k}$ stands for the average belief about future market prices for period $t+k$ among all subjects, elicited in period t, with $k \in \{0,...,2\}$. Thus, we focus on average beliefs about this period's market price and the ones of the next two periods separately. $\mathrm{OPT}(\mathrm{P}_{m,t,t+k})$ is a proxy for the optimists' beliefs by calculating the 85-percentile among all beliefs. We subtract the past period price $\overline{P}_{m,t-1}$ from each of the two variables.

$$y1_{m,t,t+k} = \alpha + \epsilon_{m,t};\ k \in \{0,...,2\}. \tag{3}$$

With the market-fixed-effects (cross section, CS) panel regression of Equation (3) we test each treatment separately for significance. $y1_{m,t,t+k}$ is a generic placeholder for $\overline{BeP}$ and BeP^{OPT} (BeP is an acronym for "Beliefs about Prices"). A positive value of the intercept indicates that beliefs about future prices are higher than last period's average trading price and is therefore an indication of a speculative motive.

Table 6: Market (CS) fixed-effects panel regression of Equation (3). BeP and BeP^{OPT} detect speculative motives by comparing beliefs about future market prices up to $t+2$, elicited in period t (market average and 85-percentile, respectively), with the average market price of the last period. For the robustness check treatments CAT^{14}, CAT$^{\mathrm{INFO}}$, and CAT$^{\mathrm{OUTFLOW}}$ the analyses are shown for the inflow phase up to period 8 and for the entire data set of 14 periods.

Treatment	$BeP_{m,t,t+k}$			$BeP^{\mathrm{OPT}}_{m,t,t+k}$		
	t,t	t,t+1	t,t+2	t,t	t,t+1	t,t+2
BASE	4.45	4.10*	4.23	7.44***	9.30***	11.30***
CASH	1.64	1.64	−0.81	2.50	2.20	2.01
TRADERS	9.73*	9.83**	14.33*	27.43**	25.90***	32.07***
CAT	−0.14	−0.19	1.65	19.47***	22.44***	25.27*
CAT^{14}, t 1-8	−16.26***	−17.67***	−18.31***	11.51***	13.87***	16.63***
CAT$^{\mathrm{INFO}}$, t 1-8	−14.44	−8.96	−5.83	51.06***	65.56***	73.68***
CAT$^{\mathrm{OUTFLOW}}$, t 1-8	8.93**	9.72**	11.42**	41.49***	45.97***	53.54***
CAT^{14}, t 1-14	−14.07***	−15.86***	−17.44***	8.05***	11.28***	14.69***
CAT$^{\mathrm{INFO}}$, t 1-14	−10.76	−5.20	−2.57	53.99***	77.19***	93.57***
CAT$^{\mathrm{OUTFLOW}}$, t 1-14	0.74	2.61	4.97	36.04***	45.28***	54.80***
N	42(78)	36(72)	30(66)	42(78)	36(72)	30(66)
Fixed effects	CS	CS	CS	CS	CS	CS

*, ** and *** represent the 10%, 5%, and 1% significance levels of a double-sided test.
Sample size N for the 14-period data set of treatments CAT^{14}, CAT$^{\mathrm{INFO}}$ and CAT$^{\mathrm{OUTFLOW}}$ is indicated in parentheses.

The findings in Table 6 corroborate those gained from Figure 4: optimists expect future prices up to $t+2$ to be higher than last period's prices in treatments CAT, CAT^{14}, CAT^{INFO}, and $\text{CAT}^{\text{OUTFLOW}}$ and therefore show a speculative motive (Table 6, columns 4-6). In addition, optimists expect prices to be even higher, the further in the future they are. This is evident by increasing coefficient values with longer prediction horizons and this pattern does not appear for the average beliefs (columns 1-3). Patterns in the other treatments are qualitatively similar, but less pronounced.

4 Conclusion and Discussion

With a novel experimental design that features heterogeneous information about the (constant) fundamental value of the asset we explored conditions for the formation and bursting of bubbles. In four basic treatments we disentangled the effect of trader inflow from the effect of cash inflow. In three additional treatments with longer trading horizons we tested the "inflow-effect" for robustness in a longer setting and we investigated price dynamics after all traders have entered the market.

We found (i) an "inflow-effect", as only the joint inflow of new traders and cash triggers bubbles, while each of these factors per se is not sufficient for bubble formation. We found that this effect is very robust and strong in magnitude, particularly in markets with longer trading horizons. With these results we support the arguments of Galbraith (1994), Kindleberger (2000) and Xiong and Yu (2011).

We also showed that (ii) in treatments with trader and cash inflow only in the first half of the market, prices converged to fundamentals towards maturity of the asset. We found that as soon as the inflow of new traders stops prices start to decline until maturity of the asset. We reported that only providing a subset of traders with complete information leads to stronger crashes as prices fall within the boundaries of both buyback prices and are significantly lower than 80.

Turning to traders' beliefs, we found that (iii) beliefs about fundamentals co-moved with the bubble/crash price patterns in treatments featuring joint inflow of new inexperienced traders and cash. This finding is remarkable as fundamentals did not change over time. This paper offers the first experimental evidence showing that subjects collectively become overly optimistic about fundamentals. Finally, we also reported a speculative motive only among optimists in treatments where bubbles occur. In particular, optimists expected future prices to be higher than current trading prices. Only in treatments leading to bubbles future market prices did converge to or even exceed the most optimistic price beliefs for these periods.

The high magnitude of bubbles in almost all of the 24 markets of treatments with joint inflow of new traders and cash provides substantial new findings. The observed "inflow-effect" is extraordinary because we neither apply the bubble-prone setting of Smith et al. (1988) nor do we set up the markets with high initial CA-Ratios that also reliably produce bubbles (Caginalp et al., 1998, 2001; Haruvy and Noussair, 2006). The novelty of our approach is the combination of a constant fundamental value setting with heterogeneous information and new trader inflow with cash. It appears that the latter two ingredients are major drivers of bubbles as hypothesized by Galbraith (1994), Kindleberger (2000) and Xiong and Yu (2011).

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Appendix

Appendix A: Instructions of the Experiment

Appendix A.1: Experimental Instructions - Inflow Treatments[15]

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 have any questions concerning the experimental procedure or the instructions, please raise your hand and the supervisor will answer your questions privately.

Background of the experiment This experiment is concerned with replicating an asset market where 4-16 traders can trade an asset of a fictitious company over 14 (**8**) periods, whereas each period lasts for 3 minutes (180 sec.).

Your role in the Experiment

Not each one of you will be acting as an active trader from the start of the experiment. Basically, you can be designated to act as a trader in the market from the beginning or to take the role of an inactive trader up to a certain period, i.e., you will be entering the market later on at a given time.

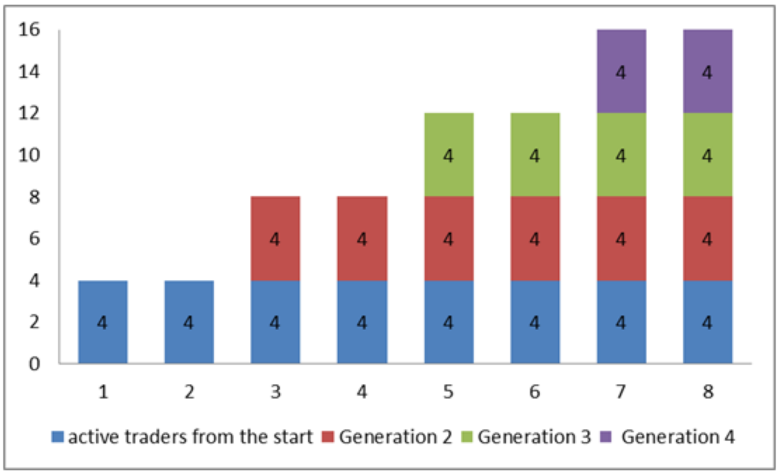
Active traders: As an active trader you participate in trading the asset on the market and are able to buy and sell assets. There are at least 4 and at most 16 active traders in the market.

Inactive traders: A maximum of 12 persons are assigned to the role of inactive traders. As an inactive trader you are asked to fulfill different tasks in different periods.

Information about the market entry

[15] Instructions are for CAT^{14}, CAT^{INFO} and $CAT^{OUTFLOW}$, text changes in CAT and TRADERS are (**bold**) and paragraphs that are differently formulated in the instructions for TRADERS are *italicized.*

Participants taking the role of an inactive trader at the beginning of the experiment will be assigned to one of three generations of traders, who enter the market at different periods. Generations consist of 4 persons each, who enter the market at the beginning of period 3, 5 and 7 so that beginning with period 7 in total 16 traders will be active on the market. The following illustration gives an overview of the points of time in which new generations enter and about how many persons are active on the market (y-axis) in each period (x-axis).



In what follows you receive information about your tasks as an inactive and as an active trader.

Your tasks as an inactive trader

Multiplying numbers

Doing this task you earn money by solving as many arithmetic problems as possible, where each problem consists of multiplying a one-digit by a two-digit number. If your calculation was correct, the problem will be counted as solved, whereas if you fail, an error message will appear.

Adding numbers

This task also involves solving as many arithmetic problems as possible in 3 minutes (180 sec.). In each problem your task is to add five two-digit numbers correctly. Entering your solution, you get informed about whether your solution was correct immediately. If you fail to calculate the correct sum, contrary to the task "multiplying numbers", a new problem will be generated.

For both tasks the use of calculators is not permitted. Please use the additionally distributed sheets of paper to solve the calculations.

Slider task

This task involves positioning as many sliders as possible correctly within 3 minutes (180 sec.). On the screen 48 sliders are displayed, which at the beginning of the period are all positioned at 0 and can be adjusted up to position 100. The current position of the slider is displayed to the right of each slider. Your earnings from this task depend on how many sliders you are able to adjust exactly to position 50. To do so you can use the mouse and you are allowed to readjust each single slider as many times as you want to.

Your tasks as an active trader

Trading

Participating in the market as an active trader you can sell and buy assets. 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 for the asset with prices ranging from 0 to a maximum of 999 Taler (with at most two decimal places). For every quote you make, you have to enter the number of assets you intend to trade as well. Market price is only determined by supply and demand of the active traders in the market.

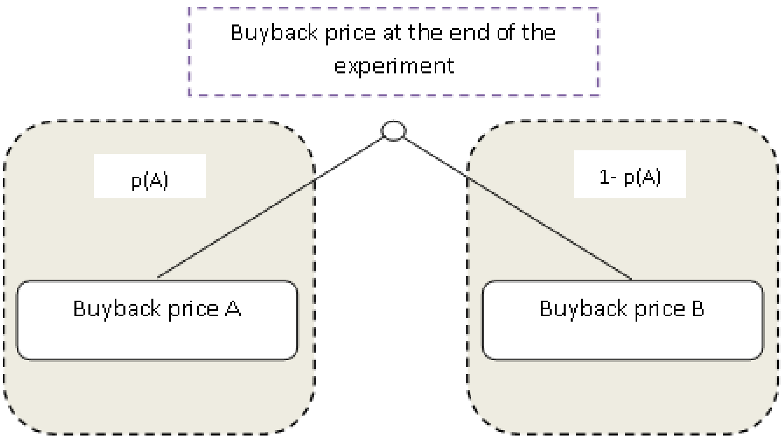
If you buy assets, your Taler holdings will be decreased by the respective expenditures (price * quantity) and the number of assets will be increased by the quantity of newly bought assets. Inversely, if you sell assets, your Taler holdings will be increased by the respective revenues (price * quantity) and the number of assets will be decreased by the quantity of newly sold assets.

Each trader gets a certain amount of Taler as part of their initial endowment,

which will be announced to them before market entry. Traders actively participating in the market from the beginning of the experiment receive 40 units of the asset. Traders entering in later periods receive their whole initial endowment in the form of Taler and do not obtain any assets when entering the market.
Each trader gets a certain amount of Taler as part of their initial endowment, which will be announced to them before market entry, and 40 units of the asset. Note that your asset and Taler holdings carry over from one period to the next and that (**your Taler and**) asset holdings cannot drop below zero.

Information about the asset´s buyback price

At the end of the experiment the units of asset you own are bought back by the experimenter at one of two possible buyback prices (A or B with probabilities p(A) and 1-p(A)) per unit of the asset. The actual buyback price is determined randomly. Every trader gets information on one of the two possible buyback prices: Before entering the market 8 of 16 traders receive information on the probability of occurrence and the value of buyback price A, whereas the other half of the traders receives information on the probability of occurrence and the value of buyback price B.



Predictions

Additionally to your trading activity you will be asked to predict the develop-

ment of mean market prices over all remaining periods and to give an estimation of the second, unknown buyback price, in each period.
Your earnings from predicting the market price and estimating the second buyback price depend on the accuracy of your prediction and your estimation and are calculated separately as follows:

Accuracy of your prediction/estimate	**Earnings**
within +/-10% of the correct value	2.25 EUR
within +/-20% of the correct value	1.50 EUR
within +/-40% of the correct value	0.50 EUR

At the end of the experiment one of your market price predictions and one of your buyback price estimates will be chosen randomly. Only these two guesses will be relevant for your payoff from this task.

Example: Your estimate of the buyback price in period 2 and your prediction of the mean market price in period 3 for period 5 were chosen randomly. If for instance your prediction for the market price deviates by 18% from the actual mean market price in this period and your estimate of the second buyback price is 9% higher than the actual second buyback price, you will earn 3.75 EUR in total, consisting of 1.5 EUR from predicting the market price and 2.25 EUR from guessing the second buyback price.

Calculation of your payment

Your payout as an inactive trader (in EUR) is calculated as follows:

Per 10 multiplication problems solved correctly you receive 75 cent.

Earnings from the multiplication task = number of correctly solved problems*0.075

For each correctly solved addition you receive 25 cent.

Earnings from the addition task = number of correctly solved problems*0.25

Earnings from the slider task = number of correctly solved problems*0.045

Per 10 correctly positioned sliders you receive 45 cent.
Your payout as an active trader (in EUR) is calculated as follows: The number of units of the asset you hold is multiplied with the randomly drawn buyback price and then added to your Taler holdings.

Wealth as active trader in Taler = asset holdings * buyback price + Taler

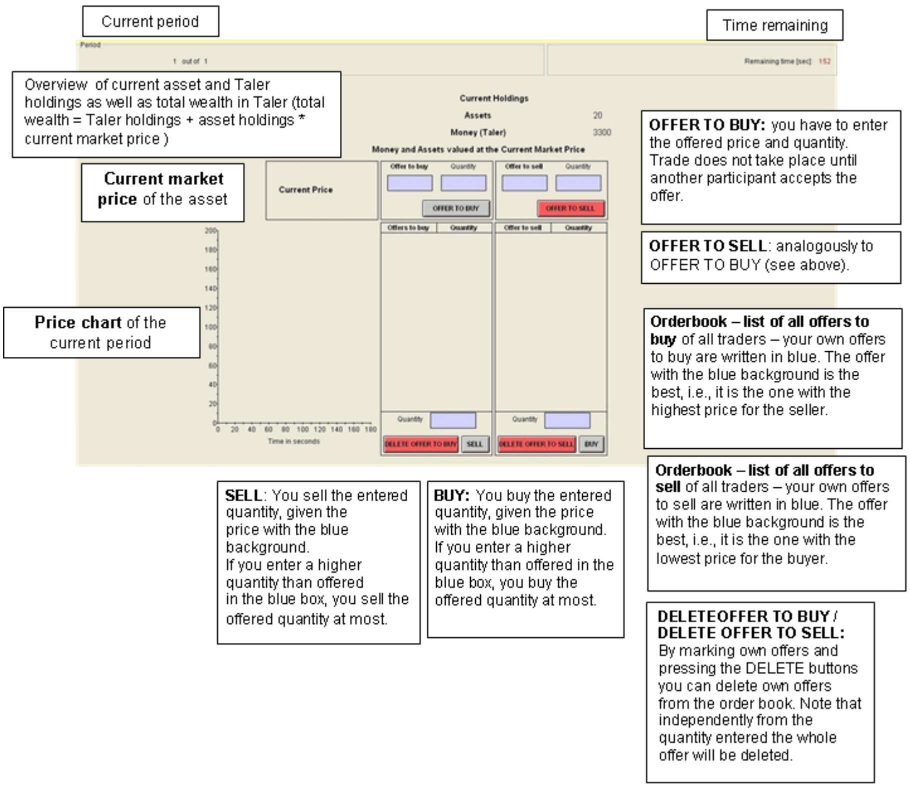
Your earnings from trade will then be converted to EUR using a certain conversion rate (Taler per EUR) you will be informed about before market entry. Additionally you receive earnings from predicting prices and guessing the second buyback price.

Wealth as active trader in EUR = wealth as active trader in Taler/conversion rate + earnings from predicting prices and guessing the second buyback price

Your total earnings from the experiment consist of your payout as an active trader and as an inactive trader.

Total earnings = payout as active trader + payout as inactive trader

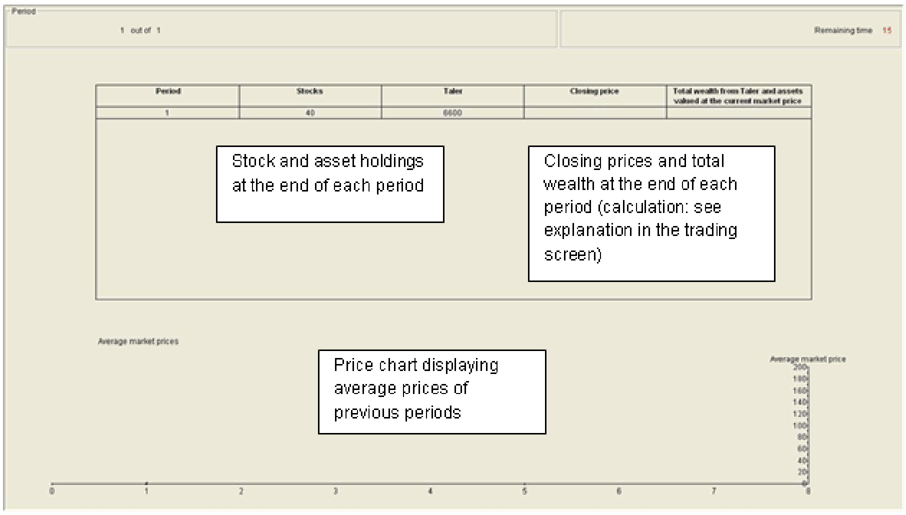
Trading screen[16]



[16] For all treatments the same trading screen was used.

History screen[17]

After each period the following screen will appear for 15 seconds, providing you with information on your asset and Taler holdings as well as your wealth at the end of the current period (in periods where you have not been actively participating in the market, for closing prices and total wealth a value of -1 will be shown). Additionally you receive information on the price development for all periods (you have been actively participating in the market). (Inactive traders will be given information on the task to be fulfilled in the following period.)



[17]History screens for all treatments looked similar, while evidently in CAT^{INFO} and $\text{CAT}^{\text{OUTFLOW}}$ average mean prices up to period 14 were displayed and self-evidently in CASH and BASE passages in brackets where left out in the description of the history screen.

Appendix A.2: Experimental Instructions - No Inflow Treatments[18]

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 have any questions concerning the experimental procedure or the instructions, please raise your hand and the supervisor will answer your questions privately.

Background of the experiment This experiment is concerned with replicating an asset market where 8 traders can trade an asset of a fictitious company over 8 periods, whereas each period lasts for 3 minutes (180 sec.).

Information on the market architecture and your tasks as a trader

Trading

Participating in the market as an active trader you can sell and buy assets. 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 the asset with prices ranging from 0 to a maximum of 999 Taler (with at most two decimal places). For every quote you make, you have to enter the number of assets you intend to trade as well. Market price is only determined by supply and demand of the active traders in the market.

If you buy assets, your Taler holdings will be decreased by the respective expenditures (price * quantity) and the number of assets will be increased by the quantity of newly bought assets. Inversely, if you sell assets, your Taler holdings will be increased by the respective revenues (price * quantity) and the number of assets will be decreased by the quantity of newly sold assets.

Each trader gets a certain amount of Taler as part of their initial endowment, which will be announced to them before market entry, and 20 units of the asset. Note that your asset and Taler holdings carry over from one period to the next and that your Taler and asset holdings cannot drop below zero.

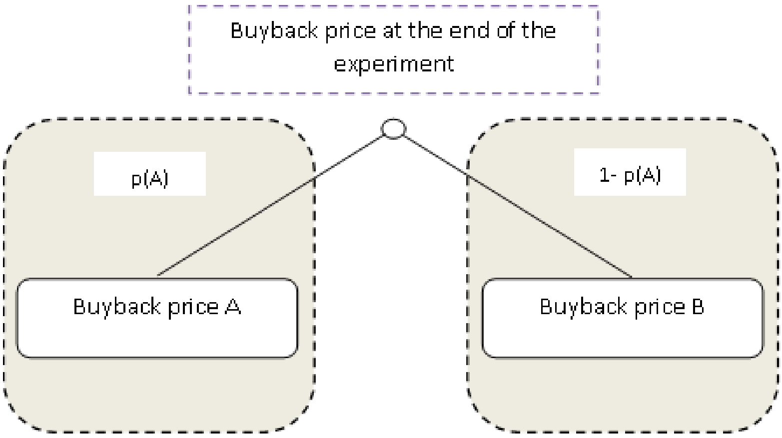
[18] Instructions are for BASE, text changes in CASH are (**bold**).

At the end of period 2, period 4 and period 6 you will receive earnings from other sources of income, which will be added to your current Taler holdings (see table below for details).

End of Period	1	2	3	4	5	6	7	8
Additional earnings	0	4400	0	4400	0	4400	0	0

Information about the asset´s buyback price

At the end of the experiment the units of asset you own are bought back by the experimenter at one of two possible buyback prices (A or B with probabilities p(A) and 1-p(A)) per unit of the asset. The actual buyback price is determined randomly. Every trader gets information on one of the two possible buyback prices: Before entering the market 4 of 8 traders receive information on the probability of occurrence and the value of buyback price A, whereas the other half of the traders receives information on the probability of occurrence and the value of buyback price B.



Predictions

Additionally to your trading activity you will be asked to predict the development of mean market prices over all remaining periods and to give an estimation of the second, unknown buyback price, in each period.

Your earnings from predicting the market price and estimating the second buyback price depend on the accuracy of your prediction and your estimation and are calculated separately as follows:

Accuracy of your prediction/estimate	**Earnings**
within +/-10% of the correct value	2.25 EUR
within +/-20% of the correct value	1.50 EUR
within +/-40% of the correct value	0.50 EUR

At the end of the experiment one of your market price predictions and one of your buyback price estimates will be chosen randomly. Only these two guesses will be relevant for your payoff from this task.

Example: Your estimate of the buyback price in period 2 and your prediction of the mean market price in period 3 for period 5 were chosen randomly. If for instance your prediction for the market price deviates by 18% from the actual mean market price in this period and your estimate of the second buyback price is 9% higher than the actual second buyback price, you will earn 3.75 EUR in total, consisting of 1.5 EUR from predicting the market price and 2.25 EUR from guessing the second buyback price.

Calculation of your payment

Your payout as a trader (in EUR) is calculated as follows:

The number of units of the asset you hold is multiplied with the randomly drawn buyback price and then added to your Taler holdings.

Wealth in Taler = asset holdings * buyback price + Taler

Your earnings from trade will then be converted to EUR using a certain conversion rate (Taler per EUR) you will be informed about before market entry. Additionally you receive earnings from predicting prices and guessing the second buyback price.

Wealth in EUR = wealth in Taler/conversion rate + earnings from predicting prices and guessing the second buyback price

Appendix B: Individual Market Data[19]

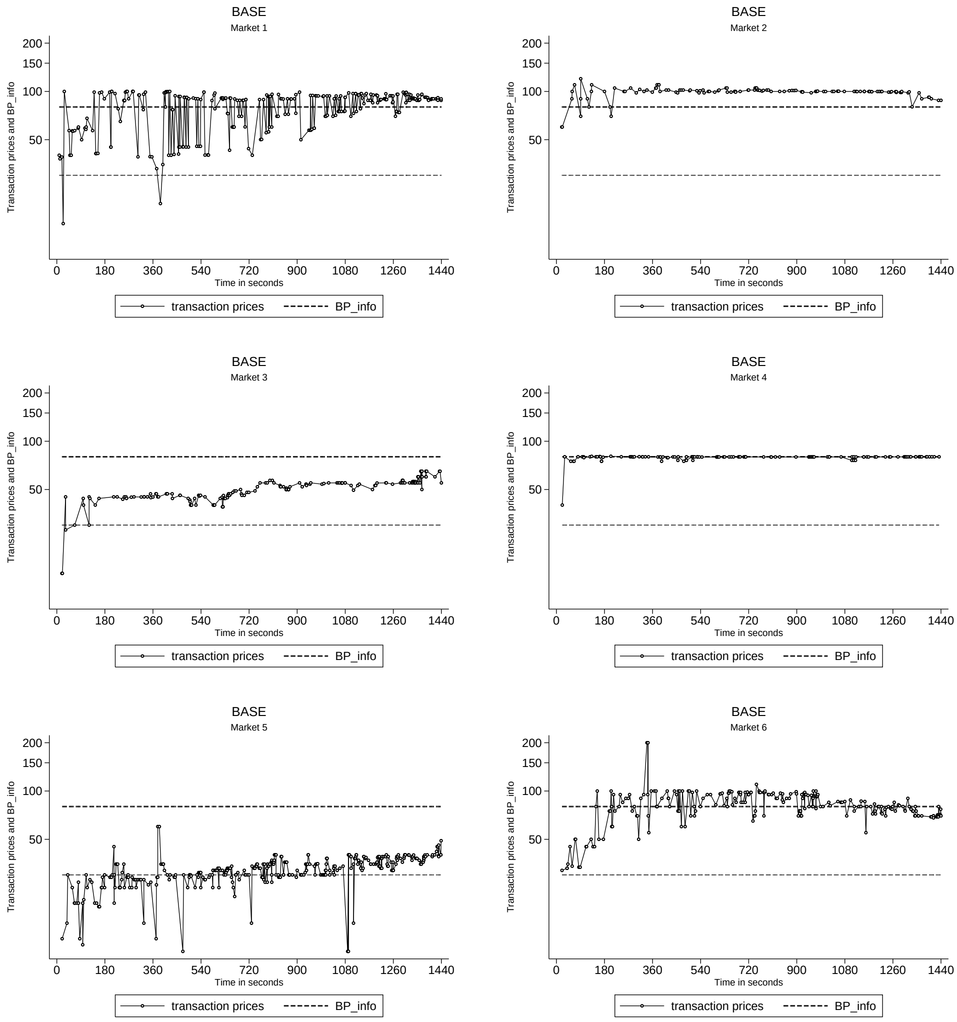


Figure A1: Single transaction prices over time for all markets of Treatment BASE.

[19]For online publication only.

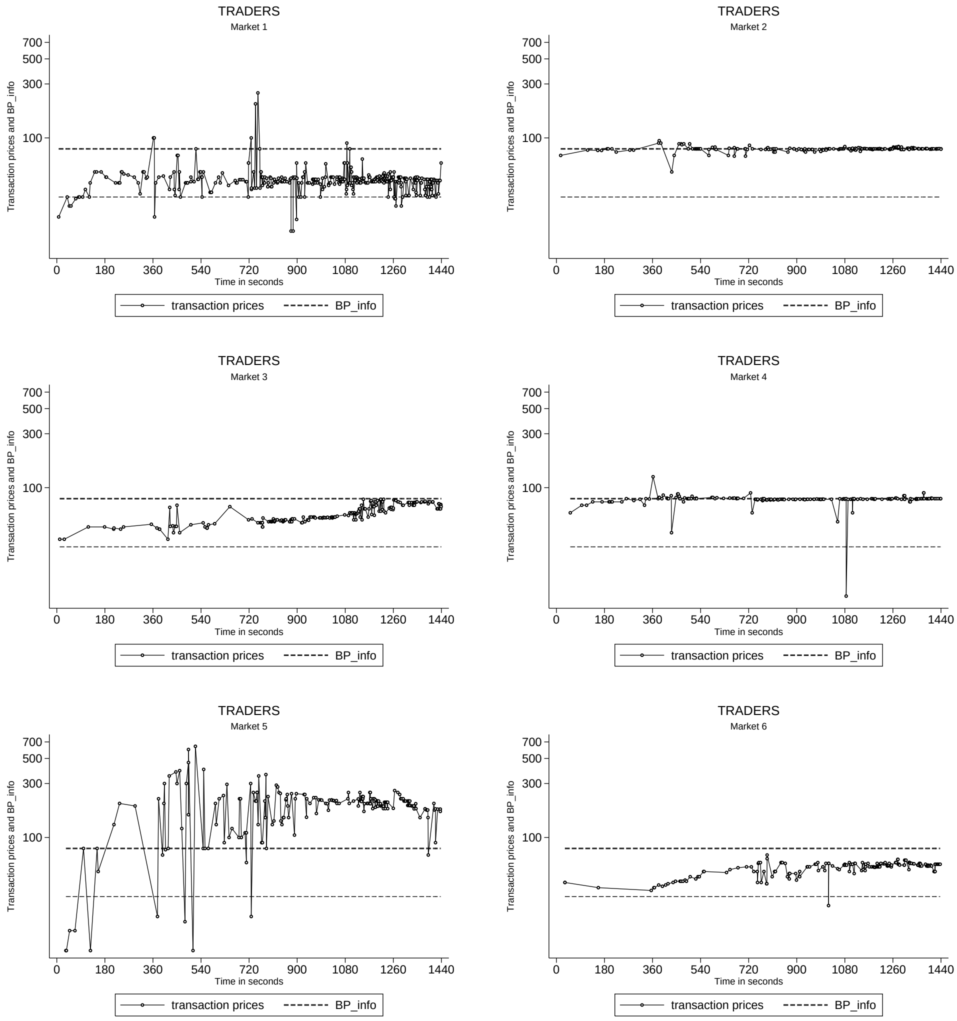


Figure A2: Single transaction prices over time for all markets of Treatment TRADERS.

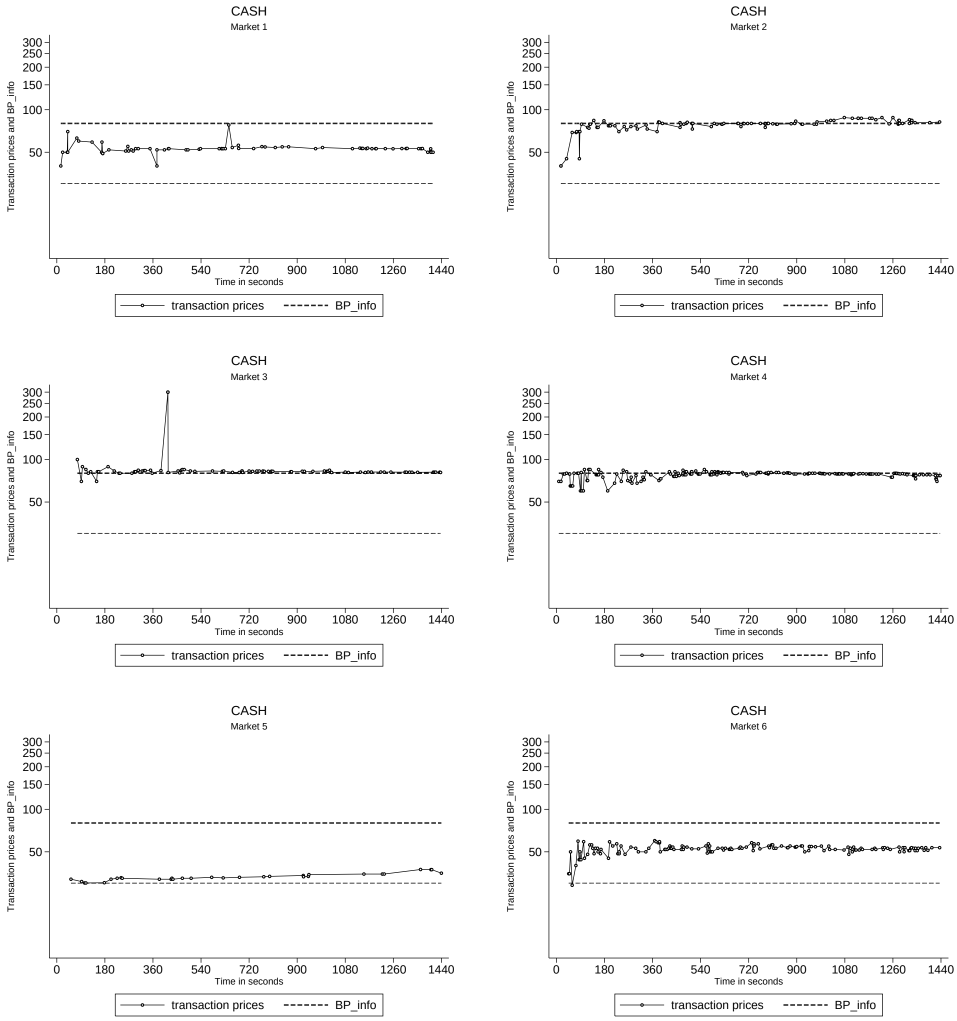


Figure A3: Single transaction prices over time for all markets of Treatment CASH.

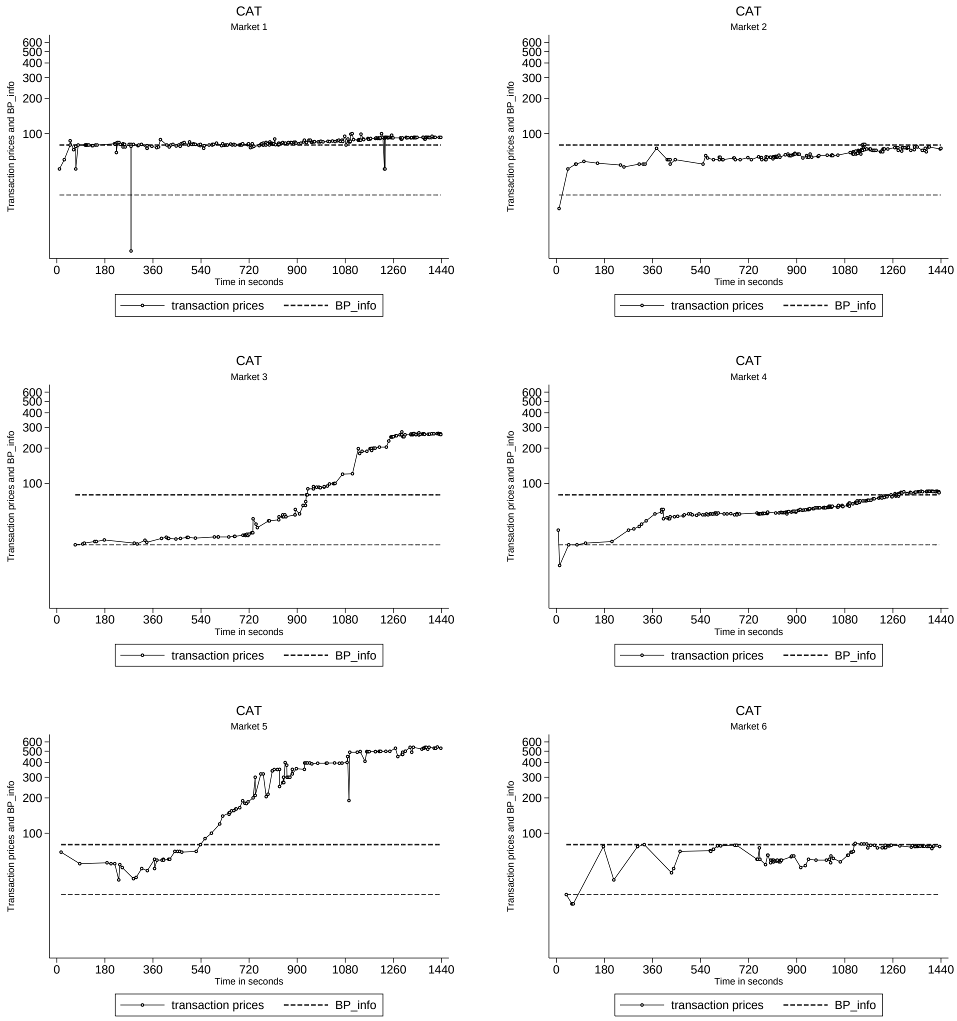


Figure A4: Single transaction prices over time for all markets of Treatment CAT.

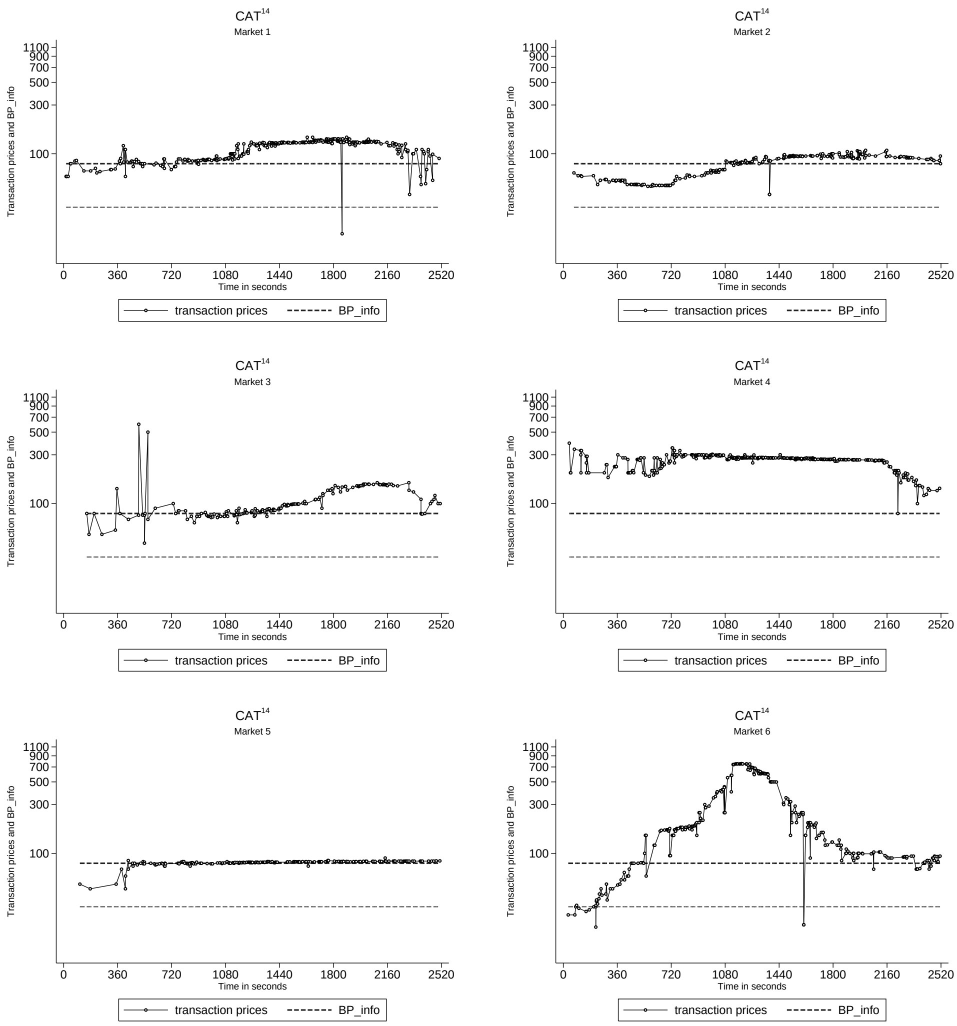


Figure A5: Single transaction prices over time for all markets of Treatment CAT^{14}.

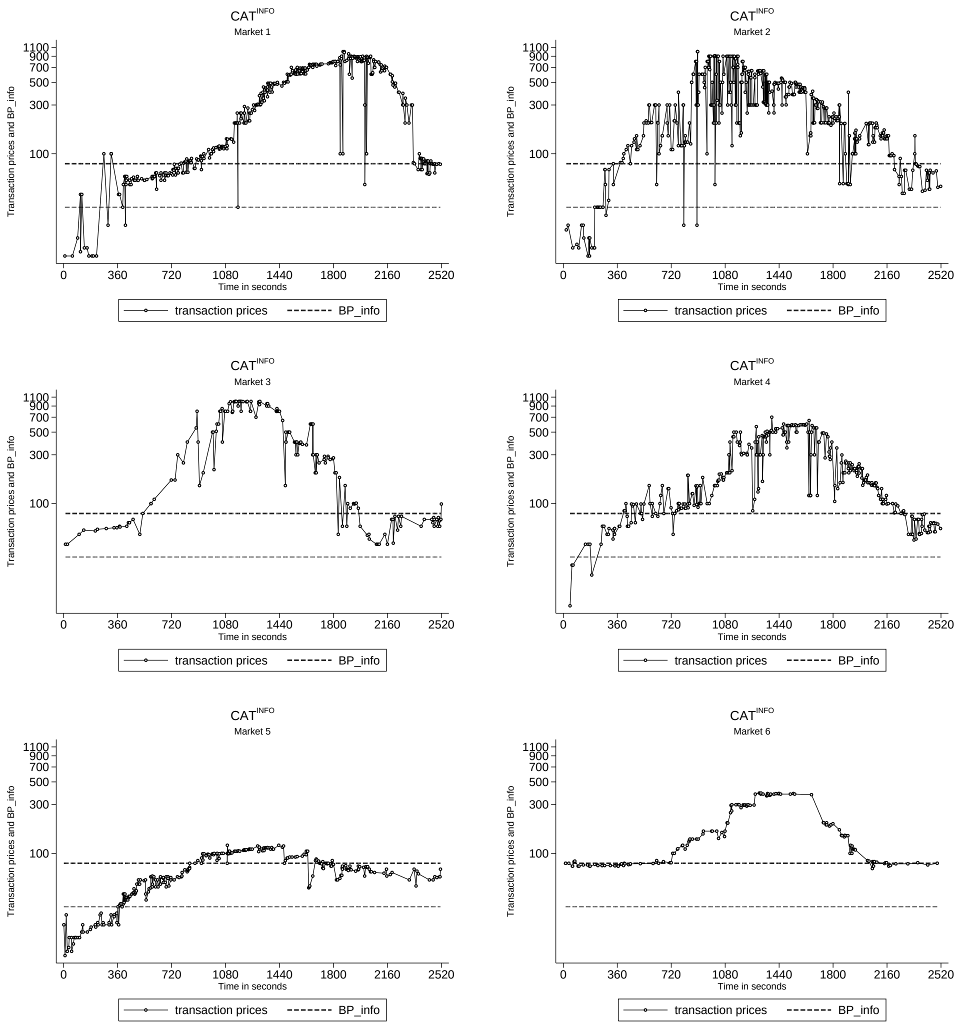


Figure A6: Single transaction prices over time for all markets of Treatment CAT$^{\text{INFO}}$.

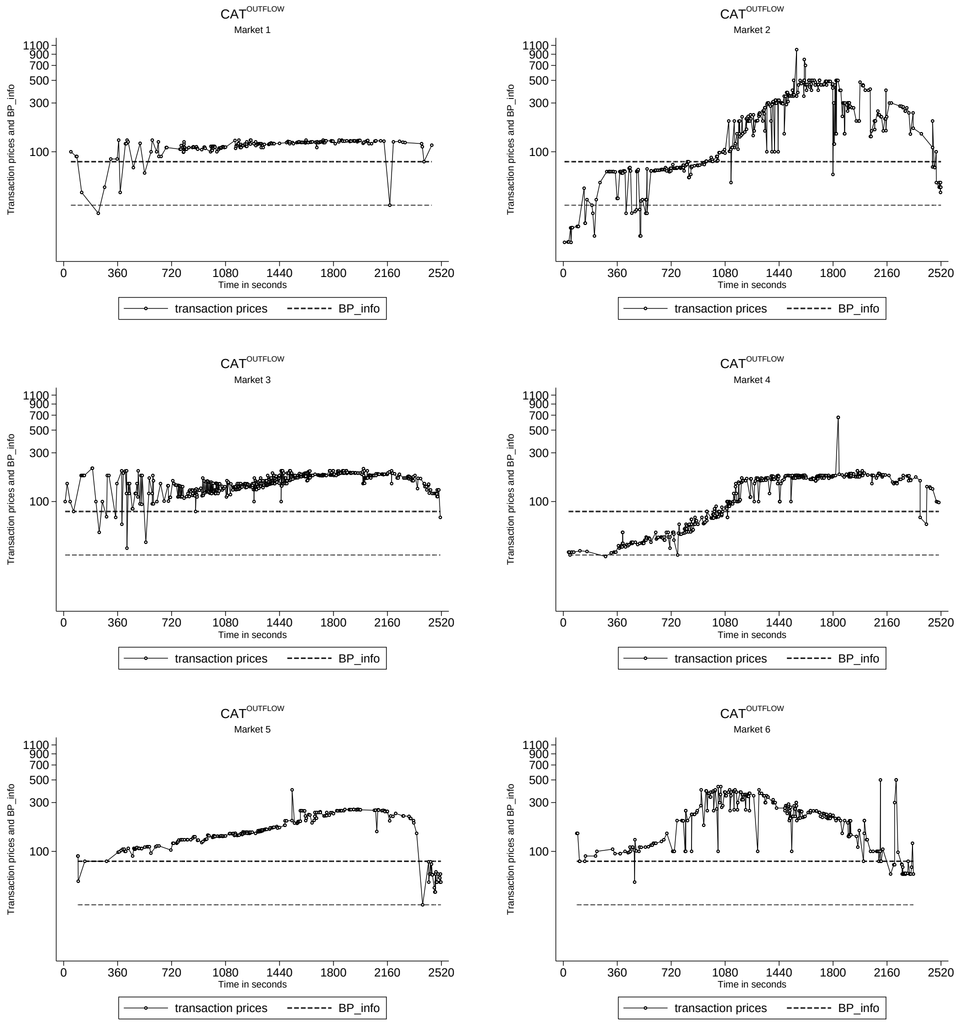


Figure A7: Single transaction prices over time for all markets of Treatment CAT$^{\text{OUTFLOW}}$.

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Michael Kirchler, Caroline Bonn, Jürgen Huber, Michael Razen

The "Inflow-Effect" - Trader inflow and bubble formation in asset markets

Abstract
We investigate the impact of trader and cash inflow on bubble formation in asset markets with a novel design featuring heterogeneous information and a constant fundamental value. Implementing seven treatments we find that (i) only the joint inflow of traders and cash triggers bubbles ("inflow-effect"). (ii) In treatments with trader and cash inflow only in the first half of the market, prices converge to fundamentals towards maturity of the asset. This inflow-effect is very robust as we observe bubbles in almost all of the 24 markets with trader inflow. The analysis of traders' beliefs reveals that (iii) despite fundamentals staying constant, beliefs about fundamentals co-move with upwardly trending prices. Finally, we report a speculative motive only among the optimists in treatments where we observe bubbles.

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