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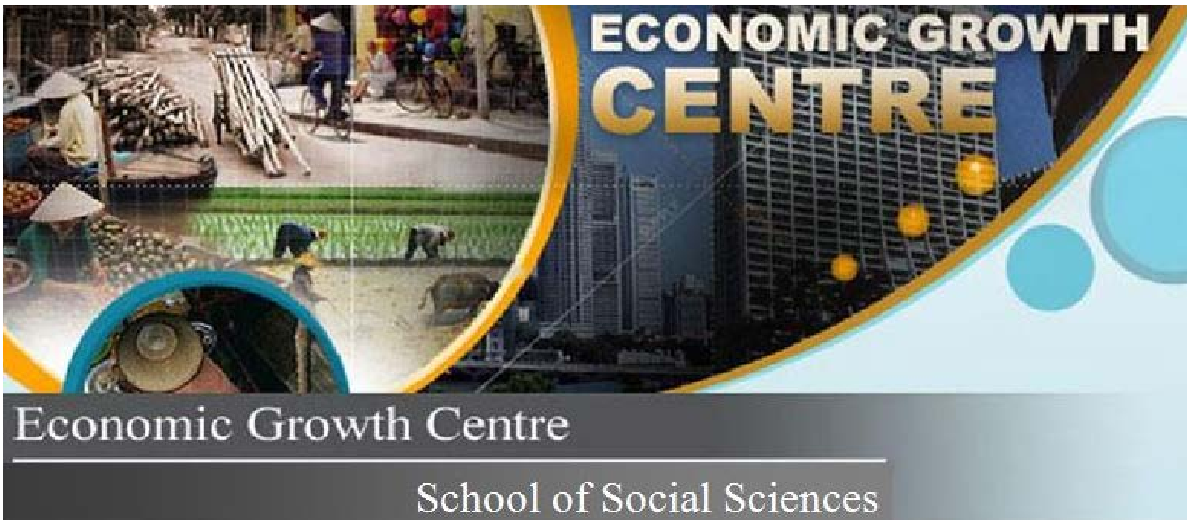

The Impact of Interest Rate Policy on Individual Expectations and Asset Bubbles in Experimental Markets[1]

Te Bao and Jichuan Zong

Abstract: Previous literature in experimental finance finds little support for the effectiveness of interest rate policy in stabilizing asset price bubbles. We run a learning to forecast experiment with an interest rate policy that is strongly responsive to deviation of asset prices from the fundamental. Our result shows that the average price deviation is significantly lower in the treatments with the interest rate policy than in the baseline treatment without the policy. Our result also suggests that the policy is effective irrespective of whether or not the purpose of it is announced/explained to the participants.

Keywords: interest rate policy, asset bubble, experimental economics, learning to forecast experiment, behavioral finance

JEL Classification: C92, C93, D84, G01

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Introduction

In recent years, there is a heated debate on the role of monetary policy on asset prices. Many economists believe that high interest rate can be an effective tool to stabilize asset bubbles. For example, Taylor (2010) claims that the housing bubble could have been avoided if the Federal Reserve Bank had imposed a higher interest rate. While on the other hand, Bernanke (2010) pointed out there were many other concerns behind the low interest rate in early 2000s, and monetary policy may not be a suitable tool in mitigating price deviation in asset markets.

This paper does not aim at addressing whether interest rate policy SHOULD be used for stabilizing asset prices. Instead, we study if interest rate can be used for this purpose, will it be an EFFECTIVE tool in achieving the goal.

While the question is worthwhile being addressed using empirical data from the field, one concern with studies of that type is that the central banks in reality usually adjust the interest rate in response to other economic variables that are correlated with asset prices, which makes it difficult to explain the correlation between the interest rate and asset prices as one-side causal relationship. Therefore, laboratory experiment has the advantage in disentangling the causal relationship by controlling for other variables.

We are not the first to study this question. To our knowledge, Fischbacher et al. (2013) is the first experimental study on the impact of monetary policy on asset prices. They find that higher interest rate does lead to lower liquidity in the market, but has little impact on the asset price. Similarly, Giusti et al. (2016) also conclude that introducing opportunity cost of speculation in the form of interest has limited success in lowering the bubble. A main difference between their studies and ours is that their experiments are continuous double auction experiment (or more broadly, "learning to optimize experiment" as in Duffy, 2016) as Smith et al. (1988), while we employ the learning to forecast experiment (LtFE, Marimon et al., 1993, Hommes et al., 2005, 2008, Hommes, 2011) design where the subjects only submit a price forecast, and their trading quantity and the asset prices will be calculated automatically by a computer program. The feature of learning to forecast experiment allows us to focus on subjects' bounded rationality, or deviation from rational expectation hypothesis in expectation formation only, and rule out the influence of other factors, such as failure in calculating the optimal quantity decision for a given price expectation.

We find that the interest rate policy is very effective in stabilizing asset prices in our experiment. The price deviation from the fundamental value drops more than 2/3 in the treatment with the interest rate policy compared to the baseline treatment. Why is the result of our experiment different from previous experiments, e.g. Fischbacher et al. (2013)? There are two possible reasons: (1) Fischbacher et al. (2013)

use a double auction design. So the fact that a similar interest rate policy works in our setting but not in theirs may suggest that interest rate policy is effective in stabilizing expectations, but has a limited role in stabilizing bounded rationality in trading. (2) The details of the interest rate policy in Fischbacher et al. (2013) are not announced in a very explicitly way to the subjects. In a third treatment, Fischbacher et al. (2013) find that a pre-announced reserve requirement policy can effectively stabilize asset bubbles. One possibility is that interest rate policy will only be effective if it is announced openly.

To isolate the effect of the announcement of interest rate policy, we design a third treatment where the policy is implemented but not announced in a clear way. It turns out the result in this treatment is very similar to the treatment with both the policy and announcement. In other words, the policy also works without the announcement, and the difference between the baseline treatment and the policy treatment is caused mainly by the policy itself, instead of the announcement of it.

Our result also goes in the same direction as the experiments that compares learning to forecast and learning to optimize experiments (Bao et al., 2013, 2017), where the market price always tends to depart from the Rational Expectations Equilibrium more in the treatments using the learning to optimize design than the learning to forecast design.

Experimental Design

We ran a learning to forecast experiment following Hommes et al. (2005, 2008) where the realized price is an increasing function of the average price expectation in the market,

$$p_t = \frac{1}{1+r}\left(\overline{p_t^e} + d\right) + \epsilon_t$$

where r is the interest rate of the risk free asset, $\overline{p_t^e}$ is the average price expectation of the subjects in the same market, d is the dividend of the risky asset, and $\epsilon_t \sim i.i.d\ N(0,1)$ is a small random noise term. The parameterization of the original design is $r = 0.05, d = 3$. By substituting in the rational expectation condition $\overline{p_t^e} = p_t$, the unique rational expectation equilibrium and steady state of the system is $p^* = 60$. This price determination equation can be derived from a mean-variance optimization problem by the investors, and a price adjustment rule based supply and demand at the market level.

We design two treatments:

- Baseline treatment (Treatment B): where there is no monetary policy, and the interest rate for the risk-free asset is always 5%.

- Policy treatment (Treatment P): where the central bank is going to raise the interest rate to 10% if the asset price in the last period is larger than 90 (50% higher than REE), and lower it to 2.5% if the asset price in the last period is lower than 30 (50% lower than REE). This design is similar to the one in Fischbacher et al. (2013). The subjects know the qualitative information that the central bank is going to raise (lower) the interest rate when the asset price is considered too high (low), but not the threshold of 90 and 30 from the instructions, and they can observe the real time interest rate from the computer interface of the experiment.
- Policy treatment without policy announcement (Treatment PN): this treatment is the same as treatment P except that while subjects see the real time interest rate in each period, the sentence in the instructions telling them the reason for interest rate adjustment (i.e. the central bank is going to set the interest rate higher/lower when the asset price is too high/too low) is removed. That is, while the interest rate policy is still at work in this treatment, the subjects do not see the announcement/explanation of its purpose. The comparison between treatment P and PN is helpful for us to isolate the effect of the interest rate policy and the announcement of its purpose.

Mathematically, the price determination function in Treatment P and PN is as the following:

$$p_t = \begin{cases} \frac{10}{11}\left(\overline{p_t^e} + 3\right) + \epsilon_t & if \quad p_{t-1} > 90 \\ \frac{20}{21}\left(\overline{p_t^e} + 3\right) + \epsilon_t & if \quad 30 \leq p_{t-1} \leq 90 \\ \frac{40}{41}\left(\overline{p_t^e} + 3\right) + \epsilon_t & if \quad p_{t-1} < 30 \end{cases}$$

It is not difficult to obtain that the unique steady state of the system is $p_t = p_{t-1} = p^* = 60$, and a steady state does not exist when $p_{t-1} > 90$ or $p_{t-1} < 30$.

We understand that the adjustment of the interest rate in our Treatment P is much larger than the adjustments made by the central banks in recent years, especially after the Great Moderation. But in history, Federal Reserve board led by Volcker did raised the federal funds rate from 11.2% in 1979 to 20% in 1981 when fighting against high inflation. The design of our interest policy against asset bubbles follows the same spirit. In addition, parallel to this paper, Hennequin and Hommes (2017) conduct another experiment with learning to forecast setting to test the impact of interest rate on asset prices. Their interest rate policy is a continuously increasing function of the bubble measure as in Bernanke and Gertler (2000) with a small (0.05) slope coefficient. They find that continuously increasing interest rate policy is not effective in reducing bubbles. It is hence interesting to study if a stronger policy is able to achieve this goal.

We formulate the following testable hypotheses for the experiment.

Hypothesis 1: *There is no difference between the price deviation from the REE in Treatment B and Treatment P.*

If Hypothesis 1 is rejected, and the deviation of asset prices from the REE is smaller in Treatment P, it is supporting evidence for stabilizing effect of the interest rate policy.

Hypothesis 2: *There is no difference between the price deviation from the REE in Treatment P and Treatment PN.*

If Hypothesis 2 is rejected, and the asset prices in Treatment PN is closer to Treatment B compared to Treatment P, it suggests that the difference between Treatment P and Treatment B is mainly driven by the announcement of the interest rate policy instead of the policy itself.

Experimental Result

<u>Market Price Dynamics</u>

The experimental results show a sharp difference between the Treatment B versus P and PN. Figure 1 plots the average market price in the three treatments, and Figure 2 shows the price in each of the eight markets of each of the three treatments. Clearly, the market price is much closer to 60 in Treatment P and PN than in the Treatment B.

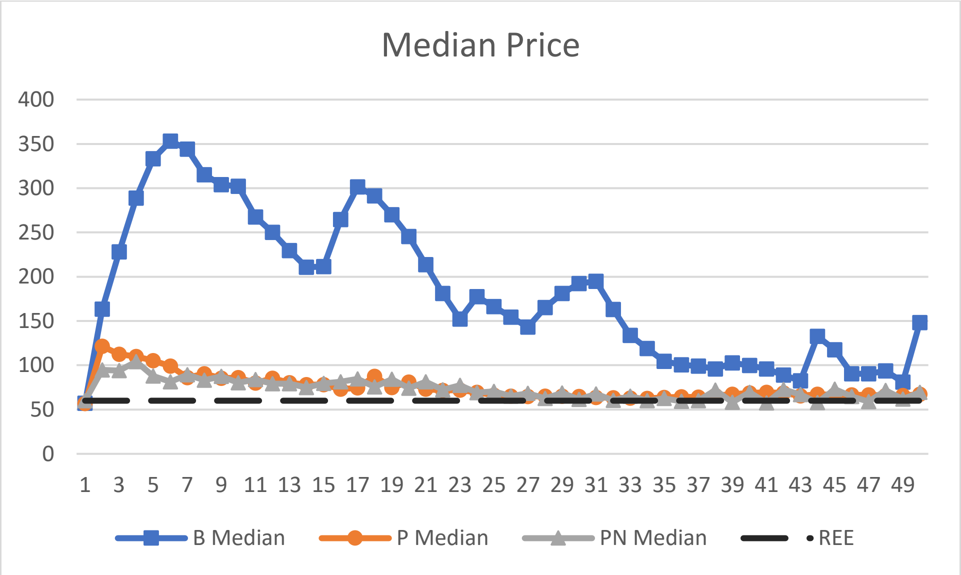

Figure 1: Median Market Prices in the treatment B, P and PN.

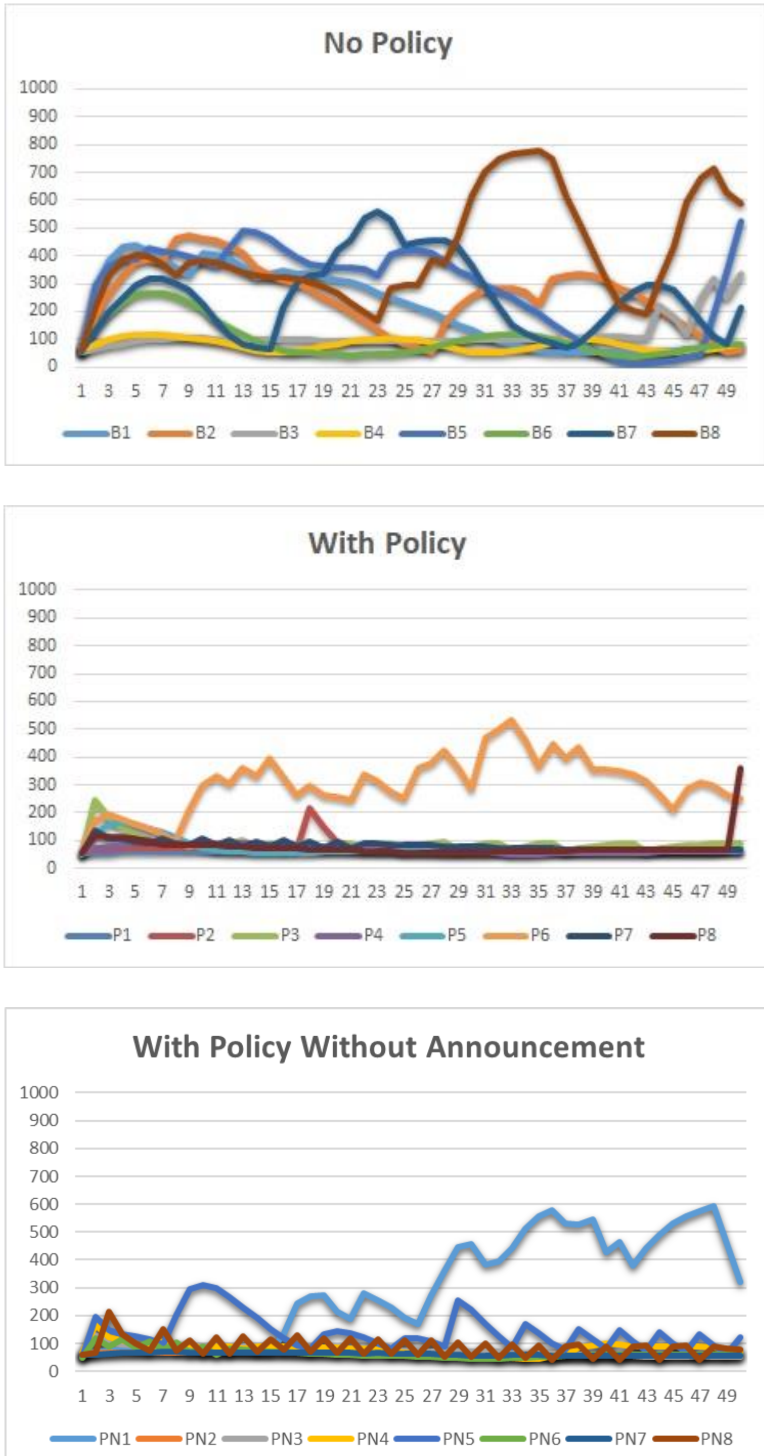

Figure 2: the asset price in each of the eight markets in the treatment with no policy intervention (top panel) and with policy intervention (bottom panel).

Following Stockl et al. (2010), we calculate the relative absolute deviation (RAD) in each market in the two treatments. The results are reported in Table 1. The average RAD is 262.9% in the baseline treatment, 74.9% in the policy treatment, and 85.6% in the treatment with policy but without announcement. The difference of the RAD is significant at 5% according to rank sum test between the Treatment B and P (z=2.472, p=0.0134), and also between B and PN (z=2.209, p=0.0272), but not between P and PN (z=0.309, p=0.7573).

Treatment	RAD1	RAD2	RAD3	RAD4	RAD5	RAD6	RAD7	RAD8	Average
Baseline	252.4%	324.2%	93.4%	37.4%	395.1%	84.8%	324.5%	591.2%	262.9%
Policy	2.9%	20.9%	51.6%	21.6%	26.3%	407.8%	36.8%	31.2%	74.9%
Policy without Announcement	394.6%	8.0%	27.7%	40.4%	133.9%	19.4%	7.5%	53.1%	85.6%

Table 1: RAD of the market price in each market of the two treatments. For each treatment, $RADk$ means the relative absolute deviation for market k.

Table 2 reports the variance of prices in each market of different treatments. The average variance is 14977.7 in Treatment B, 1863.0 in Treatment P and 5088.6 in Treatment PN. That is, compared to Treatment B, the market volatility is reduced to about 1/8 in Treatment P, and about 1/3 in Treatment PN. The difference in the variance is significant at 5% according to rank sum test between Treatment B and P, (z=2.626, p=0.0087), B and PN (z=2.100, p=0.0357), but not between P and PN (z=0.000, p=1.0000). All these results suggest that the interest rate policy is very effective in stabilizing the asset prices, irrespective of whether the purpose of it is announced or not.

Market	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Average
Baseline	19535.9	14138.4	3309.5	403.7	24208.2	4555.1	19661.1	34009.4	14977.7
Policy	4.3	586.9	887.3	210.5	832.3	10236.2	232.6	1913.8	1863.0
Without Announcement	34558.5	13.9	269.5	459.8	3957.5	311.7	23.1	1114.4	5088.6

Table 2: Variance of the market price in each market of the two treatments. For each treatment, $VARk$ means the relative variance of the market price in market k.

We can summarize the results into Result 1 and 2:

Result 1: *We reject Hypothesis 1. The deviation of asset prices from the REE is significantly smaller in Treatment P than in Treatment B. The interest rate policy is effective in reducing price deviation from the REE in our experiment.*

Result 2: *We do not reject Hypothesis 2. There is no difference between Treatment P and PN, but significant difference between B and PN. This suggests that the policy is effective even when the announcement is removed.*

Interest Rate

The findings in the previous section suggest that interest rate policy is an effective tool to stabilize asset bubbles. Then, how long does the central bank need to implement the high interest rate policy in order to stability bubbles?

Table 3 reports the number of periods when the interest rate is raised to 10% in the Treatment P. We find that in most markets (market P1, 2, 4, 5 and 8), the high interest rate is implemented for fewer than 10 periods. Indeed, except for market P6, the high interest rate is implemented for fewer than 20 periods in all other markets, and none of those markets experience a very large bubble (i.e. greater than 100%). It seems that market P6 is an outlier where the asset bubble is so severe (greater than 400%) that the high interest rate is not sufficient to stabilize it. For the other cases, in particular market P1, the participants seem to be deterred from coordinating on a bubble by the “threat” of high interest rate, though the high interest rate is in fact never implemented.

Similar patterns can be observed for Treatment PN. While the high interest rate is implemented for more than 20 periods for three out of eight markets (PN1, PN5, PN8), it is implemented for fewer than 10 periods for the other markets, including two markets where the policy is never implemented (PN2 and PN7).

Our findings suggest that the possibility of the existence of the interest rate adjustment policy alone already has some deterrence effect on the formation of bubbles. Related to this point, we understand that some may argue that the interest rate adjustment rule in this paper is too responsive to asset prices when it hits the thresholds, and not like the gradual, little by little interest adjustment announced by the central banks in real life. Parallel to this paper, Hennequin and Hommes (2017) conduct another experiment on the impact of interest rate on asset prices. Their interest rate policy is a continuously increasing function of the bubble measure as in Bernanke and Gertler (2000) with a small (0.05) slope coefficient. The result of their paper suggests that such interest rate policy is usually insufficient to stabilize bubbles, even when the interest rate determined by their function becomes very high (e.g. 50%). Put the results of the two studies together, the implied message seems to be: if stabilizing asset prices is the sole target of the central bank, they should choose an interest rate policy that is highly responsive to deviation of asset prices. This policy is usually more effective in achieving the goal to stabilize asset prices, and when the participant are fully aware of the policy, it is likely that the central bank can deter potential bubbles even without implementing the policy.

Market	P1	P2	P3	P4	P5	P6	P7	P8	Average
Number of Periods	0	3	16	3	8	48	12	5	11.88

Market	PN1	PN2	PN3	PN4	PN5	PN6	PN7	PN8	Average
Number of Periods	34	0	7	10	39	5	0	22	14.63

Table 3: Number of periods when the interest rate is raised to 10% for each market in the Policy treatment.

Payoff

Table 4 reports the average payoff of the subjects in each market of the two treatments. The average payoff is 2081.7 in Treatment B, and 3664.2in Treatment P. That is, compared to Treatment B, the average payoff is 80% higher in Treatment P. The difference in the average payoff between the treatments is significant at 5% level according to rank sum test between Treatment B and P (z=2.205, p=0.0274), significant at 10% level between B and PN (z=-1.785, p=0.0742) but not significant between P and PN (z=0.525, p=0.5995). These results suggest that the subjects earn a higher payoff in the treatments with the interest rate policy.

Market	E1	E2	E3	E4	E5	E6	E7	E8	Average
Baseline	2231.8	966.0	3376.4	4061.6	1299.3	3196.6	890.1	632.0	2081.7
Policy	4823.9	4290.7	3427.9	4259.6	4037.6	492.1	3722.8	4259.2	3664.2
Without Announcement	1497.6	4754.9	4048.8	3356.5	1171.1	4140.4	4903.5	2639.6	3314.0

Table 4: average payoff in each market of the two treatments. For each treatment, Ek means the average payoff of the market price in market k.

Individual Forecasting Strategies

The subjects in the experiment do not seem to use rational expectations when forming their price forecast in this experiment. Since previous experiments (e.g. Hommes et al., 2015, Bao et al., 2012) suggest individuals may use simple heuristics in the experimental asset markets, we estimate the following two simple forecasting strategies for each individual:

Adaptive expectations: $p_{i,t}^e = p_{i,t-1}^e + \gamma(p_{t-1} - p_{i,t-1}^e)$

Trend following expectations: $p_{i,t}^e = p_{t-1} + \theta(p_{t-1} - p_{t-2})$

We claim the estimation for an individual is successful if the estimated coefficient is significant at 5% level. It turns out for adaptive expectations, the estimation is successful for 46 out of 48 subjects in the baseline treatment, 45 out of 48 subjects in the policy treatment, and 46 out of 48 subjects in the policy treatment. For the trend following expectations, the estimation is successful for 41 out of 48 subjects in the baseline treatment, 28 out of 48 subjects in the policy treatment, and 34 out of 48 subjects in the policy treatment without announcement. The average estimated coefficient for adaptive expectations is $\overline{\gamma} = 1.137$ in the baseline treatment, $\overline{\gamma} = 0.979$ in the policy treatment and $\overline{\gamma} = 0.927$ in the policy treatment without announcement. The average estimated coefficient for trend following expectations is $\overline{\theta} = 0.655$ in the baseline treatment, $\overline{\theta} = 0.078$ in the policy treatment $\overline{\theta} = -0.126$ in the policy treatment with announcement. This sharp difference suggests that there are fewer people using trend following strategy in the policy treatment, and for those who use this rule, they also chase the trend to a lesser extent. As previous experiments find the trend following expectation rule is usually the driving force of bubbles in the experimental asset markets, our result shows clearly that bubbles are less likely to emerge in the policy treatments mainly because people chase trend to a lower degree.

Conclusion

We investigate experimentally whether a piecewise linear monetary policy can be used to stabilize asset bubbles in experimental asset markets. Our result shows that the average price deviation is significantly lower in the treatment with the policy. Compared to findings from other papers in the literature, our results suggest that the interest rate policy is effective in stabilizing expectations on asset prices. In order for the policy to be effective, the adjustment of interest rate in response to asset bubbles needs to be sufficiently large, and the effect tends to stay when the announcement of it is removed.

For possible future works, one interesting question would be whether the interest rate policy works better when the subjects have better cognitive ability. Previous studies (Hanaki et al., 2014, Bosch-Rosa et al., 2015) show that bubbles are usually smaller in markets with subjects with high CRT scores, and it will be interesting to see if subjects with different cognitive ability learn the effect of the policy in different ways. For example, is it more likely for the high CRT subjects to play the no bubble outcome without the policy being implemented? It is also interesting to test the effect of interest rate policy in call markets (Akiyama et al., 2017, Hanaki et al., 2018a, b) to see if the result is different from learning to forecast experiments and double auction markets.

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Appendix A: Estimation of the Individual Prediction Rules

Table A.1: The result of estimating $p_{i,t}^{e} = p_{i,t-1}^{e} + \gamma(p_{t-1} - p_{i,t-1}^{e})$ for the baseline treatment.

Subject	γ	p-value	R2	MSE
b11	1.534	0.000	0.977	460.08
b12	1.238	0.000	0.968	655.11
b13	0.931	0.000	0.676	8058.86
b14	1.035	0.000	0.698	9717.21
b15	0.922	0.000	0.598	11012.38
b16	1.343	0.000	0.913	2076.55
b21	1.163	0.000	0.343	18637.66
b22	1.343	0.000	0.953	712.36
b23	1.019	0.000	0.619	9789.93
b24	0.871	0.000	0.471	10007.39
b25	1.380	0.000	0.951	782.20
b26	0.720	0.000	0.851	2343.42
b31	1.316	0.000	0.357	11172.97
b32	0.533	0.000	0.508	814.41
b33	1.251	0.000	0.074	40047.67
b34	1.012	0.000	0.925	194.13
b35	0.891	0.000	0.878	364.02
b36	0.363	0.000	0.771	180.70
b41	1.075	0.000	0.863	62.01
b42	0.451	0.150	0.748	119.03
b43	1.052	0.000	0.807	88.33
b44	1.494	0.000	0.865	57.80
b45	1.940	0.000	0.868	59.02
b46	0.137	0.635	0.789	99.99
b51	1.021	0.000	0.771	5849.06
b52	1.012	0.000	0.919	2016.37
b53	1.195	0.000	0.801	5088.41
b54	1.771	0.000	0.644	12389.19
b55	1.256	0.000	0.963	953.73
b56	0.504	0.001	0.399	36975.64
b61	1.062	0.000	0.968	164.52
b62	1.483	0.000	0.930	346.72
b63	1.675	0.000	0.962	188.02
b64	1.027	0.000	0.871	706.59
b65	1.284	0.000	0.952	240.78
b66	0.907	0.000	0.379	5832.59
b71	1.151	0.000	0.852	2718.52
b72	0.989	0.000	0.753	7804.25
b73	1.031	0.000	0.700	6390.00

b74	1.527	0.000	0.932	1481.62
b75	0.865	0.000	0.143	52250.95
b76	1.367	0.000	0.841	3709.20
b81	1.084	0.000	0.762	11143.21
b82	1.424	0.000	0.941	2131.16
b83	1.073	0.000	0.055	68971.36
b84	0.790	0.000	0.323	53978.48
b85	1.390	0.000	0.932	2343.12
b86	0.974	0.000	0.871	5957.51

Table A.2: The result of estimating $p^e_{i,t} = p^e_{i,t-1} + \gamma(p_{t-1} - p^e_{i,t-1})$ for the policy treatment.

Subject	θ	p-value	R2	MSE
p11	0.928	0.000	0.903	0.34
p12	0.467	0.000	0.869	0.50
p13	0.971	0.000	0.955	0.20
p14	0.981	0.000	0.812	0.74
p15	1.116	0.000	0.064	19.38
p16	1.019	0.000	0.923	0.39
p21	1.001	0.000	0.997	1.59
p22	0.986	0.000	0.847	59.31
p23	1.128	0.000	-0.025	17784.29
p24	0.539	0.000	0.937	18.48
p25	0.059	0.248	-1.063	78.35
p26	1.190	0.000	0.784	100.83
p31	1.336	0.000	0.791	235.18
p32	0.539	0.000	0.155	218.98
p33	1.248	0.000	0.837	186.57
p34	1.047	0.000	-0.088	9448.32
p35	0.422	0.000	0.012	441.30
p36	1.487	0.000	-0.199	4293.84
p41	1.114	0.000	0.479	280.78
p42	0.681	0.000	0.960	8.09
p43	1.347	0.000	0.879	35.28
p44	1.027	0.000	0.826	45.72
p45	0.872	0.000	0.963	8.03
p46	1.851	0.000	0.964	8.21
p51	1.381	0.000	0.895	73.11
p52	1.134	0.000	0.946	46.62
p53	0.973	0.000	0.905	74.35
p54	0.963	0.000	0.092	4104.95
p55	0.775	0.000	0.512	1909.22
p56	1.022	0.000	0.959	28.09
p61	0.801	0.000	-0.054	102004.90

p62	1.186	0.000	0.835	1873.69
p63	1.016	0.000	0.059	47523.95
p64	0.951	0.000	0.627	5832.06
p65	1.030	0.000	0.052	22971.95
p66	0.928	0.000	0.739	2378.20
p71	0.670	0.000	0.354	173.22
p72	0.518	0.000	0.400	104.91
p73	0.780	0.000	0.520	100.69
p74	0.769	0.000	0.508	158.29
p75	0.862	0.000	0.347	203.89
p76	0.950	0.000	-0.102	5202.81
p81	1.448	0.000	0.906	38.90
p82	0.573	0.000	0.828	34.39
p83	1.189	0.594	-0.021	17818.07
p84	0.945	0.000	-0.004	2392.36
p85	0.381	0.842	-0.021	17799.26
p86	1.061	0.000	0.879	51.16

Table A.3: The result of estimating $p_{i,t}^{e} = p_{i,t-1}^{e} + \gamma(p_{t-1} - p_{i,t-1}^{e})$ for the policy treatment without announcement.

Subject	γ	p-value	R2	MSE
pn11	0.771	0.000	0.970	1069.76
pn12	1.332	0.000	0.977	822.76
pn13	1.224	0.000	0.981	735.15
pn14	0.579	0.000	0.216	145561.40
pn15	1.161	0.000	0.960	1477.38
pn16	1.062	0.000	0.978	712.62
pn21	1.007	0.000	0.460	18.34
pn22	1.014	0.000	0.986	0.20
pn23	1.367	0.000	0.918	1.32
pn24	0.871	0.379	0.159	33.80
pn25	1.088	0.000	0.991	0.13
pn26	0.911	0.000	0.966	0.53
pn31	0.512	0.000	0.595	134.77
pn32	0.560	0.000	0.905	25.16
pn33	0.608	0.000	0.946	12.18
pn34	1.162	0.000	0.963	12.61
pn35	0.545	0.000	0.869	32.53
pn36	0.974	0.000	-0.015	3993.92
pn41	1.080	0.000	0.554	253.44
pn42	0.875	0.000	0.903	37.97
pn43	0.296	0.000	0.774	84.79

pn44	1.022	0.000	0.265	800.41
pn45	0.551	0.000	0.732	86.79
pn46	0.966	0.000	-0.006	7233.08
pn51	0.953	0.000	0.546	2062.30
pn52	1.108	0.000	0.069	6079.84
pn53	0.990	0.000	-0.050	30984.47
pn54	0.882	0.000	0.471	2098.50
pn55	1.029	0.000	0.133	18261.03
pn56	1.018	0.000	0.510	2259.71
pn61	0.778	0.000	0.476	167.01
pn62	0.704	0.000	0.493	143.20
pn63	0.909	0.000	0.630	127.06
pn64	0.400	0.007	0.486	184.64
pn65	0.611	0.000	0.479	139.54
pn66	1.046	0.000	-0.062	4164.14
pn71	1.157	0.000	0.994	0.13
pn72	1.189	0.000	0.959	1.03
pn73	1.286	0.000	0.985	0.38
pn74	1.321	0.000	0.971	0.74
pn75	0.560	0.001	0.892	2.76
pn76	1.453	0.000	0.978	0.54
pn81	0.927	0.000	-1.126	2082.60
pn82	0.847	0.004	-1.321	2663.29
pn83	0.201	0.404	-1.760	2385.52
pn84	1.024	0.000	-0.957	3106.21
pn85	0.733	0.009	-1.611	2383.48
pn86	1.044	0.000	-0.150	20338.77

Table A.4: The result of estimating $p_{i,t}^{e} = p_{t-1} + \theta(p_{t-1} - p_{t-2})$ for the baseline treatment.

Subject	γ	p-value	R2	MSE
b11	0.624	0.000	0.982	355.68
b12	0.482	0.000	0.981	374.19
b13	0.316	0.000	0.988	240.71
b14	0.098	0.789	0.693	9712.42
b15	0.334	0.000	0.976	504.78
b16	1.042	0.000	0.972	660.59
b21	0.099	0.812	0.496	13320.54
b22	0.540	0.000	0.973	382.57
b23	0.639	0.063	0.634	9116.90
b24	0.750	0.030	0.488	9201.85
b25	0.674	0.000	0.985	233.62
b26	0.690	0.000	0.970	464.56

b31	2.551	0.000	0.637	6263.47
b32	-0.795	0.000	0.597	637.64
b33	-2.545	0.005	0.176	35461.20
b34	-0.029	0.659	0.925	189.06
b35	-0.094	0.278	0.891	324.78
b36	-0.394	0.000	0.281	533.21
b41	0.744	0.000	0.941	26.28
b42	1.089	0.000	0.972	13.10
b43	0.956	0.000	0.937	28.78
b44	0.854	0.000	0.971	12.53
b45	0.918	0.000	0.985	6.79
b46	0.971	0.000	0.975	11.41
b51	0.744	0.000	0.991	226.18
b52	0.519	0.000	0.967	824.28
b53	0.241	0.003	0.965	852.51
b54	1.007	0.000	0.802	6726.53
b55	0.408	0.000	0.973	660.78
b56	1.292	0.020	0.322	40404.38
b61	0.377	0.000	0.978	110.61
b62	0.967	0.000	0.995	25.74
b63	0.786	0.000	0.994	30.87
b64	1.262	0.000	0.983	90.22
b65	0.676	0.000	0.984	80.59
b66	0.711	0.000	0.977	110.58
b71	0.725	0.000	0.920	1411.62
b72	0.753	0.001	0.792	6356.88
b73	0.708	0.000	0.978	433.73
b74	0.768	0.000	0.983	354.16
b75	0.155	0.816	0.116	52667.93
b76	1.033	0.000	0.941	1336.52
b81	1.095	0.000	0.881	5290.85
b82	0.508	0.000	0.949	1679.94
b83	0.297	0.587	0.015	68805.25
b84	1.484	0.000	0.637	27007.83
b85	0.620	0.000	0.969	979.64
b86	0.386	0.010	0.879	5232.72

Table A.5: The result of estimating $p^e_{i,t} = p_{t-1} + \theta(p_{t-1} - p_{t-2})$ for the policy treatment.

Subject	θ	p-value	R2	MSE
p11	-0.022	0.736	0.944	0.18
p12	0.319	0.001	0.901	0.38
p13	0.181	0.003	0.958	0.16
p14	0.326	0.005	0.836	0.59

p15	0.885	0.182	0.064	18.85
p16	0.396	0.000	0.942	0.25
p21	0.002	0.779	0.997	1.59
p22	0.066	0.144	0.854	56.62
p23	-0.423	0.597	-0.032	17882.98
p24	-0.397	0.000	0.882	34.15
p25	-0.500	0.000	-26.517	447.32
p26	0.184	0.002	0.782	101.20
p31	0.171	0.016	0.781	246.08
p32	-0.236	0.003	-0.322	318.75
p33	0.167	0.012	0.803	220.30
p34	-0.065	0.289	0.683	186.19
p35	-0.621	0.000	0.315	304.47
p36	-0.546	0.000	-0.565	298.17
p41	0.704	0.181	0.507	264.98
p42	-0.212	0.035	0.952	9.72
p43	0.678	0.000	0.893	31.09
p44	0.131	0.259	0.947	12.96
p45	-0.032	0.729	0.962	8.11
p46	0.723	0.000	0.948	11.77
p51	0.343	0.001	0.886	78.39
p52	0.190	0.012	0.949	43.88
p53	0.003	0.975	0.903	74.48
p54	0.021	0.752	0.965	32.49
p55	3.140	0.000	0.902	381.00
p56	0.073	0.218	0.960	27.21
p61	0.619	0.441	-0.110	104140.40
p62	0.296	0.004	0.829	1745.90
p63	-0.735	0.132	0.210	38374.25
p64	-0.078	0.682	0.602	5820.90
p65	-0.151	0.689	0.019	22891.76
p66	0.016	0.897	0.698	2403.10
p71	-0.732	0.000	0.812	48.52
p72	-0.537	0.000	0.608	63.14
p73	-0.446	0.000	0.724	54.43
p74	-0.514	0.000	0.661	94.89
p75	-0.487	0.000	0.514	144.35
p76	-0.290	0.002	0.586	107.34
p81	0.895	0.000	0.990	4.22
p82	-0.395	0.000	0.969	6.01
p83	-0.050	0.981	-0.022	17820.44
p84	0.054	0.109	0.981	4.39
p85	-0.626	0.770	-0.022	17805.85
p86	0.423	0.000	0.912	36.80

Table A.6: The result of estimating $p^e_{i,t} = p_{t-1} + \theta(p_{t-1} - p_{t-2})$ for the policy treatment without announcement.

Subject	θ	p-value	R2	MSE
pn11	-0.042	0.684	0.963	1280.79
pn12	0.464	0.000	0.979	713.52
pn13	0.379	0.000	0.986	518.38
pn14	1.378	0.234	0.100	163995.70
pn15	0.361	0.000	0.966	1216.22
pn16	0.144	0.053	0.979	672.20
pn21	0.130	0.869	0.459	18.33
pn22	0.116	0.150	0.986	0.19
pn23	-0.170	0.022	0.988	0.16
pn24	0.293	0.784	0.160	33.76
pn25	0.268	0.000	0.993	0.10
pn26	0.727	0.000	0.990	0.14
pn31	-0.803	0.000	0.704	96.20
pn32	-0.550	0.000	0.959	10.77
pn33	-0.343	0.000	0.940	13.25
pn34	0.225	0.000	0.969	10.39
pn35	-0.551	0.000	0.938	15.11
pn36	0.102	0.029	0.958	13.58
pn41	-0.097	0.398	0.645	191.59
pn42	-0.107	0.038	0.900	38.74
pn43	-0.652	0.000	0.663	122.06
pn44	-0.222	0.338	0.275	785.28
pn45	-0.427	0.000	0.732	85.90
pn46	0.127	0.004	0.941	28.48
pn51	-0.212	0.089	0.557	1946.86
pn52	-0.164	0.184	0.519	1919.48
pn53	-0.273	0.582	-0.054	30787.67
pn54	-0.185	0.146	0.471	2032.18
pn55	0.648	0.044	0.307	13023.72
pn56	-0.043	0.749	0.496	2253.53
pn61	-0.672	0.000	0.835	51.92
pn62	-0.631	0.000	0.833	46.40
pn63	-0.485	0.000	0.805	65.87
pn64	-0.748	0.000	0.727	97.36
pn65	-0.661	0.000	0.823	46.29
pn66	-0.705	0.000	0.810	53.46
pn71	0.108	0.084	0.994	0.15
pn72	0.876	0.000	0.993	0.18
pn73	0.583	0.000	0.993	0.16
pn74	0.831	0.000	0.990	0.26

pn75	0.702	0.000	0.993	0.16
pn76	0.859	0.000	0.999	0.03
pn81	-0.602	0.000	-0.097	1058.65
pn82	-0.762	0.000	0.090	1036.23
pn83	-0.896	0.000	0.223	663.57
pn84	-0.799	0.000	0.166	1299.47
pn85	-0.759	0.000	0.119	794.85
pn86	-0.696	0.065	-0.073	18974.85

Appendix B: Experimental Instructions

Below are the experimental instructions for the Treatment P. The instructions are the same for both treatments except that the text in [] is only included for the Treatment P and the text in {} is only included for Treatment PN. The original instructions are in Chinese, and here is the English translation.

Experimental Instructions (P)

Welcome to our experiment! You are participating in an experimental with real monetary reward. The experiment consists of 50 periods. We are going to divide participants into different markets, 6 in each market. What happens in other markets does not influence your market. Your payoff from the experiment depends on your decision and decision of other participants in your market. You earn points for your decision in each period. When the experiment finishes, we are going to pay you according to the total number of points that you earned. The exchange rate is 120 points = 1 RMB.

The experiment is anonymous. You do not know the identity of other participants, nor do they know yours. You are not allowed to communicate with others during the experiment, and please place your cell phone in the place assigned by the experimenter.

The following is the detailed description of the experimental setup. Please read it carefully and listen to the explanation by the experimenter. If you have any questions, please feel free to ask.

Your role in the experiment is a financial advisor to an investment fund that wants to optimally invest a large amount of money. The fund is a major player in the market. The investment fund has two investment options: a risk-free investment and a risky investment. The risk-free investment is like putting money on a bank account paying a fixed interest rate. The interest rate for the risk-free asset is 5% at the beginning of the experiment. The alternative risky investment is like an investment in the stock market. The expected value of the dividend of the stock is 3. According to finance theory, the fundamental value of the risky asset is positively correlated with its dividend, and negatively correlated with the interest rate of the risk-free asset. In each period, the investment fund has to decide which fraction of their money to put on the bank account and which fraction of the money to spend on buying stocks. In order to make an optimal investment decision the investment fund needs an accurate prediction of the stock price. As their financial advisor, you have to predict the stock price during 50 subsequent time periods.

Your earnings during the experiment depend upon your forecasting accuracy. The smaller your forecasting errors in each period, the higher your total earnings.

1. The determination of the stock price.

The stock price is determined by a price adjustment rule based on the law of supply and demand: the price goes up/down when demand is larger/smaller than supply. The supply of stock shares is fixed. The demand for stocks is determined by the sum of demand of a number of large investment funds. There are also some small random shocks to stock prices due to fluctuation in the cost of construction materials etc.

Each of the investment funds is advised by a financial advisor played by a participant in the experiment (like you), and there is no difference between these funds except that they may receive different price forecast from their own advisors. The precise investment strategy of the investment fund that you are advising and the investment strategies of the other investment funds are unknown. As the financial advisor of an investment fund you are only asked to forecast the stock price in each period. Based upon your price forecast, your investment fund will make an optimal investment decision. The higher your price forecast the larger will be the fraction of money invested by your investment fund in the stock market, so the larger will be their demand for risky asset.

[Note that there is a policy maker played by a computer program in the experimental markets of your session. The idea of the policy making is the following:

When the policy maker thinks that the price of the risky asset is too high compared to the reasonable level, they will raise the interest rate of the risk-free asset above 5%. When the interest rate of the risk-free asset increases, the demand for risk-free asset tends to increase, and the demand for risky asset tends to decrease, which tends to drive down the price of the risky asset.

When the policy maker thinks that the price of the risky asset is reasonable, they will keep the interest rate at 5%.

When the policy maker thinks that the price of the risky asset is too low compared to the reasonable level, they will lower the interest rate of the risk-free asset below 5%. When the interest rate of the risk-free asset increases, the demand for risk-free asset tends to decrease, and the demand for risky asset tends to increase, which tends to drive up the price of the risky asset.]

{Note that there is a policy maker played by a computer program in the experimental markets of your session. The policy maker may change the interest rate during the experiment. You can read the interest rate for the current period on your experimental screen. When the interest rate of the risk-free asset increases, the demand for risk-free asset tends to decrease, and the demand for risky asset tends to increase, which tends to drive up the price of the risky asset.}

2. Your task in the experiment

The only task of the financial advisors in this experiment is to forecast the housing price in each time period as accurate as possible. The initial housing price is between 0 and 100 per unit, and the price forecast for all the other periods can be between 0 and 1000. The stock price has to be predicted one period ahead. At the beginning of the experiment, you have to predict the stock price in the first period. After all participants have given their predictions for the first period, the housing price in the first period will be revealed and based upon your forecasting error your earnings for period 1 will be given. After that you have to give your prediction for the second period. After all participants have given their predictions for period 2, the stock market price in the second period will be revealed and, based upon your forecasting error your earnings for period 2 will be given. This process continues for 50 periods.

To forecast the housing price p_t in period t, the available information thus consists of

- past prices up to period $t - 1$,
- your past predictions up to period $t - 1$,
- past earnings up to period $t - 1$.
- the interest rate of the risk-free asset in period t.

3. Your payoff

Earnings will depend upon forecasting accuracy only. The better you predict the housing price in each period, the higher your aggregate earnings. Earnings points are calculated in the following table

$$e_{h,t} = \max\left\{100 - \frac{100}{49}(P_t - P^e_{h,t})^2,\ \ 0\right\},\ \ h=1,2\ldots,\ \ 6$$

where $e_{h,t}$ it the points earned by participant h at period t， P_t is the market price of the risky asset in period t， $p^e_{h,t}$ is the prediction of participant h for the price in period t. The larger your prediction error, the smaller your payment. When the experiment finishes, we are going to pay you according to the total number of points that you earned. The exchange rate is 120 points = 1 RMB.