INTEREST ON CASH, FUNDAMENTAL VALUE PROCESS AND BUBBLE FORMATION: AN EXPERIMENTAL STUDY[1]

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Abstract

In this paper we investigate the formation of asset bubbles in a laboratory setting where cash earns interest. There are three main results (i) increasing the opportunity cost of speculation on the asset market in the form of interest payment on cash is not sufficient to eliminate asset bubbles, (ii) price inflation tends to be suppressed in an environment where the fundamental value increases over time, and (iii) an environment with an increasing fundamental value and positive dividend is conducive to fundamental trading.

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1. Introduction

The recent global financial crisis has once again demonstrated the damaging impact that a collapse in over-inflated asset prices following excessive speculative frenzy can have on the real economy. As a result, there has been renewed debate on policies to prevent the formation of asset bubbles.

One commonly proposed policy is to disincentivize speculation by raising the interest rate. In terms of theory, there is no common consensus about the effectiveness of this measure. For instance, Cecchetti et al. (2000), Borio and White (2004) and Roubini (2006) favor the use of this policy in containing price inflation. On the other hand, Greenspan (1996), Gilchrist and Leahy (2002) and Galí (2014) argue that such a policy can have undesired or even opposite effect from the one intended by the policymaker. Regarding empirical evidence, testing these competing views with field data is challenging: one problem is that it is often difficult if not impossible to identify asset fundamental value and as a consequence the existence of an asset bubble.

In this paper, we follow an alternative route and study the effect of raising interest rate on asset bubbles in controlled laboratory environments. The experimental approach constitutes a good complement to research using field data. The advantages include cleaner control of trading environments and clearer definition of the fundamental value.

The implementation of our first treatment closely follows the design in the seminal paper by Smith, Suchanek and Williams (1988, hereafter SSW), with a major deviation: cash earns interest. Our results indicate that increasing the opportunity cost of speculation on the asset market in the form of interest payment on cash is not sufficient to eliminate asset bubbles.

In addition, we explore the flexibility created by the introduction of interest rate payment on cash to address a methodological issue. Researchers have suspected that the fundamental value generating process in the SSW design, in particular, the negative time trend of the fundamental value, leads to confusion and bubble formation. In the absence of interest payment on cash, one can only control the time trend by changing the sign of the expected dividend payment. To generate decreasing, flat, or increasing fundamental values, the expected dividend must be positive, zero, or negative, respectively. As a result, the effects of the time trend and the sign of the dividend payment are inevitably entangled together. Introducing interest payment breaks the tie between the time trend and sign of the dividend, allowing us to separate their effects. More specifically, we design a second treatment similar

to our first treatment regarding dividends and interest payment, but with an increasing fundamental value. By comparing the two treatments, we can identify the effect of an increasing (versus a decreasing) trend. We find that the upward trend in the fundamental value is effective in suppressing price inflation: in treatment R, the trading price follows the fundamental value very closely, and bubbles completely disappear.

2. Related Literature

Our experimental design follows the framework used in SSW. SSW study the trading of a single asset in a simple experimental asset market environment. The asset has a finite lifetime and pays a random dividend in each period. The dividend payment and a fixed terminal buyout value are the only sources of intrinsic value of the asset. The distribution of the dividend process is common knowledge to all traders. SSW find that the trading price frequently exceeds the fundamental value.[2] Following SSW, various measures have been proposed to reduce or eliminate price bubbles in experimental asset markets. In the following, we discuss papers closely related to our work (see Palan 2013 for a detailed survey of the literature).

Besides our study, two papers, Bostian and Holt (2009) and Fischbacher, Hens and Zeisberger (2013), also feature interest payment on cash. Bostian and Holt (2009) conduct a non-incentivized classroom experiment where cash earns interest and the fundamental value is flat, and they find substantial pricing bubbles. Our paper complements Bostian and Holt (2009) by conducting an incentivized experiment, and focusing on the cases with monotonically changing fundamentals. The treatment with decreasing fundamentals is more comparable to the standard SSW design so that we can infer the effect of interest payments on cash more directly. Our second treatment differs from the first treatment in that it has an increasing fundamental so that we can check the effect of a positive fundamental value trend. Fischbacher, Hens and Zeisberger (2013) examine the effect of counter-bubble interest rate policies, raising (cutting) interest rate when the trading price is high (low), and they find that these policies have limited impact on bubble formation. In their experimental setting, the fundamental value is difficult to define because it constantly changes with the adjustment of the interest rate. Our focus is to investigate whether paying a positive interest on cash helps to

[2] In the experimental literature, the fundamental value is usually calculated under the assumption of risk neutrality. If agents are risk averse, then the fundamental value will be lower than that implied by risk neutrality, which makes the observation of pricing bubbles (relative to risk-neutral fundamental values) even more striking.

prevent bubble formation, which can be better studied in an environment with a constant interest rate and a clearly defined fundamental value.[3]

Our paper is also closely related to studies that investigate the trading behavior under different specifications of the time trend of the fundamental value. Smith, van Boening, and Wellford (2000), Noussair, Robin and Ruffieux (2001) and Stöckl, Huber and Kirchler (2014) find that bubbles are greatly reduced if the fundamental value of the asset is constant. The latter studies the case with increasing fundamental values as well and finds negative mispricing in that environment. Noussair and Powell (2010) and Breaban and Noussair (2014) examine environments where the fundamental value changes in a non-monotonic way, and bubbles continue to exist in such environments[4]. These studies are conducted in environments without interest payment on cash, and as discussed in the introduction, tend to confound the effects of the time trend of the fundamental value and the sign of the expected dividend. In Bostian and Holt (2009), the expected dividend is positive as in SSW, but they too introduce two deviations simultaneously: the fundamental value is flat and cash earns interest. In our paper, we take advantage of the flexibility created by the introduction of the interest rate to separate the effect of an increasing (versus decreasing) time trend of the fundamental value. Both of our treatments feature positive dividends and interest payment on cash, with the only significant difference being the time trend of the fundamental value.

3. Experimental Setup

3.1 General setup

Our experimental design follows the SSW design with a major departure: cash earns interest payment. Within this framework, we can study whether positive interest payments on cash, which increase the opportunity cost of asset-market speculation, will reduce speculation and bubbles on the asset market. We can also investigate the effect of different fundamental value

[3] Other measures aiming to "cool" the asset market include imposing transaction fees and price-change limits; (King et al.1993), removing speculative/resale opportunities and/or adding a non-asset market (Lei, Noussair and Plot, 2001), reducing liquidity or controlling for cash/asset ratio (Caginalp, Porter and Smith, 2001; Fischbacher, Hens and Zeisberger, 2013; Kirchler, Huber, and Stöckl, 2012), and imposing holding caps (Lugovskyy et al., 2012).

[4] Noussair and Powell (2010) and Breaban and Noussair (2014) examine environments where the fundamental values experience different time trends during the trading game. Noussair and Powell (2010) conduct two sets of experiments. In the "peak" treatment, fundamentals first rise and then fall, while in the "valley" treatment fundamentals first fall and then recover. They find that bubbles still occur in both treatments, but in smaller magnitudes in the peak treatment. Breaban and Noussair (2014) study markets in which a trend in fundamentals sets in after an interval of constant value. They find that prices tend to track fundamentals more closely when the trend is decreasing than when it is increasing. Breaban and Noussair (2014) conclude that the contrast between their results and those from previous studies indicate that the timing of the onset of a trend in fundamentals is an important feature influencing how the trend affects the price discovery process.

generating processes, taking advantage of the flexibility created by the introduction of interest on cash.

Shares have a finite life of *T* periods. Each share pays a random dividend at the end of each period from time *1* to *T*, plus a fixed buyout value, *K*, at the end of period *T*. The distribution of the dividend is *iid* over time. The expected value of the dividend is fixed at *d*. Cash is parked in an interest-bearing savings account and earns interest at the net rate of *r*. Subjects can use money from their savings account to purchase shares. Revenues from share sales and interest payments are automatically deposited into or deducted from the savings account. Following the usual practice in the literature, we define the fundamental value as the holding value for a risk-neutral agent (the fundamental values for a risk-averse agent is lower). The fundamental value of the asset at the beginning of period *t* is calculated as the net present value of all remaining dividend payments and the buyout value at the end of *T*, i.e.,

$$FV_t = d\left[\sum_{\tau=1}^{T-t+1}(1+r)^{-\tau}\right] + K(1+r)^{-(T-t+1)}$$

$$= \begin{cases} d(T-t+1) + K \; if \; r = 0, \\ \frac{d}{r} + \left(K - \frac{d}{r}\right)(1+r)^{-(T-t+1)} \; if \; r \neq 0. \end{cases}$$

The time trend of the fundamental value is therefore given by:

$$\frac{d(FV_t)}{dt} = \begin{cases} -d \; if \; r = 0, \\ \left(K - \frac{d}{r}\right)[ln(1+r)](1+r)^{-(T-t+1)} \; if \; r \neq 0. \end{cases}$$

Note that in the absence of *r* (or *r = 0*), the time trend of the fundamental value is fully tied to the sign of the dividend payment (negative dividend payments can be interpreted as carrying costs). If *d > 0* as in the SSW design, the fundamental value must decrease over time. To create an environment with a flat or increasing fundamental value, *d* must be *0* or positive, respectively. This tie between the two aspects of the fundamental value generating process makes it difficult to separate their effects. Introducing interest solves this problem. For example, it is possible to have a positive dividend payment with either an increasing fundamental (by setting *K > d/r*) or a decreasing fundamental (by setting *K < d/r*).

3.2 Treatments

Using the above framework, we design two treatments to investigate two possible factors that may affect bubble formation: (1) interest payment on cash, and (2) the time trend of the fundamental value.

The first treatment is designed to investigate whether interest payment on cash is effective in reducing asset bubbles. The dividend payment has four possible realizations, *0, 8, 28,* and *60*, with equal probabilities, which implies an expected dividend payment with $d = 24$. Cash earns interest payments with $d = 10\%$ or 15%.[5] As in SSW, the fundamental value decreases over time, achieved by setting the buyout value K to be less than d/r. This treatment is labeled "F" to reflect the falling fundamental value. We run six experimental sessions (sessions F1-6) of this treatment. We can then compare the results from this treatment and those following the SSW design to identify the effect of paying interest on cash. Given that the SSW design has been replicated by numerous studies, we choose not to repeat it. Instead, we refer to two recent papers by Kirchler, Huber, and Stöckl (2012) and Stöckl, Huber and Kirchler (2014), each including a treatment that replicates the SSW design.[6]

The second treatment is similar to the first treatment in terms of interest rate and dividend payments, but with $K > d/r$, which implies increasing fundamentals. We label the second treatment "R" to capture the rising fundamental value. By comparing treatments F and R, we can identify the effect of increasing (versus decreasing) fundamental values. We run seven experimental sessions (sessions R1-7) of this treatment.

Each subject has the same endowment of shares and cash before trading in the market. The share endowment for each subject is 4. The amount of cash endowment affects the cash/asset ratio and, in turn, the pricing behavior (see Caginalp, Porter and Smith 1998, 2001). Given the lack of consensus about appropriate level for this parameter, we try different cash/asset ratios ranging from 1 to 3.[7] However, we are careful that our two treatments have comparable cash/asset ratios: the average value is 1.7 for treatment F and 1.8 for treatment R. The ratio is

[5] The interest rate is decided arbitraly to be of 10% or 15%. Given that subjects play with small stakes in the experiment, we set the interest rate at conspicuously high levels to induce meaningful responses from subjects.

[6] Pooled together, the SSW replication treatment in Kirchler, Huber, and Stöckl (2012) and Stöckl, Huber and Kirchler (2014) have initial cash/asset ratios similar to our treamtment F. They also provide the same set of statistics, which we can use directly to compare with our treatment.

[7] The initial cash/asset ratio ranges from 0.41 to 1.21 in SSW. It is set to 1 in Kirchler, Huber, and Stöckl (2012), and 2 in Stöckl, Huber and Kirchler (2014). The parameter ranges from 0.875 to 1.86 in Caginalp, Porter and Smith (1998), and was set to 0.5 or 2 in Caginalp, Porter and Smith (2001).

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also comparable to Kirchler, Huber, and Stöckl (2012) and Stöckl, Huber and Kirchler (2014), which, pooled together, have an average cash/asset ratio of 1.5.

Table 1 reports the parameters used in the experiment for each session.

Table 1*:* Parameters used in the experiment

Treatment	Session	Location	Subjects	Trading periods	Dividend	Interest rate *(r)*	Buyout *(K)*	*CA 1*
F	F1	UIBE	10	15	(0,8,28,60)	0.1	72	2.50
	F2	UIBE	10	15	(0,8,28,60)	0.1	72	2.50
	F3	UPF	9	15	(0,8,28,60)	0.1	0	1.40
	F4	UPF	10	15	(0,8,28,60)	0.1	24	1.40
	F5	UPF	10	15	(0,8,28,60)	0.15	60	1.40
	F6	UPF	10	15	(0,8,28,60)	0.15	60	1.00
R	R1	UPF	10	15	(0,8,28,60)	0.1	720	1.41
	R2	UPF	10	15	(0,8,28,60)	0.1	720	1.41
	R3	UPF	10	15	(0,8,28,60)	0.1	720	1.41
	R4	UPF	10	15	(0,8,28,60)	0.1	720	3.00
	R5	UIBE	10	15	(0,8,28,60)	0.15	720	2.19
	R6	UPF	10	15	(0,8,28,60)	0.15	720	2.19
	R7	UPF	10	12	(0,8,28,60)	0.15	300	1.00

Following the usual practice in the literature, we provide subjects with a table to list the holding value of a share in terms of cash. The trading mechanism is a continuous double auction with open order books. Subjects initiate a transaction by posting offers to buy (bids) and offers to sell (offers). Each offer is for a single share, but subjects can post multiple offers to buy or sell. Active orders to buy and orders to sell are ranked in two separate columns, with the best available offers at the bottom of the lists. Subjects execute a trade by selecting the best order and press the "buy" or "sell" button located at the bottom of the order book. Each trading period lasts for 150 seconds. Subjects are given the opportunity to practice with the trading interface. There is also a training period during which subjects familiarize themselves with the task that they will perform. See Appendix A for the experimental instructions. To facilitate the comparison between our results and those from other papers that study the effect of interest payments and the fundamental value dynamics, we adopt the same design to ban short sales of shares and borrowing money to buy shares.

The program used to conduct the experiment is written in z-Tree (Fischbacher, 2007). There are 9 or 10 subjects participating in each session, trading a single asset called "shares." Communication among subjects is prohibited during the experiment. The number of trading

periods, *T*, is 15, except for session R7, which has 12 trading periods. The sessions were conducted from October 2011 to March 2012 at two universities: Universitat Pompeu Fabra (UPF), Barcelona, and University of International Business and Economics (UIBE), Beijing. Each session of experiment lasts for about 90 minutes. The average earning is 13 euros at UPF and 100 RMB at UIBE.

3.3 Hypotheses

We test two hypotheses, the first about the effect of paying interest on cash, and the second about the effect of increasing versus decreasing fundamental values.

Hypothesis 1: The presence of an alternative investment in the form of an interest-bearing saving account, which increases the opportunity cost for speculation on the asset market, tends to lower both the trading activity and price. To test this hypothesis we compare the result of treatment F with the pooled result of the SSW-treatment in Kirchler, Huber, and Stöckl (2012) and Stöckl, Huber and Kirchler (2014). Both treatments have positive dividend payments and decreasing fundamental values, and the only significant difference concerns interest payment on cash holdings.[8]

Hypothesis 2: Pricing bubbles are suppressed in an environment where the fundamental value increases over time (relative to the case with decreasing fundamental values). To test this hypothesis, we compare the two treatments, F and R, which share the same dividend payment and interest rates, and the only significant difference is about the time trend of the fundamental value.

4. Experimental Results

The experimental results are documented in Figures 1-5 and Tables 2-6. Before discussing the experimental results, we first describe the information in these figures and tables.

Figures 1-2 plot the time series of the fundamental value (FV_t), the median trading price (P_t) and the trading volume (N_t) for each of the experimental sessions for treatments F and R, respectively.[9] The six sessions with treatment F are graphed in Figure 1 (F1–F6). Figure 2 reports the seven treatment-R sessions (R1–R7). The horizontal axis indicates the trading

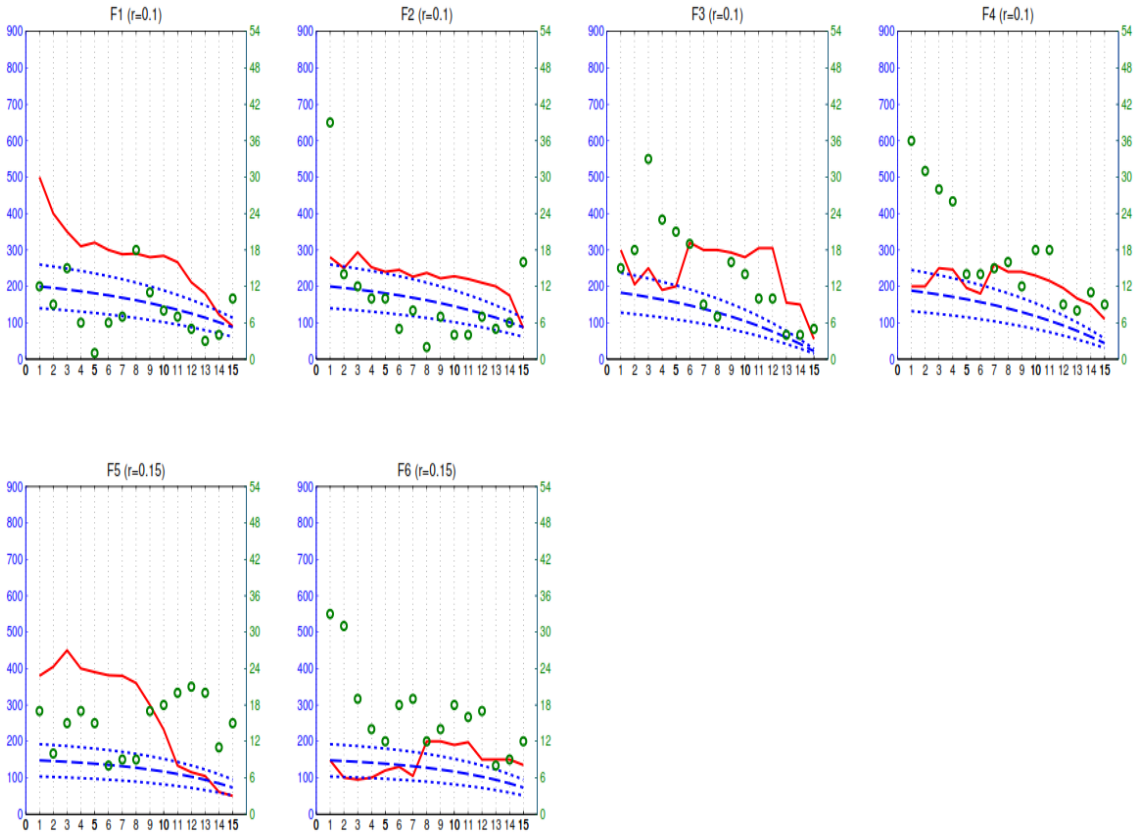
[8] In order to induce different fundamental value trends we vary the buyout value. As far as we know, the buyout value itself does not significantly affect trading behaviors. For example, the SSW design can be conducted with or without a buyout value; pricing bubbles are frequently observed in either case.

[9] We use the median (instead of the average) trading price because it is less affected by errors made by subjects while posting offers. Nevertheless, the difference between these two statistics is very small (see the statistics for treatment F in tables 3 and 4).

period running from 1 to 15. Prices are depicted along the left vertical axis: the solid line is the path of the trading price P_t, the dashed line represents FV_t, the upper dotted line indicates $(1 + 30\%) \times FV_t$, and the lower dotted line represents $(1 - 30\%) \times FV_t$. The two dashed lines help to visualize the extent of mispricing. The trading volume is graphed against the right vertical axis in circles. Figure 3 plots the price deviations from the FV (in percentage) for the two treatments. The left panel shows the six treatment-F sessions and the right panel shows the seven treatment-R sessions.

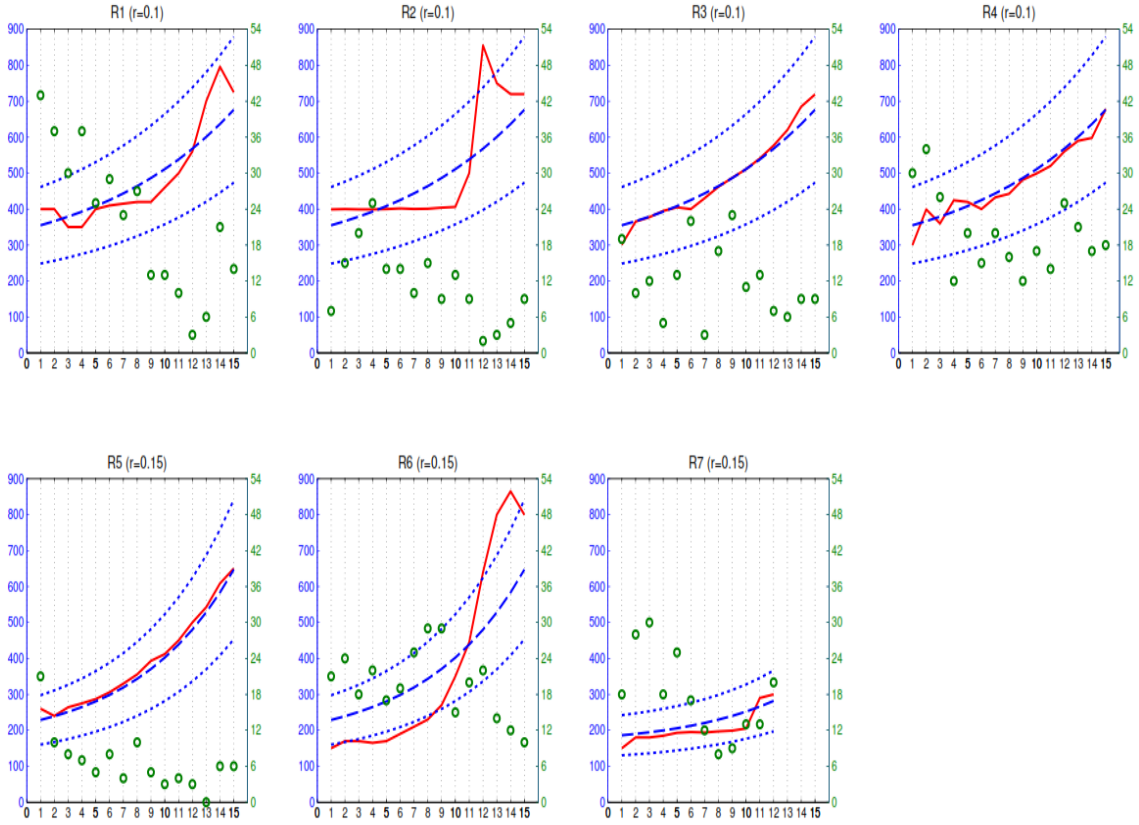
In Table 2, we identify the incidence of bubbles. We use a commonly adopted rule in the literature: we say that a bubble occurs in a session if the median transaction price exceeds the fundamental value by at least *x%* for more than five consecutive periods (see, for example, Noussair, Robin and Ruffieux 2001; Lugovskyy et al. 2012; and Giusti, Noussair and Voth 2014).

Figure 1: Experimental results - treatment F



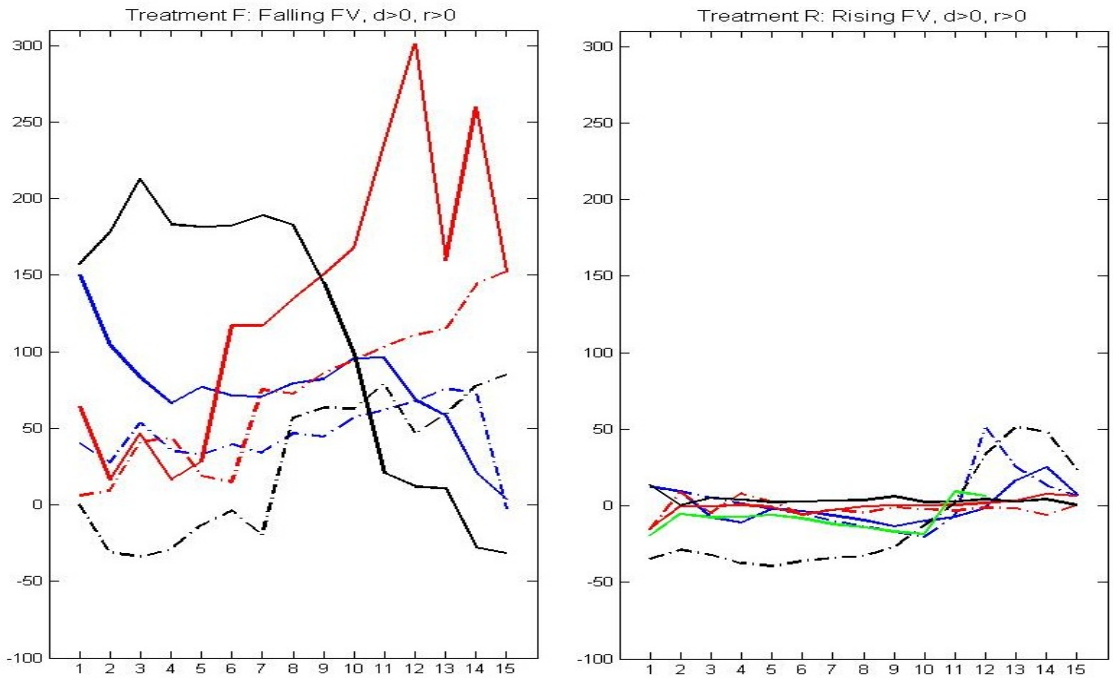
Note. Horizontal axis: trading period; Left vertical axis: trading price; Solid line: median trading price; Dashed line: *FVt*; Upper dotted line: *(1+30%)*x*FVt*; Lower dotted line: *(1+30%)*x*FVt*; Circles and Right vertical axis: trading volume.

Figure 2: Experimental results - treatment R



Note. Horizontal axis: trading period. Left vertical axis: trading price. Solid line: median trading price. Dashed line: *FVt*. Upper dotted line: *(1+30%)*x*FVt*. Lower dotted line: *(1+30%)*x*FVt*. Circles and Right vertical axis: trading volume

Figure 3: Pricing deviations from the fundamental value



Note. Horizontal axis: trading period. Vertical axis: price deviations from *FVt* in percentage.

Table 2: Incidences of bubbles

Treatment	Number of Sessions	Number of Sessions with Bubbles		
		30% rule	40% rule	50% rule
F	6	6	6	5
R	7	0	0	0

Note. A bubble is defined as the situation where the median transaction price exceeds the fundamental value by at least *x%* for more than five consecutive periods.

Table 3 provides four statistics to quantify the trading behavior. We provide the statistics for each individual session, and the treatment statistics (in bold face) averaged across sessions of the same treatment. There are three statistics to measure price deviations: relative absolute deviation (RAD), relative deviation (RD) and price amplitude (PA). The fourth statistic, share turnover (ST), measures trading intensity. The four statistics are calculated as follows.

Table 3: Statistics for the trading behavior

Session	RAD	RD	PA	ST
F1	0.81	0.81	1.92	3.05
F2	0.45	0.45	0.67	3.73
F3	1.03	1.03	1.71	5.78
F4	0.57	0.57	0.77	6.63
F5	1.33	1.28	2.72	5.55
F6	0.40	0.20	1.12	6.30
Treatment F Average	**0.77**	**0.72**	**1.49**	**5.17**
R1	0.10	0.01	0.47	8.28
R2	0.14	0.04	0.81	4.25
R3	0.03	0.00	0.21	4.48
R4	0.04	-0.02	0.18	7.43
R5	0.04	0.04	0.08	2.50
R6	0.32	-0.01	1.04	7.43
R7	0.11	-0.08	0.32	5.28
Treatment R Average	**0.11**	**0.00**	**0.44**	**5.66**

Let $\overline{FV} = (\sum_{t=1}^{T} FV_t)/T$ be the average lifetime fundamental value. Denote the number of outstanding shares as N_0, which is equal to 40 in sessions with 10 subjects and 36 in sessions with 9 subjects. The relative absolute deviation $RAD = [\sum_{t=1}^{T} |P_t - FV_t|/\overline{FV}]/T$ measures the average level of mispricing relative to the average lifetime fundamental value of the asset.

The relative deviation $RD = [\sum_{t=1}^{T}(P_t - FV_t)/\overline{FV}]/T$ measures the extent of over or under-valuation. The price amplitude $PA = \max_{1\le t\le T}[(P_t - FV_t)/\overline{FV}] - \min_{1\le t\le T}[(P_t - FV_t)/\overline{FV}]$ measures the overall size of mispricing. The share turnover is calculated as $ST = \sum_{t=1}^{T} N_t/N_o$. Note that we use the average lifetime fundamental value, $\overline{FV}$, to calculate the three measures of price deviation. As discussed in Stöckl, Huber and Kirchler (2010), it is more appropriate to use $\overline{FV}$ (than FV_1, as in many studies) for comparison among different experimental settings, especially among treatments with different time paths of the fundamental value.

Table 4 reports the results from two-tailed Mann-Whitney tests that compare the trading patterns of treatment F with the SSW treatment in Kirchler, Huber, and Stöckl (2012) and Stöckl, Huber and Kirchler, (2014). Each session is counted as one observation of the treatment. The test is performed for each of the four trading statistics, RAD, RD, PA and ST, respectively. For each test, we report the average treatment statistic, the Z-statistic, the *p*-value and the combined sample size. Table 5 compares treatments F and R.

Table 4: Mann-Whitney test for treatment F and the SSW treatment

		RAD	RD	PA	ST
F		0.778	0.739	1.375	5.017
Replication SSW		0.423	0.348	0.603	3.580
	Z-value	1.967	2.06	2.242	1.967
	p -value	5%	4%	3%	5%
	Sample size	18	18	12	18

Note. (1) The statistics for the SSW treatment is extracted from Kirchler, Huber and Stöckl (2012) and Stöckl, Huber and Kirchler (2014), each with six sessions of the SSW treatment. (2) Because these two papers use average trading prices, we compute the statistics for our treatment F using average trading prices as well. During the process, we remove potential errors by removing trades where the price is higher than 6xFV or lower than FV/6 (this is why ST is lower in table 4 than that reported in tables 3 and 5). (3) We scale up the ST in the SSW treatment by 5/4 because each period lasts for 150 seconds in our treatments and 120 seconds in the SSW treatment. (4) PA is only compared with the first paper because the second paper does not have this information.

Table 5: Mann-Whitney test for treatments F and R

		RAD	RD	PA	ST
F		0.766	0.723	1.486	5.171
R		0.111	-0.003	0.445	5.661
	Z-value	3.000	3.000	2.429	-0.429
	p -value	0%	0%	1%	67%
	Sample size	13	13	13	13

Note. Statistics are based on median trading prices.

4.1 The Effect of Interest Payment on Cash

We first check whether paying positive interest on cash in effective in reducing asset bubbles. Our conjecture is that the presence of an interesting-bearing saving account will increase the opportunity cost for speculation on the asset market and, in turn, reduce the likelihood of asset bubbles. However, the evidence suggests otherwise.

Result 1: Increasing the opportunity cost of speculation on the asset market in the form of interest payment on cash is not sufficient to eliminate asset bubbles.

As shown in Figure 1, the trading price frequently exceeds the fundamental value by more than 30%. In fact, as reported in table 2, if we define a bubble as the situation where the median transaction price exceeds the fundamental value by at least 40% for at least five consecutive periods, then bubbles appear in all six treatment-F sessions. Even if we use a more stringent rule of 50% for bubble identification, bubbles are still observed in five out of six sessions. Furthermore, from Table 3, which provides the trading statistics, treatment F exhibits substantial overpricing, with the average treatment RAD and RD being high at 77% and 73%, respectively. The price amplitude is also very high averaged at 149%.

To gain further insight into the effect of interest payment on cash, we compare treatment F with a standard SSW treatment. Note that both treatments have positive dividend payments and decreasing fundamental values, with the only major difference being interest payment on cash holdings. The rank-sum tests in table 4 suggest that treatment F involves even higher mispricing and overpricing than the SSW treatment in Kirchler, Huber and Stöckl (2012) and Stöckl, Huber and Kirchler (2014). In particular, the average RD is 73% in treatment F versus 35% in the SSW treatment, and the rank-sum test between the RD of the two treatments has a Z-value of 2.06. A similar result is observed for RAD. Price amplitude is also significantly larger for treatment F compared to the SSW replications (with a *p*-values of 3%). Treatment F also involves more active trading with ST of 5.02 versus 3.58 in the SSW treatment.

Since treatment F involves significant overpricing accompanied with active trading, we can conclude that paying interest on cash is not sufficient to suppress overpricing by increasing the opportunity cost for speculation. The result is consistent with the findings in previous studies that have interest payments on cash, Fichbacher, Hens and Zeisberger (2013), where interest rate is raised (lowered) when the trading price is high (low), and the classroom experiment conducted by Bostian and Holt (2009), where the fundamental value is constant.

4.2 The Effect of Increasing Fundamental Values

Regarding the effect of the time trend of the fundamental value, we conjecture that there will be less price inflation in the environment with increasing fundamental values (versus where the fundamental value decreases). The experimental evidence supports our conjecture. In particular, we have the following result:

Result 2: Price inflation is suppressed in an environment where the asset has increasing fundamental values. As a result, the trading price follows the fundamental value more closely in treatment R than in treatment F.

As shown in Figure 2, in treatment R, the median trading price rarely exceeds the fundamental value by more than 30%. From table 2, the median trading price never exceeds the fundamental value by more than 30% for more than five consecutive periods in any of the seven sessions. That is, bubbles completely disappear in treatment R (even if we use the 30% rule, which leads to higher bubble counts than the 40% and 50% rule). Furthermore, as reported in Table 3, treatment R exhibits very low levels of overpricing and mispricing, with the average treatment RAD and RD at 11% and 0%, respectively. The price amplitude is also low averaged at 45%.

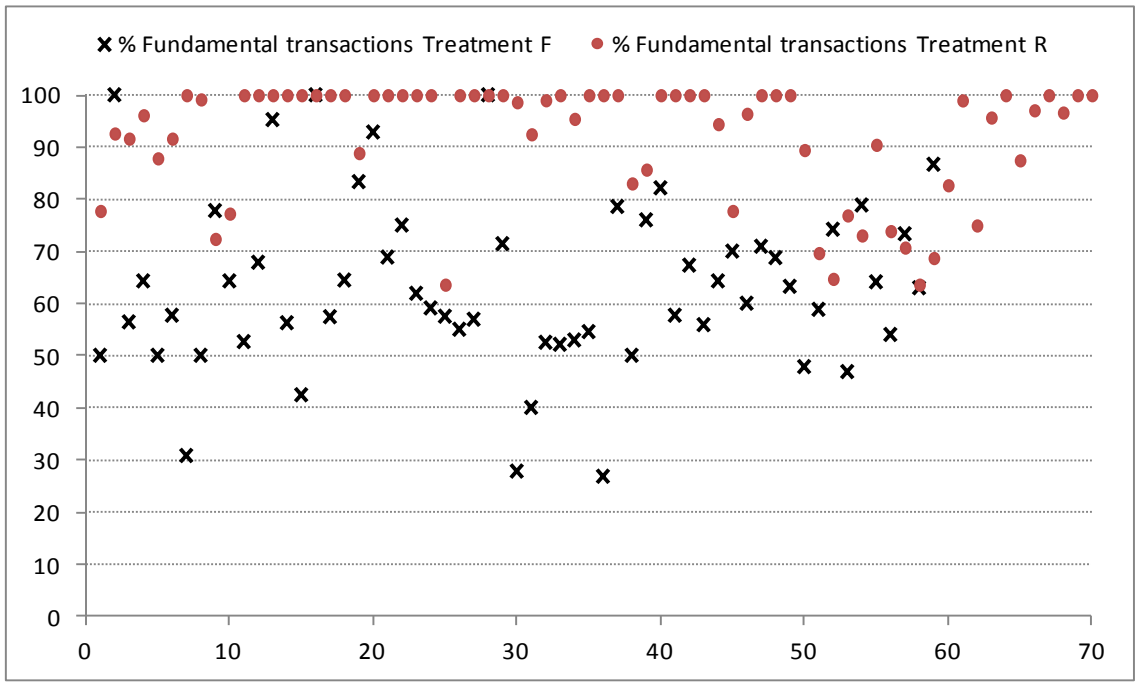
We can further investigate the effect of an increasing fundamental value by comparing treatments F and R. Both treatments feature the same dividend process and the same interest rates and differ only in terms of the time trend of the fundamental value. Figure 3 graphs the extent of mispricing for each session of each of the two treatments. While wild deviations (as high as 300%) from the fundamental value are observed for treatment F, treatment R only involves mild mispricing: the maximum overpricing is about 50%, and most of the time, the median trading price falls into the +/-20% range of the fundamental value.

The Mann-Whitney tests reported in table 4 confirm the result. The average RD is 73% in treatment F and 0% in treatment R, with a *p*-value of 0%. A similar result is observed for RAD. In fact, the RADs (and RDs) for all seven treatment-R sessions are universally lower than those for all six treatment-F sessions. The average PA is 1.486 for treatment F versus 0.445 for treatment R, with a *p*-value of 1%. In terms of trading intensity, the two treatments are very close: the ST is 5.171 for treatment F and slightly higher at 5.661 for treatment R, and the two treatments are not statistically different (with a *p*-value of 67%).

The result that bubbles completely disappear in treatment R despite active trading suggests that the environment featured in this treatment is conducive to fundamental trading. To gain

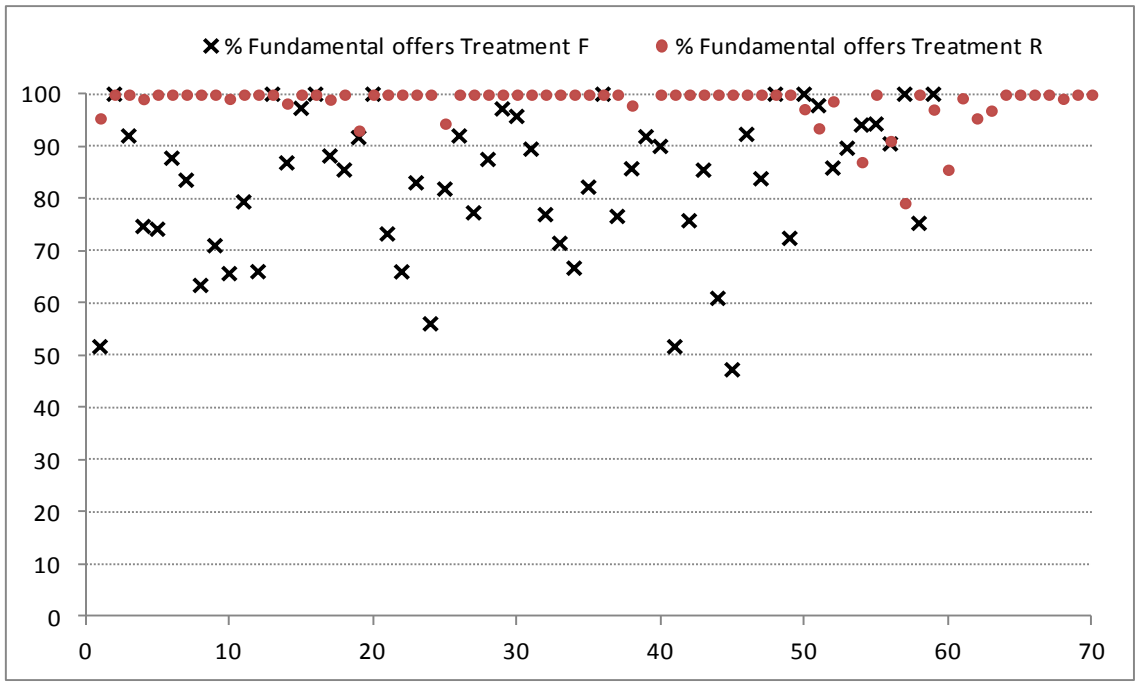
more insight into subjects' perception about the fundamental value, we investigate individual subjects' activity in more detail (to complement the above analysis of aggregate market behavior). In particular, we measure the extent of "fundamental play" for each individual. We define a transaction or offer as "fundamental" if the price is ≤ (1+30%) x FV_t for share purchases, and ≥ (1-30%) x FV_t for share sales. We then measure the extent of fundamental trading and posting for each individual by the percentage of fundamental transactions and offers that the individual engages in the session. We graph the distribution of the percentage of fundamental transactions (offers) in Figure 4 (5). The values are listed in Table 6 in the Appendix B.

Figure 4: Distribution of percentage of fundamental transactions



Note. Each subject counts as one observation. A total of 59 subjects participated in the six treatment-F sessions. A total of 70 subjects participated in the seven treatment-R sessions. The vertical axis is the percentage of fundamental transactions. A transaction is "fundamental" if the transaction price is ≤ (1+30%) x FV_t for share purchases, and ≥ (1-30%) x FV_t for share sales.

Figure 5: Distribution of percentage of fundamental offers



Note. Each subject counts as one observation. A total of 59 subjects participated in the six treatment-F sessions (all of them posted offers). A total of 70 subjects participated in the seven treatment-R sessions (among them two subjects did not post any offer). The vertical axis is the percentage of fundamental transactions. An offer as "fundamental" if the posted price is ≤ (1+30%) x FV_t for share purchases, and ≥ (1-30%) x FV_t for share sales.

From Figures 4-5 and Table 6, we can see that subjects engage more fundamental playing in treatment R than in treatment F, in terms of both offer posting and realized transactions. For example, 99% (65 out of 68) subjects post more than 90% fundamental offers in treatment R. In contrast, only 37% (22 out of 59) subjects post more than 90% fundamental offers in treatment F, suggesting that a large proportion of subjects post offers far away from the asset's fundamental value in this treatment. In terms of transaction prices, 70% subjects in treatment R, versus 8% in treatment F, engage in more than 90% fundamental transactions. In general, subjects are more rational (in the sense of following the fundamental value) when they post offers than when they accept offers.

The stark contrast between the performances of the two treatments suggests that the fundamental value generating process greatly impacts bubble formation on experimental asset markets. For some reason, which we explore next, it is easier for subjects to perceive the fundamental value in treatment R than in treatment F.

One explanation, as formulated in Smith (2010) and Oechssler (2010), is that, since asset prices tend to increase or stay constant in the long run in real life, subjects may find it

difficult to comprehend that the fundamental price of the asset could decrease over time. According to this explanation, we should observe little mispricing in treatments with a flat or increasing fundamental value. However, Bostian and Holt (2009) find positive bubbles with a flat fundamental value, and Stöckl, Huber and Kirchler (2014) find under-pricing or negative bubbles with increasing fundamental values.

Stöckl, Huber and Kirchler (2014) provide another explanation, proposing that anchoring on information generated by the trading process drives under-reaction and, in turn, mispricing on the experimental asset market. According to this explanation, there should be overpricing, no mispricing and underpricing if the fundamental value increases, remains flat and decreases over time, respectively. This explanation is again incompatible with some existing evidence. For example, there is minimal mispricing in our treatment R, where the fundamental value increases over time, and significant overvaluation in Bostian and Holt (2009), which has a flat fundamental value.

The above two explanations focus exclusively on the time trend of the fundamental value. Is it possible to augment the two explanations to reconcile all existing evidence? In particular, as mentioned earlier, many papers control the time trend of the fundamental value by changing the sign of the dividend payment. Could this additional change impact trading activities too? If the answer is yes, then a reasonable conjecture is that subjects tend to overvalue the asset when dividend is positive and undervalue it when the dividend is negative. One would attempt to hold on to (get rid of) the asset if it generates continuous positive (negative) cash flows.

It seems that combining the mechanism suggested by Stöckl, Huber and Kirchler (2014) with the dividend payment effect can reconcile the results in all existing studies. For example, the positive bubble in the SSW design and our treatment F is due to the anchoring to higher previous prices and the positive dividend. In contrast, the negative bubble in the increasing-fundamental-value treatment in Stöckl, Huber and Kirchler (2014) is caused by anchoring to lower previous prices enhanced by the negative dividend. In our treatment R, the two effects tend to offset each other so that little mispricing is observed. In the treatment with flat fundamentals induced by zero dividend, both effects are absent so the trading price follows the fundamental value closely too. In Bostian and Holt (2009), the positive dividend payment causes subjects to overvalue the asset. To further evaluate the synthesized conjecture, we exploit the flexibility created by the introduction of interest payment on cash and conduct an auxiliary treatment (labeled treatment "N"), where the expected dividend is negative and the

fundamental value decreases (by setting $r < 0$ and $K > d/r$). This new treatment exhibits consistently lower overpricing than treatment F and the replication of the SSW treatment. For example, if we use the 40% rule to identify bubbles, then only one out of six sessions of treatment N has a bubble versus six out of six for treatment F.[10] In treatment N, the decreasing fundamental value causes overvaluation but the negative dividend causes undervaluation, and these two forces offset each other, inducing only mild mispricing.

5. Conclusion

In this paper, we investigate the formation of price bubbles in an experimental asset market with interest payments on cash holdings. First, we implement an experimental asset market similar to the original SSW design with a major deviation: cash earns interest. The objective is to study whether the presence of an alternative risk-free investment in the form of an interest bearing saving account, by increasing the opportunity cost for speculation, can reduce mispricing and asset bubbles. Our experimental result suggests that this measure has limited effect on bubble formation.

In addition, we exploit the flexibility created by the introduction of interest payment on cash to study how the fundamental value generating process affects bubble formation. We run a second treatment where the asset earns positive dividends and its fundamental value increases over time. We find that in that environment, the trading price closely tracks the fundamental value and bubbles are completely eliminated. Combining the result from our treatments and other papers that study the effect of the fundamental value generating process, we conclude that both the time trend of the fundamental value and the sign of the dividend payment are important factors.

Given that the fundamental value generating process greatly affects subjects' perception of the fundamental value, one must take it into consideration while designing asset-trading experiments. If reducing misperception about the fundamental value is an important issue, one should consider selecting a fundamental value generating process that minimizes such misperception. As far as we know, two types of fundamental value generating processes could work. The first involves a flat fundamental value induced by zero dividends (without interest payment on cash). The other is our treatment R which features an increasing fundamental value and positive dividend payments (where cash earns interest).

[10] The design and detailed results for treatment N are in Appendix C.

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Appendix A: Experimental Instructions

You are taking part in an experiment on investment behavior. If you follow the instructions carefully and make the right decisions, you can earn some money, which will be paid to you at the end of the experiment.

The experiment consists of a sequence of trading periods, each one lasting for 150 seconds. During each period, you will make decisions to invest your money between two forms of investment: shares of stocks of a fictitious Company, and a savings account. The currency used in the market is called EURUX, which will be converted into RMB at the end of the experiment. The conversion rate is 1000 EURUX for 1 RMB.

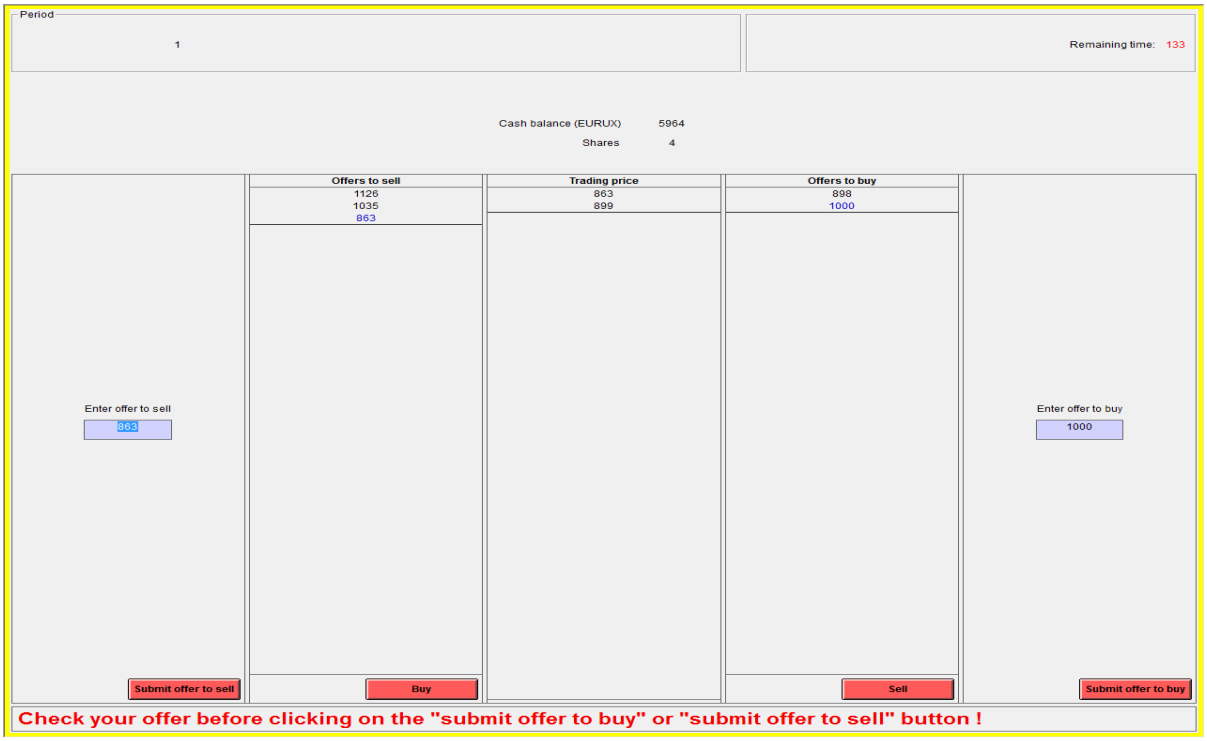
The experiment will proceed in the following sequence. First, we will show you the trading interface you will use (you will practice with it as we explain), and then we will discuss the features of the two forms of investments. After that, you will have the opportunity to practice trading for one period. We will then give you further instructions and information to help you make trading decisions. If anything is unclear during the instructions or practice, you can raise your hand and ask the administrator whatever question you may have.

Before the experiment formally starts, you will be required to complete a quiz to demonstrate that you have a complete and accurate understanding of these instructions. After you have completed the quiz, the administrator will check your answers and discuss with you any question that has been answered incorrectly.

TRADING INTERFACE

In each trading period, you start with some money invested in two forms of investment: savings account and shares. Money in the savings account earns interest. Shares earn dividends (dividends and interests will be described later).

During each trading period, you make investment decisions to allocate money between the two forms of investment: you can use money in the savings account to buy shares, or sell shares and deposit the revenue in your savings account. Here is a sample trading screen.



The top left corner shows the current trading period, and the top right corner shows how much time (in seconds) is left in the current period. Your investment portfolio – money in your saving account and the number of shares you own – are shown in the middle of the screen. On this screen you can buy or sell shares in **four** ways.

First, you can **initiate a sale** of shares by **submitting** an **offer to sell.**

If you have shares, you may choose to sell them. You can initiate a sale in the text area below "Enter offer to sell" in the first column. Here you can enter the price at which you are offering to sell a share. To send the offer, you have to click the "Submit offer to sell" button. After that, your offer to sell will appear in the second column labelled "Offers to sell". Each offer introduced corresponds to **one single** share. If you want to sell more shares, repeat this process.

Note that by submitting an offer to sell, you initiate a sale, but the sale will not be executed until someone accepts it.

Try offering to sell a share now. Write a number (integer) in the text area labelled "Enter offer to sell" and then click on the button "Submit offer to sell". You can see that a set of numbers will appear in the column labelled "Offers to sell". Each number corresponds to an offer from one of the participants. Your own offers are shown in blue; others' offers are shown in black. The offers to sell are ranked from high to low, so that the **cheapest (best)** price is displayed at the **bottom** of the list.

Second, you can **realize a purchase** of shares by **accepting** an **offer to sell.**

If you have enough money in your savings account, you can buy a share at one of the prices in the "Offers to sell" column (which also contains your previously submitted offer to sell). You buy a share by selecting one of the **others'** offers (shown in black) and then clicking on the red button "Buy". Note that you are not allowed to accept your own offers, which are shown in blue. Remember that the **cheapest (best)** price is displayed at the **bottom** of the list.

It may happen that when you select the best price and press the "Buy" button, someone else is doing the same thing but acting slightly faster than you. In that case, a message "someone has been faster than you" will show up.

Try buying a share now. Choose a price in the column "Offer to sell" and then click on the "Buy" button; or directly click on the "Buy" button and buy at the cheapest price listed in the column "Offers to sell".

Whenever an offer is accepted, a transaction is executed. Immediately when you **accept** an offer to sell, you realize a purchase and the number of EURUX in your savings account goes down by the trading price; at the same time, your trading partner realizes a sale and the balance in his/her savings account increases by the trading price. In contrast, when your offer to sell **is accepted**, you realize a sale, your trading partner realizes a purchase, and money is transferred from your trading partner's savings account to your savings account by the amount of the trading price.

Given that you all submitted one offer to sell and accepted one offer to sell, you all realized one purchase and one sale so you have the same number of shares as you started out with.

Third, you can **initiate a purchase** of a share by **submitting** an **offer to buy**.

If you have money in your savings account and would like to buy a share, you can initiate the purchase by submitting an offer to buy. Enter a number in the text box under "Enter offer to buy" situated on the right side of the screen and then click on the "Submit offer to buy" button.

Try submitting an offer to buy a share now. Write a number in the text area "Enter offer to buy." Then press the red button labelled "Submit offer to buy". Immediately in the column labelled "Offers to buy" you will see a list of numbers ranked from low to high, so that the **highest (best)** price is displayed at the **bottom** of the list. If you want to sell more shares, repeat this process. Again, your own offers are shown in blue; others' offers are shown in black.

Fourth, you can **realize a sale** of a share by **accepting** an **offer to buy.**

You can sell a share at one of the prices offered in the "Offers to buy" column (which also contains your previously submitted offer to buy). Select one of the offers and then click on the red button "Sell". Again, note you are not allowed to accept your own offers (shown in blue). Remember that the **highest (best)** price is displayed at the **bottom** of the list.

Try selling a share now. Choose a price in the column "Offer to buy" and then click on the "Sell" button.

Again, a transaction is executed whenever an offer to buy is accepted. If you accept an offer to buy posted by others, you realize a sale and as a result, the amount of EURUX in your savings account increases by the trading price. In contrast, when your offer to buy is accepted by someone else, you realize a purchase and the number of EURUX in your savings account decreases by the trading price. The reverse happens to your trading partner.

You can see that the these four trading methods are complementary: you can **initiate** a trade by **offering** a price to sell or buy and wait for the offer to be accepted by others; you can **execute/realize** a trade by **accepting** an offer to buy or sell submitted by other participants.

In the column situated in the middle of the screen and labelled "Trading price", you can see the prices at which shares have been traded during the trading period by all participants present in the market.

The above is the trading interface you will use during the experiment. In the following, we will give more instructions about the two forms of investment. After that, you will have time to practice a full trading period. ***Do not press the "continue" button until the instructor tells you so.***

SHARE and SAVINGS ACCOUNT

Shares

At the end of the trading period, you receive dividends for the shares you hold. Dividends are automatically added to your savings account.

The amount of dividend **per share** is determined by a random device (the Company's business may go well or bad, which will affect how much dividend you get) and takes one of four values with the same probability:

1/4 probability you get 0 EURUX per share,

1/4 probability you get 8 EURUX per share,

1/4 probability you get 28 EURUX per share, and

1/4 probability you get 60 EURUX per share

Each participant gets the same dividend per share. There is a new random dividend draw for each new trading period.

Since all four outcomes are equally likely, we can calculate the average dividend as (0 + 8 + 28 + 60)/4=24 EURUX.

At the end of the game, the Company will purchase your shares at a **buyout value** of 72 EURUX per share.

Savings Account

The money in your savings account earns interest rate at 10% per period.

An Example

Here is an example to illustrate how dividends and interest are paid. Suppose after trading, you have 2 shares and 1000 EURUX in your savings account. The random device shows that each share receives a dividend of 28 EURUX. At the end of the period, you will receive 28x2=56 EURUX of dividend and 1000x10%=100 EURUX of interest. As a result, the balance in your savings account at the end of the period will be 1000+56+100=1156.

END-OF-PERIOD INFORMATION SCREEN

At the end of the trading period, after dividends and are paid and deposited in your savings account, you will be shown an "information screen". The screen shows you the dividend payment, and also the information about your end-of-period inventory of shares and the balance in your saving account.

The "information screen" contains the following information:

1. *Period*: the period just finished
2. *Your shares*: number of shares you own after trading in the period
3. *Savings account balance before dividend and interest*: amount of *EURUX* you have in your savings account right after trading and before dividend and interest payment
4. *Dividend per share:* the amount of dividend in *EURUX* you receive for each share you own.
5. *Total dividend:* calculated as *Your shares* x *dividend per share*.

6. *Interest:* net amount of interest you receive in the period for money in your savings account, which is calculated as *Savings account balance before dividend and interest* x *10%.*
7. *Savings account balance after dividend and interest:* money in your savings account after dividend and interest have been paid and deposited, which is calculated as *Savings account balance before dividend and interest + Total dividend + Interest*

TRIAL

In the next 3-4 minutes you will practice trading in this market for **one** period. Your actions in this period will not count toward your earning in this experiment and do not influence your position in the real experiment.

Now, please click on the "Continue" button on your screen and we will start the trial.

Now that you know how to trade shares and how dividends are paid, before the experiment formally starts, let us go through some instructions to help you maximize your earnings in the experiment.

The experiment consists of 15 consecutive trading periods. Each period will last for 150 seconds. You start period 1 with a certain investment portfolio of shares and money in your savings account. In each of the 15 trading periods, you trade among yourselves using the interface you just practiced with. At the end of each trading period, you see the "information screen" which shows your end-of-period portfolio position after dividend payment.

Your inventory of shares and savings account balance carry over from one period to the next. For example, if at the end of period 4 you have 2 shares and 1000 EURUX. You start period 5 with the same portfolio of 2 shares and 1000 EURUX before trading.

The game ends after 15 periods. If you own some shares at the end of period 15, the Company will purchase your shares at a **buyout value** of 72 EURUX per share.

For example, suppose after trading in period 15, you own 3 shares and 2000 EURUX. At the end of period 15, after dividend and interest payment, you can sell your shares to the Company at the buyout value. If the dividend payment is 8 EURUX per share, you receive 3x8=24 EURUX as dividends. The interest payment is 2000x10%=200 EURUX. Your 3 shares are sold to the Company for 3x72=216 EURUX. Your total earnings in this game are calculated to be 216+24+200+2000=2440 EURUX, which will be converted into RMB.

HOLDING VALUE TABLE

The objective of your investment decisions is to maximize your end-of-game total earnings. In each trading period, you decide how to allocate your money between the two forms of investment: shares and savings account.

To facilitate your decision-making, we provide you a table called "Holding value table" (See next Page), which can be used through the entire experiment. The table calculates the **average** amount of money you earn **if** you buy a share in the current period and **hold it until the end of the game**. Of course, you may choose **not** to hold the share until the end of the game, if, for example, you can sell it at a good price before the end of the game. The holding value table is just for your reference.

The table has 6 columns, which we will go through one-by-one.

1. *Current period*: The current trading period.

2. *Average dividend*: The average amount of dividend per share per period. This, as explained earlier, is equal to 24 EURUX.
3. *Average remaining dividends*: If you hold 1 share of stock until the end of the game, you will be entitled to a dividend payment at the end of each of the remaining periods. The remaining dividend is calculated as the total amount of money you will accumulate **at the end of the game** if you deposit all dividend payments into your savings account which earns 10% interest per period. For example, for each share you hold in period 14, there are two remaining dividend payments: one at the end of period 14, and one at the end of period 15. You deposit the period 14 dividends in your savings account, which will increase your money balance at the end of the game by 24x1.1=26.4 EURUX. The period 15 dividend is paid at the end of the game (so will not earn interest) and will increase your end-of-game money balance by 24 EURUX. The average remaining dividends is calculated as the sum of the two amounts = 26.4+24=50.4 EURUX.
4. *Buyout value.* **At the end of game**, each share you own will be purchased by the Company at 72 EURUX.
5. *End average holding value*. The average amount of EURUX you will receive **at the end of the game** if you hold one share for the remainder of the experiment. It is calculated as the sum of *average remaining dividend* (column 3) and the *buyout value* (column 4). For example, the average holding value I for a share in period 14 is calculated as 50.4+72=122.4 EURUX.
6. *Current average holding value*. To buy a share in the **current** period, you have to use money **currently** in your savings account. When you make the buying decision, you may want to know the average holding value of a share measured in terms of **money in the current savings account.** Call this the *current average holding value*. Let us illustrate how to calculate the value by an example. Suppose you are trading in period 14. One EURUX in the current saving account will generate 1.1^2 (there are two remaining interest payments) units of EURUX at the end of the game. Holding one share generates (on average) 122.40 EURUX at the end of the game. Holding one share is thus (on average) equivalent to holding 122.40/1.21=101 EURUX in the **current** savings account.

Holding Value Table

1 Current period	2 Average dividend	3 Average remaining dividends	4 Buyout value	5 End average holding value	6 Current average holding value
1	24	762.54		834.54	200
2	24	671.40		743.40	196
3	24	588.55		660.55	191
4	24	513.22		585.22	186
5	24	444.75		516.75	181
6	24	382.50		454.50	175
7	24	325.91		397.91	169
8	24	274.46		346.46	162
9	24	227.69		299.69	154
10	24	185.17		257.17	145
11	24	146.52		218.52	136
12	24	111.38		183.38	125
13	24	79.44		151.44	114
14	24	**50.40**		**122.40**	**101**
15	24	24.00	72	96.00	87

Quiz

Please read carefully the Holding Value Table and make sure that you understand it. Raise your hand whenever you have any questions. When you think you understood the table, please answer the following questions:

1. Suppose you are in period 5. How much is the *average dividend* you should expect at the end of this period? _____
2. Which is the maximum and minimum dividend you can get in any period? _____
3. Suppose you are in period 5 and a share pays the average dividend in each of the remaining periods. The *current holding value of* one share in terms of money in the current savings account is _____.
4. Please explain on one sentence or two what the *current holding value* is.

Appendix B

Table 6: Percentage of fundamental trading and posting for individual subjects

Session	Player	% Fundamental transactions	% Fundamental offers	Session	Player	% Fundamental transactions	% Fundamental offers
	1	50	52		1	78	95
	2	100	100		2	93	100
	3	56	92		3	92	100
	4	64	75		4	96	99
F1	5	50	74	R1	5	88	100
	6	58	88		6	92	100
	7	31	84		7	100	100
	8	50	63		8	99	100
	9	78	71		9	72	100
	10	64	66		10	77	99
	1	53	79		1	100	100
	2	68	66		2	100	100
	3	95	100		3	100	100
	4	56	87		4	100	98
F2	5	42	97	R2	5	100	100
	6	100	100		6	100	100
	7	57	88		7	100	99
	8	64	85		8	100	100
	9	83	92		9	89	93
	10	93	100		10	100	100
	1	69	73		1	100	100
	2	75	66		2	100	100
	3	62	83		3	100	100
	4	59	56		4	100	100
F3	5	58	82	R3	5	64	94
	6	55	92		6	100	100
	7	57	77		7	100	100
	8	100	88		8	100	100
	9	71	97		9	100	100
					10	99	100
	1	28	96		1	93	100
	2	40	89		2	99	100
	3	53	77		3	100	100
	4	52	71		4	95	100
F4	5	53	67	R4	5	100	100
	6	55	82		6	100	100
	7	27	100		7	100	100
	8	79	77		8	83	98
	9	50	86		9	86	n/a
	10	76	92		10	100	100

Table 6: Percentage of fundamental trading and posting for individual subjects (continued)

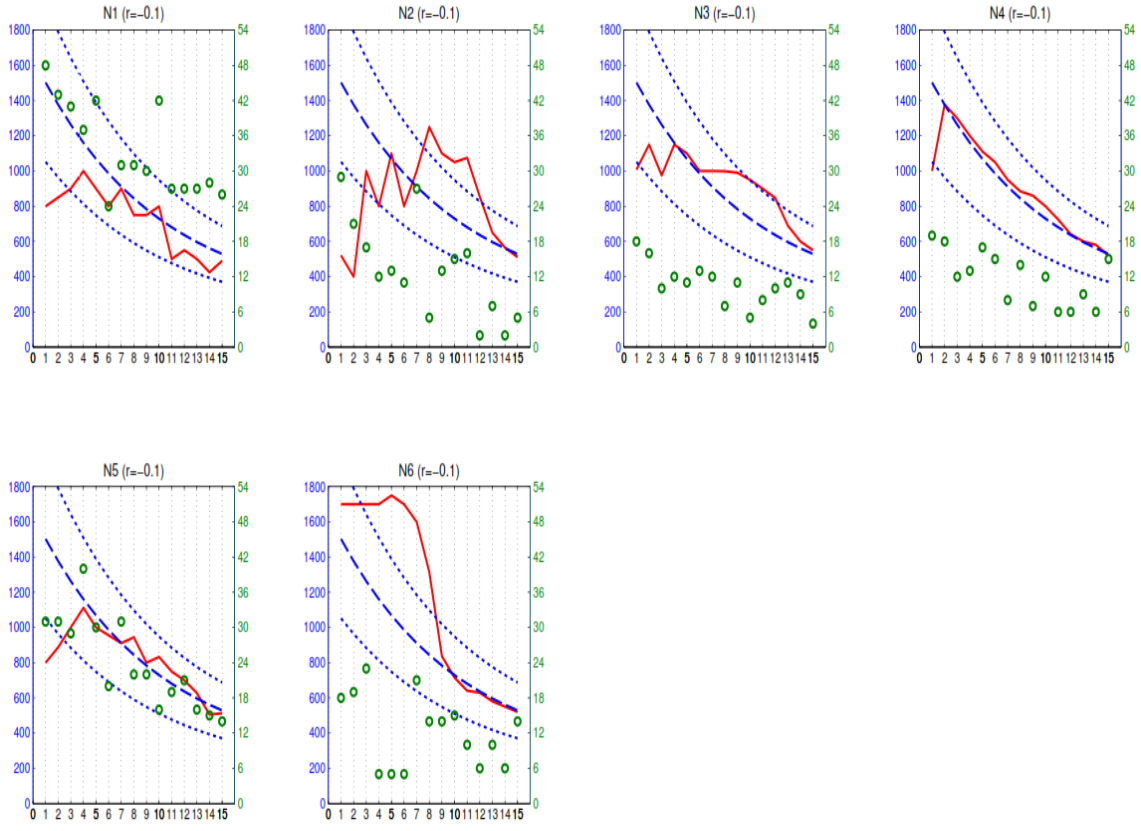
Session	Player	% Fundamental transactions	% Fundamental offers	Session	Player	% Fundamental transactions	% Fundamental offers
	1	82	90		1	100	100
	2	58	52		2	100	100
	3	67	76		3	100	100
	4	56	85		4	94	100
F5	5	64	61	R5	5	78	100
	6	70	47		6	96	100
	7	60	92		7	100	100
	8	71	84		8	100	100
	9	69	100		9	100	100
	10	63	72		10	89	97
	1	48	100		1	70	94
	2	59	98		2	65	99
	3	74	86		3	77	n/a
	4	47	90		4	73	87
F6	5	79	94	R6	5	90	100
	6	64	94		6	74	91
	7	54	90		7	71	79
	8	73	100		8	64	100
	9	63	75		9	69	97
	10	87	100		10	83	86
					1	99	99
					2	75	95
					3	96	97
					4	100	100
				R7	5	88	100
					6	97	100
					7	100	100
					8	97	99
					9	100	100
					10	100	100

Appendix C: Treatment N

Table 7: Parameters used in the experiment for treatment N

Treatment	Session	Location	Subjects	Trading	Dividend	Interest	Buyout	*CA 1*
N	N1	UPF	9	15	(0,-8,-28,-60)	- 0.1	500	8.32
	N2	UPF	10	15	(0,-8,-28,-60)	- 0.1	500	8.32
	N3	UPF	9	15	(0,-8,-28,-60)	- 0.1	500	8.32
	N4	UPF	10	15	(0,-8,-28,-60)	- 0.1	500	6.65
	N5	UPF	9	15	(0,-8,-28,-60)	- 0.1	500	6.65
	N6	UPF	10	15	(0,-8,-28,-60)	- 0.1	500	6.65

Figure 6: Experimental results - treatment N



Note. Horizontal axis: trading period; Left vertical axis: trading price; Solid line: median trading price; Dashed line: *FVt*; Upper dotted line: *(1+30%)*x*FVt*; Lower dotted line: *(1+30%)*x*FVt*; Circles and Right vertical axis: trading volume.

Table 8: Mann-Whitney test between treatment N and other treatments

		RAD	RD	PA	ST
SSW		0.423	0.348	0.603	3.580
N		0.209	-0.009	0.920	7.034
	Z-value	2.341	2.716	-1.761	-2.529
	p -value	2%	0%	8%	1%
	Sample size	18	18	13	18
F		0.776	0.723	1.486	5.171
N		0.209	-0.009	0.920	7.034
	Z-value	2.882	2.722	1.121	-0.320
	p -value	0%	0%	26%	75%
	Sample size	12	12	12	12
R		0.111	-0.003	0.445	5.661
N		0.209	-0.009	0.920	7.034
	Z-value	-1.857	0.714	-2.000	-0.429
	p -value	6%	48%	5%	67%
	Sample size	13	13	13	13

Note. (1) The statistics for the SSW treatment is extracted from Kirchler, Huber and Stöckl (2012) and Stöckl, Huber and Kirchler (2014), each with six sessions of the SSW treatment. (2) Because these two papers use average trading prices, we compute the statistics for our treatment F using average trading prices as well. During the process, we remove potential errors by removing trades where the price is higher than 6xFV or lower than FV/6 (this is why ST is lower in table 4 than that reported in tables 3 and 5). (3) We scale up the ST in the SSW treatment by 5/4 because each period lasts for 150 seconds in our treatments and 120 seconds in the SSW treatment. (4) PA is only compared with the first paper because the second paper does not have this information.