The Effect of Earned vs. House Money on Price Bubble Formation in Experimental Asset Markets

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Abstract:

Can "house money" explain asset market bubbles? We test this hypothesis in an asset market experiment with a certain dividend. We compare experiments where the initial portfolio of cash and shares is given to subjects, i.e. *house money*, to a treatment in which individual initial portfolios are constructed using subject *earned money* from a real effort task. We find that bubbles still occur; however trading volumes are significantly abated and the dispersion of earnings is significantly lower when subjects earn their starting endowments. We further investigate the role of cognitive ability in accounting for the differences in earnings distribution across treatments by using the Cognitive Reflection Test (CRT). We find that high CRT subjects earned more money on average than the initial value of their portfolio while low CRT subjects earned less. Subjects with low CRT scores were net purchasers (sellers) of shares when the price was above (below) fundamental value while the opposite was true for subjects with high CRT scores.

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1. Introduction

Do individuals make different economic decisions when they use their own money ("earned money") compared to when they don't ("house money")? Evidence of a "house money effect" was found by Thaler and Johnson (1990) in a lottery choice experiment. They found that subjects were more likely to exhibit risk-seeking behavior in the presence of a prior gain. This result raised the question about the robustness of experimental results where subjects make decisions using house money.

The effect of house money has been examined in bargaining and income redistribution experiments. When money is earned, subjects tend to recognize merit and divide money among subjects according to their respective contributions (Hoffman and Spitzer (1985), Konow (2000), Oxoby and Spraggon (2008)). In ultimatum games when money is not earned, merit does not play a role and subjects are more likely to share the initial endowment equally (Güth et al. (1982), Güth and Tietz, (1988)).[1] But Cherry et al. (2002) show that, in a dictator game, 95 percent of the dictators follow game-theoretic predictions by not transferring any amount to the other player when they earned their wealth. Reinstein and Reiner (2001) obtain similar findings in a charitable giving game. In these studies, subjects earn money prior to deciding upon the allocation of the outcome by answering a quiz (Cherry, Frykblom and Shogren (2002), Oxoby and Spraggon (2008)), playing a simple hash mark game (Hoffman and Spitzer (1985)), adding numbers (Reinstein and Reiner (2011)) or stuffing and folding envelopes (Konow (2000)). On the other hand Cherry, Kroll and Shogren (2005) find no evidence of the house money effect in voluntary contribution games. The variability of results across different games suggests that the effect may also be specific to the environment being tested.

Even though most of the previously mentioned research provides evidence of a house money effect in bargaining games, it is not clear that how these results extend to market games of exchange.

House money vs. earned money in asset markets

It is well known that prices in asset markets do not follow the theoretical prediction and bubbles are commonly observed with inexperienced subjects (Smith, Suchanek and Williams, 1988). Experimental asset markets are characterized by persistent (average) price deviation from fundamental value in early periods and subsequent crashes. The question we address is

[1] Note that despite extensive evidence of an effect of earned money on the allocation of joint outcomes, Rutstrom and Williams (2000) report no significant differences in allocations whether endowments were earned or randomly generated.

whether the use of house money to endow initial portfolios of cash and shares to subjects encourages the "mispricing" found in experimental asset markets.

Specifically, we investigate whether traders behave differently when they earn the starting endowment ("Earned Money treatment") than when they do not ("House Money baseline") in experimental asset markets with price bubbles and crashes. Prices in these markets typically start below fundamental value (as determined by the expected dividend value of the asset) and quickly rise above the intrinsic value until a crash occurs in the final periods. Asset market bubbles have been found to be robust to treatments variations such as short selling, capacity to buy on margin, brokerage fee, limit price change rules (King et al. (1993), Porter and Smith (1994)) and assets generating certain dividends (Porter and Smith (1995)). Further, even though the introduction of futures markets may reduce bubble amplitude, it does not affect their duration (Porter and Smith (1995)). Nevertheless, a complete set of futures (one for each of the 15 periods) seems to eliminate bubbles (Noussair and Tucker (2006)). Interestingly, bubbles tend to disappear with twice-experienced subjects even when experienced and inexperienced traders are mixed (Dufwenberg, Lindqvist and Moore (2005)). However, bubbles may still be observed among twice-experienced traders when the market environment is modified by increasing liquidity and dividend uncertainty (Hussam, Porter and Smith (2008)). The existence of bubbles has been partly ascribed to subjects' irrational behaviors (Lei, Noussair and Plott (2001)). The authors find evidence of systematic errors in decision making accompanying bubbles. Traders engage in unprofitable transactions at prices above the maximum possible or below the minimum possible dividend stream.

The asset market environment is a good candidate to study the house money effect as it is characterized by systematic deviations from game-theoretic predictions. In that context, we may wonder whether the house money effect can account for part of the discrepancy between the fundamental value of the asset and the prices observed in the laboratory. Earlier research on the house money effect offers little guidance to our current study as it mostly examines bargaining games and aims at studying the role of house money on distributive preferences. Market experiments differ considerably from these settings as they do not involve concerns for distributive preferences. The only work that contemplates the potential effect of house money in a market environment was conducted by Ang, Diavatopoulos and Schwarz (2010). The authors conducted experimental asset markets (as a robustness check) in which subjects played with their own money. No significant differences were found between these two cases. Besides natural concerns with a possible selection bias, the authors' results should be interpreted with caution as they conducted only two experimental sessions with subjects' own

money. This small sample follows from the fact that the primary goal of the authors was to assess the emergence of bubbles under different compensation schemes, wealth and supply constraints, as well as the effect of the relative risk aversion of traders rather than studying the house money effect per se.

In order to study the effect of earned money in experimental asset markets, we recruited subjects for a two-part experiment. In the first part, subjects had to perform a two and a half hour real effort task that consisted in developing a database for a research institute. All subjects earned the same amount in this part and were told that their money was carried over for the experiment which will be realized in the second part.[2] In the second part, which took place after three days, subjects participated in a standard experimental asset market with certain dividends (Smith, Suchanek and Williams (1988), Porter and Smith (1995)). The value of each subject's initial portfolio composed of both cash and shares was exactly equal to the fixed payment earned from the first-day task ($31.5).[3]

Our main findings are that bubbles were not completely eliminated in the earned money treatment and bubble measures were similar in the house and earned money treatments. Relative to the house money treatment, transaction volumes were 51% lower in the earned money treatment. One of the direct effects of reduced transactions is that the dispersion of earnings was more pronounced in the house money compared with earned money treatment. We investigate earnings dispersion further by categorizing subjects according to their performance on the cognitive reflection test (CRT) which is one among other possible measures of cognitive ability performance (Frederick, (2005)).[4] We find that subjects with lower CRT scores were net purchasers (sellers) of shares when the price was above (below) fundamental value while the opposite was true for subjects with higher CRT scores. As a result, high CRT subjects earned more money on average than the initial value of their portfolio while low CRT subjects earned less. This result was true for both the house and earned money treatments.

2. Experimental Design and Hypothesis

2.1. Procedure

Ninety subjects from a major university participated in the house money (henceforth HM) and earned money (henceforth EM) treatments.

[2] Further, we made no promises in terms of a safety net that subjects would be able to recover the money from the experiment (as in Clark (2002)).
[3] In addition, subjects were paid a $10 show-up fee for each appearance.
[4] This 3-minute questionnaire was administered while subjects waited for their payments to be prepared at the end of the experiment. As is common in this literature, the CRT was not incentivized.

The house money treatment

In the baseline HM treatment, subjects only participated in the asset market experiment for which they were endowed with a portfolio of cash and shares worth $31.50 from the experimenter (house money). The HM experiments were conducted as standard asset market experiments (Smith, Suchanek and Williams (1988)). Nine subjects each participated in a fifteen period asset market. Our only departure from the standard structure was that the dividend was certain (Porter and Smith (1995)). This was dictated by the design requirement of the EM treatment where we wanted to ensure that subjects did not see their earned money being put to risk. A certain dividend guaranteed that if the subjects simply held on to their shares and cash endowment they would finish the market experiment with the amount of money they had previously earned.

The earned money treatment

Subjects in the EM treatment were told that they will be participating in an experiment that has two parts (see Table 1) with the second part taking place three days after the first part. Subjects were told that they will be performing a task related to a database for a research institute in the first part and that the amount earned in the task, $31.50, will be carried over to the second part.[5] They were also informed that they would be paid in cash for the entire experiment at the end of the second part. Including the two-day show up fees subjects earned, on average, $51.50.[6]

Table 1. Experimental Parameters: Earned Money Treatment

First Day – Task	Second Day – Asset Market
– 2.5 hours – Download academic articles from JSTOR – Earned $31.50 – Money credited to buy asset market portfolio in the second part of the experiment.	– Continuous double auction – One asset traded – 15 periods (4 minutes each) – Fixed and known dividend of 24 cents – 9 subjects per market – Initial Endowment ($31.50): o 4 shares & 1710 cents o 5 shares & 1350 cents o 6 shares & 990 cents

In the first part of the experiment subjects performed a task requiring (real) effort of two and a half hours. The task consisted in developing a database of research papers for a research institute. The task performed by the subjects was intended to resemble as closely as

[5] See Appendix B for instructions.

[6] The show up fee was $10 each day. A high show up fee was used in this treatment to ensure that subjects who participated in the first day experiment would come back for the second. This was indeed the case for all subjects but one.

possible a short term job.[7] We ensured that subjects were aware of the economic significance of their work task by explicitly stating in the instructions that the database to be developed was going to be used by a research institute (which was indeed the case). In order to stress the difference between a standard laboratory experiment and the work task (in the EM treatment), we conducted the two parts, i.e. the work task and the experimental asset market, on two separate days.[8]

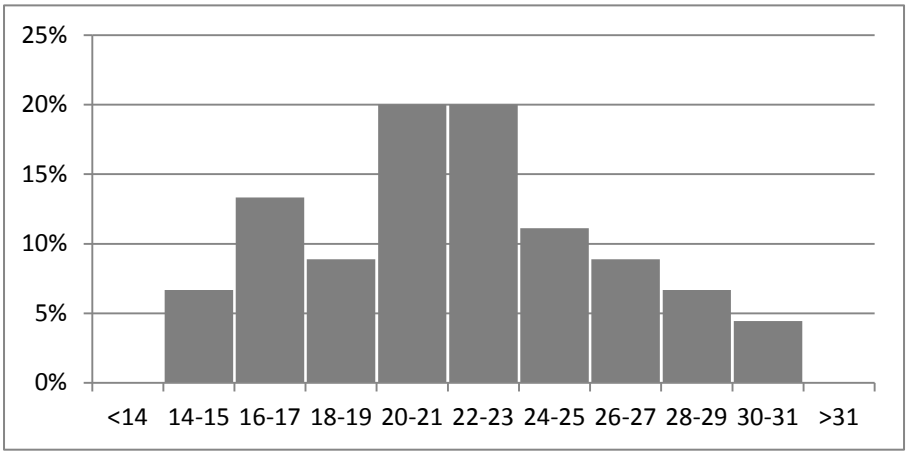

Figure 1. Histogram of number of downloaded articles.

In our work task, subjects had to search and download academic articles into a file folder with the objective of building a database. Subjects had to search on JSTOR for the articles, download them and copy them into a file folder. If they could not copy any article then they had to state the exact reason as to why it was not downloaded.[9] All subjects were paid the same fixed wage of $31.50 for the task irrespective of the effort made. This was done to ensure that the starting endowment for all the subjects was the same in the asset market experiment. Subjects were told in the instructions (see Appendix B) that they were "*expected to search a minimum of 20 articles in a JSTOR database and download them to a personal folder with their name (that will be identified later)*". A great majority of subjects (71%) were able to download 20 articles or more. On average (median) subjects downloaded 21.7 (22.0) articles, with the maximum number of articles being 31 and the minimum being 14 (see Figure 1 for a histogram of the number of downloaded articles).

[7] This task is similar to that in Falk and Ichino (2006) where recruited students folded papers and stuffed envelopes to prepare the mailing of a questionnaire study for the University of Zurich.
[8] Also, the monitors who were in charge of supervising subjects in the work task were different from the experimenters conducting the second part of the experiment. This constant supervision also helped to avoid shirking behavior from subjects.
[9] The most common reason for an article not being downloaded was lack of availability due to different restrictions on download permissions.

In the second part, the subjects participated in an asset market experiment (see Table 1). Each experiment had 9 subjects. Each asset earned a fixed dividend of 24 cents in each period and lasted for 15 periods. Subjects started the experiment with four, five or six shares and had cash endowments of 1710, 1350 or 990 cents, respectively. The total value of the endowment equaled $31.50 dollars for all subjects, which is exactly equal to the money they earned in the prior task. Subjects were told several times that their earnings will be used in the asset market experiment. For example, subjects were informed explicitly that:

(i) "Before participating in this experiment, you earned $31.50 by working on the database for the research institute during 2.5 hours. This full amount of cash will be used to pay for your initial portfolio in the current experiment."

We provided each subject with detailed calculations regarding the value of their initial portfolio which was composed of both cash and shares (see Instructions page 3 in Appendix C). We then clarified the link between the work task completed in the first part of the experiment and the initial portfolio endowment.

(ii) "Notice that the value of your initial portfolio corresponds to the earnings in the 2.5 hours you spent working on the database."

Point *(ii)* was further repeated in the experimental summary at the end of the instructions where subjects were told that the initial value of their portfolio ($31.50) corresponded to the earnings they obtained in the work task three days ago. This was done to ensure that the subjects knew that they were playing with the amount they *earned* in the earlier task. We summarize our experimental design in Table 2.

Table 2. Experimental Design

Treatment	Number of subjects per sessions	Number of sessions
House Money Baseline	9	5
Earned Money Treatment	9	5

Cognitive reflection test (CRT)

To complement our analysis of the effect of earned money on individual behavior we collected data regarding subjects' cognitive ability at the end of each experimental session. We used the CRT which is one among other possible measures of cognitive ability (Frederick, (2005)). The CRT was found to correlate with general measures of intelligence as well as different aspects of individual decision making such as risk and time preferences

(Frederick, (2005), Oechssler et al. (2009)) and levels of reasoning (Brañas, García and Hernán, (2011)). The CRT consists of the following three questions:

1. *A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?*
2. *If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?*
3. *In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?*

The CRT score corresponds to the total number of correct answers and can vary from 0 to 3.

2.2 Hypothesis

Bubbles in experimental asset markets are characterized in many dimensions such as price deviations from fundamental value, duration and trade volume. If house money has an effect it will be manifested in changes in these measures. It seems natural to suppose (and as suggested by Thaler and Johnson, 1990) that subjects might engage in greater speculative behavior when they have none of their own money at stake and that this speculative behavior will likely result in higher trading volumes and mispricing. If, as Lei et al. (2001) and Kirchler et al. (2012) suggest, bubbles are a manifestation of some underlying confusion about the market environment, then earned money should have no effect. Given this, we examine the following null hypothesis in our experiments.

Hypothesis: *Earned money will have no effect on the characteristics of price bubbles.*

3. Results

We use different measures of bubbles considered in the literature in order to check for differences between treatments and also to compare with results reported by other authors. We consider the following measures of bubbles:[10]

1. *Amplitude:* Measures the trough-to-peak change in asset value relative to its fundamental value. This is measured as, A = Max{($\frac{Pt - ft}{E}$: t = 1…15} - Min{$\frac{Pt - ft}{E}$: t = 1…15}. Where, P_t is the average market price in period *t*, f_t is the fundamental value of the asset in period *t*, and *E* is the expected dividend value over the life of the asset.

[10] See Dufwenberg et al. (2005) and Corgnet et al. (2010).

2. *Duration:* Measures the length, in periods, in which there is an observed increase in market prices relative to the fundamental value of the asset. Formally, *duration* is defined as:

$$D = \text{Max}\{m: P_t - f_t < P_{t+1} - f_{t+1} < \ldots < P_{t-m} - f_{t-m}\}.$$

3. *Haessel-R^2* (Walter W. Haessel, 1978): measures goodness-of-fit between observed (mean prices) and fundamental values. It is appropriate, since the fundamental values are exogenously given. *Haessel-R^2* tends to 1 as trading prices tend to fundamental values.
4. *Normalized Average Price Deviation (NAV):* Sums up the absolute deviation between the average price and the fundamental value for each of the fifteen periods. It is defined as follows:

$$NAV = \sum_{t=1}^{15} \frac{|Pt - ft|}{15}$$

5. *Normalized Absolute Price Deviation (NAP):* As defined in Haruvy and Noussair (2006), NAP measures the per-share aggregate overvaluation (or undervaluation), relative to the fundamental value of the asset in a given period and is defined as:

$$NAP = \sum_{k=1}^{K} \frac{|Pk - fk|}{100 \times 45}$$

where, P_k is the price of the kth transaction in the experiment, 45 the total number of shares, 100 is a normalization scalar, and f_k is the fundamental value of the asset when the kth transaction takes place. Large values of *NAP* reflect volumetric deviations from fundamentals. This measure is similar to the *Normalized Average Price Deviation*. However, *NAV* does not depend on the number of trades and can then be used to compare the extent of mispricing in sessions with different levels of *trading volumes*.

6. *Turnover:* Measures the volume of share transactions relative to the number of shares on issue in the market:

$$Turnover = \frac{\sum_{t=1}^{T} q_t}{TSU}$$

Where, T is the number of trading periods, q_t is the number of transactions in period t and *TSU* (Total Stock of Units) is the total number of shares in the market which in our case is equal to 45.

3.1 Bubble Characteristics

In Figure 2 we plot per period median price for each session in the HM treatment. Interestingly, although prices always start below the fundamental value, in two of our

sessions average prices keep close to the fundamental value for most of the periods. Table 3 reports bubble measures for each session.

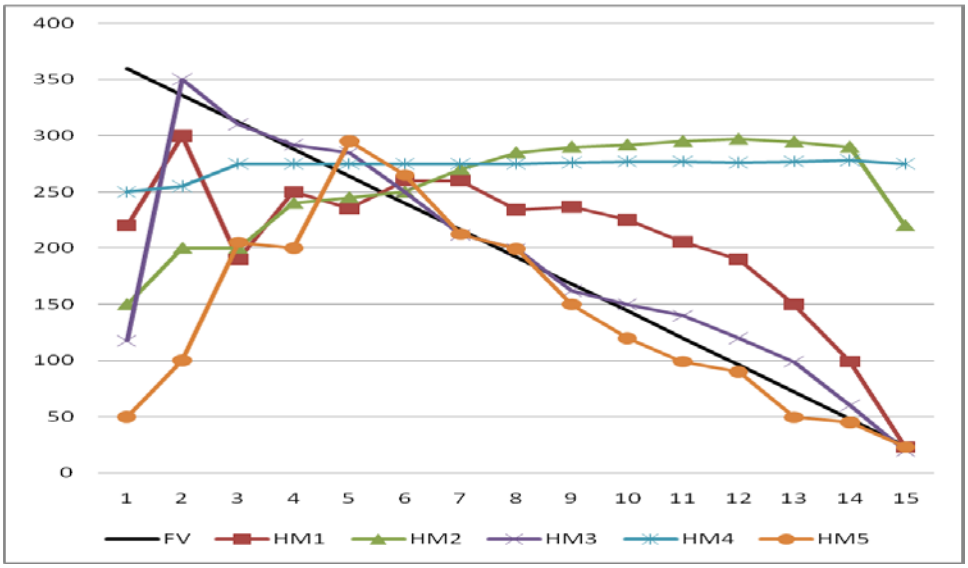

Figure 2. Period median prices in the House Money treatment.

We confirm the results of Porter and Smith (1995) by not identifying significant differences in bubble measures when comparing experimental asset markets with certain dividends versus markets with asset markets with uncertain dividends.[11] We perform a comparison of different bubble measures for treatments with randomly drawn dividends and inexperienced subjects against our HM experiments (see Table A1 in Appendix A). We find that bubble measures do not differ significantly from those obtained in the HM treatment when considering standard significance levels.[12] However, we do find a higher level of heterogeneity in bubble measures in the baseline treatment in two sessions (Sessions 2 and 4). These sessions were characterized by bubble measures which were two to three times larger than the average of bubble measures in the EM treatment.

[11] We compare our results (with certain dividends) with the results of Corgnet, Kujal and Porter (2010) (uncertain dividends).

[12] We use a multivariate test comparing all bubble measures in our study and in Corgnet, Kujal and Porter (2010). We report a p-value of 0.33. When comparing each bubble measure separately (see Table A2 in Appendix A), we report marginally significant differences for amplitude and NAP between our house money treatment and the baseline treatment in Corgnet, Kujal and Porter (2010).

Table 3. Average bubble measures for different treatments

Treatment	Session	Amplitude	Duration	Haessel-R^2	NAV	NAP	Turnover
House Money	1	0.58	9	0.65	59	4.7	7.4
	2	1.19	13	0.38	130	13.4	10.5
	3	0.53	3	0.82	25	2.1	4.3
	4	1.05	14	0.48	116	7.7	7.9
	5	0.85	4	0.35	53	4.7	4.9
Earned Money	6	0.46	6	0.82	29	1.5	3.0
	7	0.60	4	0.80	37	1.3	2.9
	8	0.84	5	0.53	69	1.8	3.0
	9	0.52	8	0.92	81	2.8	2.5
	10	0.74	4	0.61	27	2.0	5.8
House Money	Average	0.84	9	0.54	77	6.5	7.0
	Median	0.85	9	0.48	59	4.7	7.4
Earned Money	Average	0.63	5	0.74	49	1.9	3.4
	Median	0.60	5	0.80	37	1.8	3.0
MWW[+] (p-values)		0.22	0.53	0.15	0.55	0.03	0.03

[+]Mann-Whitney-Wilcoxon test.

Figure 3 shows per-period median price for the earned money treatment. Though differing in magnitudes, bubbles form in three out of five cases in both the HM and EM treatments. From Figures 2 and 3 one can see significant mispricing in both the house money and the earned money treatments.

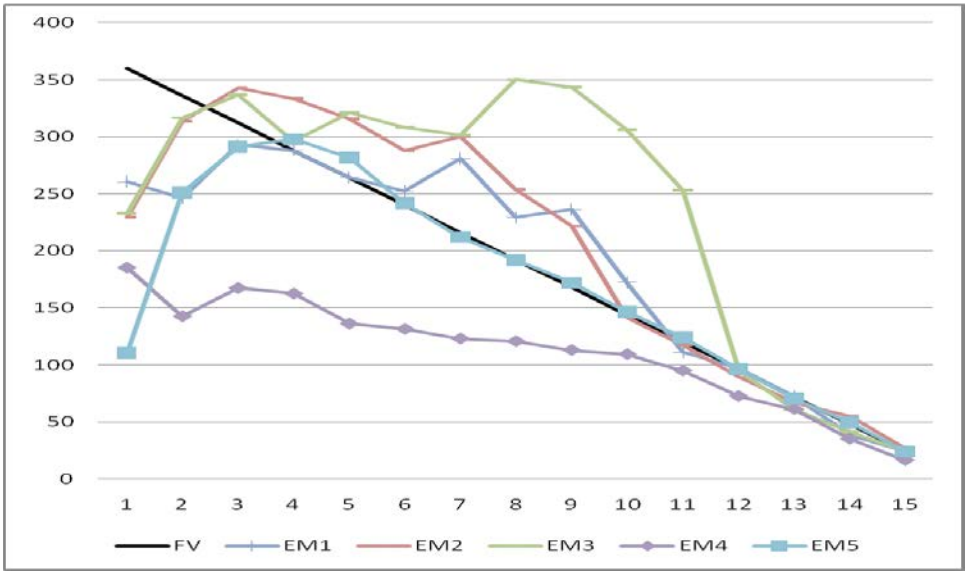

Figure 3. Period median prices in the Earned Money treatment.

Looking at bubble measures (see Table 3) we observe no significant differences between the house money and the earned money treatment. Amplitude, duration, Haessel-R^2 and normalized average price deviation (NAV) do not differ significantly across treatments. The only measures showing significant differences are the Normalized Average Price Deviation

(NAP) (p-value=0.03) and turnover (p-value=0.03). A lower NAP tells us that relative to the HM experiments, and considering all transactions, prices in the EM treatment were closer to the fundamental value. Average (median) trading volumes are 51% (60%) lower in the EM treatment compared with the HM treatment. Note that NAP is, by definition, closely linked to trading volumes. By definition, NAP automatically increases with an increase in the number of transactions *K* as long as transactions are completed at prices that are not exactly equal to fundamental values. The fact that the measures of mispricing that are not affected by trading volumes, such as NAV and Haessel-R^2 values, do not differ across treatments suggests that there are no differences in the pattern of prices across treatments. We conclude that the difference in the NAP measure across treatments is driven by differences in trading volumes. Interestingly, if we test for the similarity of all these measures, we cannot reject the hypothesis that they are equal (p-value = 0.17).[13] We summarize our findings as follows.

> ***Result 1:*** *We find that the earned money treatment has no significant effect on asset mispricing, but has a significant effect on measures of trading volume.*

Finally, we investigate the distribution of subjects' earnings across treatments. Figure 4 below shows a histogram of subjects' earnings at the end of the experiment for each treatment.

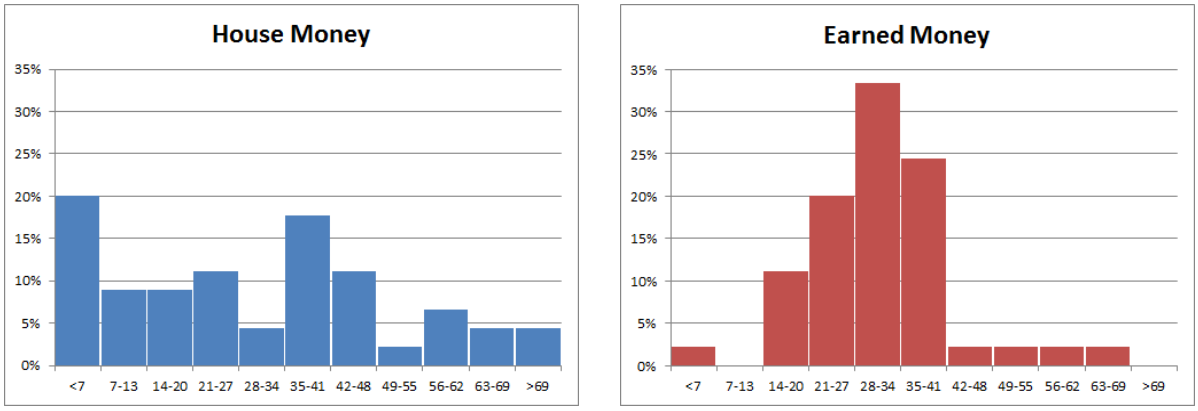

Figure 4. Histogram of subjects' earnings by treatment.

We observe that the dispersion of earnings, measured by their standard deviation and the Gini coefficient, is significantly greater in the HM treatment than in the EM treatment (Table 4). Note that a crucial element in explaining differences in earnings dispersion across

[13] We used command sr.loc.test in R to do these spatial rank tests of multivariate location. We obtained similar values using a Hotelling's T^2 test (p-value=0.20).

treatments is the difference in trading volumes (K) between the earned money and the house money treatment.[14]

Table 4. Subjects' final earnings

Treatment	Session	Standard error	Gini Coefficient
House Money	1	28.64	0.45
	2	32.61	0.53
	3	20.55	0.34
	4	17.88	0.30
	5	21.68	0.36
Earned Money	6	14.90	0.23
	7	11.37	0.19
	8	7.04	0.10
	9	7.91	0.13
	10	15.44	0.24
House Money	Average	24.27	0.40
	Median	21.68	0.36
Earned Money	Average	11.33	0.18
	Median	11.37	0.19
MWW[+] (p-values)		0.01	0.01

[+]Mann-Whitney-Wilcoxon test.

Our findings regarding earnings dispersion are summarized as follows.

> ***Result 2:*** *Compared with the house money treatment, earnings dispersion is significantly lower in the earned money treatment.*

In the next section we examine the correlation between CRT scores and individual trader behavior.

3.2 CRT Correlates

The CRT scores provide one, among other possible, measures of subjects' cognitive skills (Frederick (2005)) which can be used to sort subjects accordingly. Table 5 provides subject score (0, 1, 2, 3) on the CRT and its relationship with subjects' earnings across treatments.

In Table 5, we compare earnings for subjects with a CRT score of zero with earnings for subjects with scores greater than zero (last column).[15] With house money, subjects with a CRT score of zero earn on average $14.28, which is 64% less than the subjects who have

[14] The variance of earnings increases in K. Indeed, let us consider a market with two traders, each of them being endowed with the same amount of cash C. Let us call B the number of times trader 1 is buying the asset while S is the total number of times trader 1 is selling the asset. The variance of earnings can then be expressed as follows: $Var[C + \sum_{b=1}^{B}(f_b - P_b) + \sum_{s=1}^{S}(P_s - F_s)]$ where $f_b(f_s)$ is the fundamental value of the asset when trader 1 buys (sells) the asset for the $b^{th}(s^{th})$ times. Also, $P_b(P_s)$ is the price of the asset when trader 1 buys (sells) the asset for the $b^{th}(s^{th})$ times. Assuming that prices are independent and identically distributed random variables with variance σ^2 then the variance of earnings is: $(B+S)\sigma^2 = K\sigma^2$.

[15] The same procedure has been used in Brañas et al. (2011). Our results are stronger if we compare the tails of the CRT scores distribution (subjects with 0 and 3 scores only).

positive CRT scores ($40.11, MWW, p-value=0.0003). This result also holds for the treatment with earned money (MWW, p-value=0.0092). However, this difference in earnings across subjects with different CRT scores is significantly lower when subjects use their own money (EM treatment). In particular, the earnings of subjects with a CRT score of zero were 69% larger in the EM treatment compared with the HM treatment while the earnings of subjects with a positive CRT score were 15% lower (MWW, p=0.0248 and p=0.1504, respectively).

Table 5. Baseline Treatment – Mean (Median) Earnings

CRT	**0**	**1**	**2**	**3**	**>0**	MWW[+] (p-values)
House Money	$ 14.28 ($ 11.75) [15]	$ 41.95 ($ 2.25) [10]	$ 30.97 ($ 29.59) [10]	$ 47.42 ($ 41.16) [10]	$ 40.11 ($ 40.51) [30]	0.0003
Earned Money	$ 24.09 ($25.18) [12]	$ 34.64 ($ 33.53) [13]	$ 28.38 ($ 30.21) [7]	$ 36.88 ($ 35.86) [13]	$ 34.19 ($ 33.43) [33]	0.0092

[Number of observations]
[+]Mann-Whitney-Wilcoxon test. This test reports the comparison of subjects' earnings with CRT=0 and subjects with CRT>0.

In Figure 5 we show subjects' average portfolio value at the end of each period by CRT score. From the very beginning, subjects with a higher CRT score earn more money and this difference increases over time. Interestingly, under HM subjects earning differences across CRT scores are much sharper. Under EM, subjects with a higher CRT score cannot take full advantage of subjects with low scores.[16]

[16] For each session and period, we computed the difference in average portfolio value between subjects with zero CRT scores and subjects with higher CRT scores. We observe that this difference is significantly lower in sessions with earned money than in sessions with house money from period 4 and onwards (MWW, p-values<0.1 for every period).

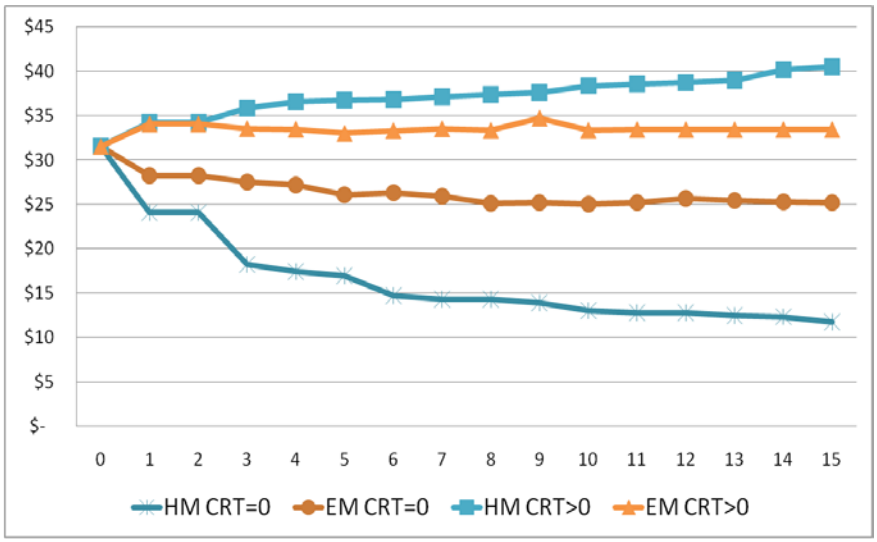

Figure 5. Portfolio value at the end of each period.

We summarize our results regarding CRT scores and earnings as follows.

> ***Result 3****: Subjects with positive CRT scores earn significantly more than subjects with a zero CRT score. Differences in earnings across subjects with different CRT scores are significantly more pronounced in the house money treatment than in the earned money treatment.*

This result is in line with the recent work of Cueva and Rustichini (2012) according to which subjects with high cognitive skills measured with non-verbal IQ tend to outperform subjects with low cognitive skills. Now, we analyze some of the possible reasons for the observed differences in subjects' earnings. We first study trading volumes and show that subjects with low CRT scores trade significantly less with earned money than with house money (see Figure 6). The average number of transactions in each period is higher in the HM treatment than in the EM treatment.

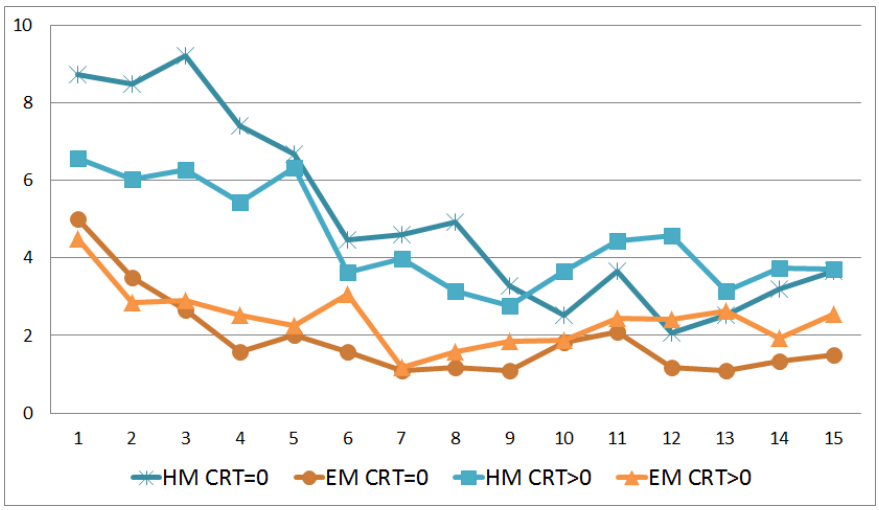

Figure 6. Average number of transactions across periods and treatments by CRT score.

In Table 6 we report the results of a Tobit panel data regression, with random effects by session, of the number of transactions in each period on subjects' CRT score. The regression in the first column shows that subjects with higher CRT scores trade less than subjects with low CRT scores in the HM treatment. However, this result is not found under earned money (second column).

Table 6. Number of transactions by period (per subject)

	House Money	Earned Money
Constant	10.77***	4.58***
Period	-1.17***	-0.77***
$Period^2$	0.04***	0.03***
CRT^d	-2.76**	-0.12
Period × CRT^d	0.29***	0.09
Log-likelihood	-1736.5	-1389.0
Wald Chi^2	142.8***	64.65***
Obs (left-censored Obs)	675 (87)	675 (190)

CRT^d =0 if subject's CRT=0 and 1 otherwise.
*p -value<.10, ** p-value<.05, and *** p-value<.01

We summarize our findings as follows.

> ***Result 4****: Subjects with a zero CRT score trade significantly more than subjects with positive CRT scores in treatment HM. In contrast, no significant differences in trading patterns are observed across subjects with different CRT scores in treatment EM.*

We now study trading patterns in more detail and assess whether subjects were net buyers or net sellers of the asset when the price was lower or higher than the fundamental value of the asset. We compute the number of net purchases per period for each period as the number of purchases minus the number of sales of an individual for that period. Table 7 presents the results of a panel data, with random effects by session, of the net number of purchases on a dummy variable capturing CRT scores (CRT^d) and on the difference between the average period price and the fundamental value ($\bar{P}_t - FV_t$). We show that subjects with a CRT score of zero are net buyers (sellers) when the asset price is above (below) the fundamental value since the coefficient associated with the variable $[\bar{P}_t - FV_t]$ is positive and significant. The opposite is true for subjects with a CRT score greater than zero since the coefficient associated with the variable $[(\bar{P}_t - FV_t) + CRT^d \times (\bar{P}_t - FV_t)]$ is negative and significant. This result is particularly interesting as it shows that higher CRT subjects may be feeding the bubble in the early stages of the experiment and get out of it before it crashes. Further, the

effect of CRT score on net purchases is much less pronounced in the house money treatment than in the earned money treatment. In particular, subjects with a CRT score greater than zero are not found to be net buyers (sellers) when the asset price is below (above) the fundamental value in the earned money treatment while this result holds in the house money treatment.

Table 7. Subjects' number of net purchases by period

Variables	House Money	Earned Money
Constant	0.1169	-0.1527
CRT^d	-0.1554	0.2068
$\bar{P}_t - FV_t$	0.0039***	0.0031*
CRT × $(\bar{P}_t - FV_t)$	-0.0060***	-0.0044**
R^2	0.0289	0.0086
Wald Chi^2	19.93***	5.80
$(\bar{P}_t - FV_t)$ + CRT^d × $(\bar{P}_t - FV_t)$	-0.0021**	-0.0013

CRT^d =0 if subject's CRT=0 and 1 otherwise.
$\bar{P}_t$ is the (session) average price of period t.
FV_t is the fundamental value of period t.
*p -value<.10, ** p-value<.05, and *** p-value<.01

Our findings regarding trading patterns across subjects with different CRT scores are summarized as follows:

> ***Result 5****: Subjects with positive CRT scores buy (sell) shares when the asset price is below (above) the fundamental value. Subjects with a zero CRT score behave in the opposite manner. These differences in trading patterns across subjects with different CRT scores are significantly more pronounced in the house money treatment than in the earned money treatment.*

This result means that in our asset market experiments (a zero-sum game), there is a transfer of earnings from subjects with low CRT scores to subjects with high CRT scores. Subjects with a high CRT purchase shares in the early periods, when prices are below the fundamental value and sell those shares when the prices exceed the fundamental value (see left panel of Figure 7). Interestingly, this transfer of wealth is much less pronounced in the earned money treatment (see right panel of Figure 7).

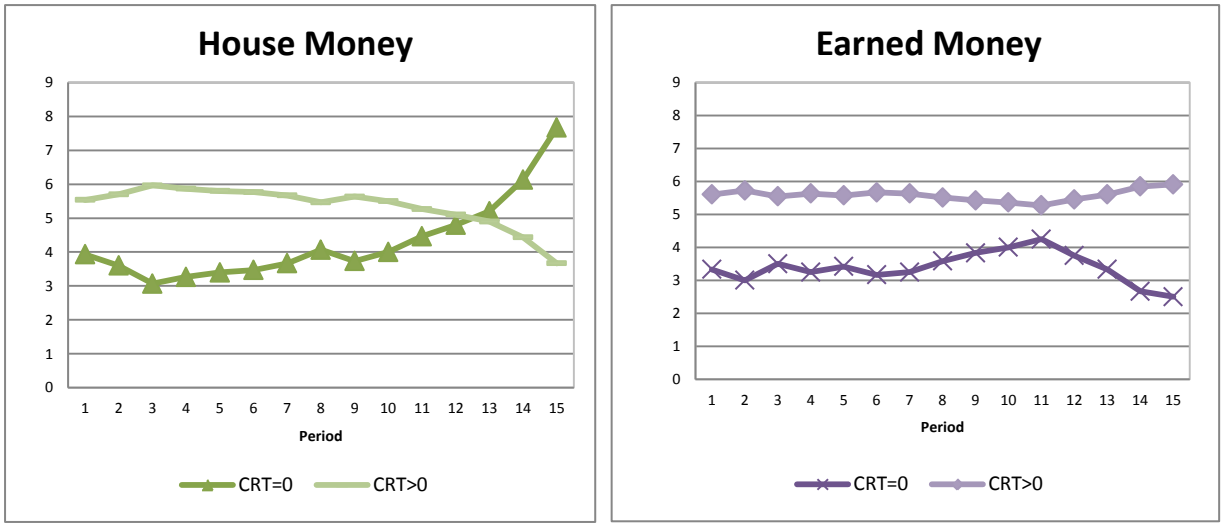

Figure 7. Average number of shares held at the end of the period by CRT score and across periods for house money (on the left panel) and for earned money (on the right panel).

4. Conclusion

In this paper, we have studied the house money effect in an experimental asset market with bubbles and crashes. We found that even though bubbles still occurred in the earned money treatment, trading volumes were significantly reduced. The sharp reduction in trading volumes implied a significant decrease in the dispersion of subjects' earnings in the earned money treatment compared with house money.

We investigated earnings dispersion by categorizing subjects according to their cognitive ability which was measured using the CRT. We found that subjects with lower CRT scores were net purchasers (sellers) of shares when the price was above (below) fundamental value while the opposite was true for subjects with higher CRT scores. Consequently, high CRT subjects earned more money on average than the initial value of their portfolio while low CRT subjects earned less. This result was true for both the house and earned money treatments. However, income distribution across CRT scores was more uniform in the earned money treatment.

Our main conclusion is that there is indeed a house money effect in experimental asset markets. The house money effect manifests itself in trading volume that subsequently affects earnings dispersion. Bubbles, however, are maintained and we find no differences between our two treatments, or comparing our results with other experiments with uncertain dividends. We take a preliminary step by studying individual behavior in asset markets as reflected by the well-known cognitive reflection test. We use the CRT to sort subject behavior in asset markets and find that cognitive abilities, as reflected by the CRT, do seem

to matter. Individuals with a high CRT score feed the bubble in the early stages and get out of it in later periods. Further research needs to be done to better understand the link between cognitive abilities and bubble formation in experimental asset markets.

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Appendices

Appendix A: Comparison with other studies

Table A1. Average bubble measures for related studies*

	Amplitude	Duration	NAV	NAP
House Money	0.84	9	6.5	77
Corgnet, Kujal and Porter (2010)	1.26	10.33	11.2	130
Smith, Van Boening and Wellford (2000)	1.39	-	5.5	-
Porter and Smith (1995)	1.53	10.15	-	-
King et al. (1993)	1.61	9.5	11.8	-
Smith, Suchanek and Williams (1988)	1.24	10.2	5.7	-

* All of them are studies with the same number of periods (15) and traders (9)
Data obtained from Corgnet, Kujal and Porter (2010)

Table A2. Average bubble measures comparing HM treatment and Corgnet, Kujal and Porter (2010)'s baseline sessions with random dividend

	Session	Amplitude	Duration	Haessel-R^2	NAV	NAP	Upward Trend	Num Transactions	Turnover
House Money	1	0.58	9	0.65	59	4.7	3	334	7.4
	2	1.19	13	0.38	130	13.4	11	473	10.5
	3	0.53	3	0.82	25	2.1	2	194	4.3
	4	1.05	14	0.48	116	7.7	9	355	7.9
	5	0.85	4	0.35	53	4.7	4	220	4.9
Corgnet et al.	N11	1.08	9	0.33	119	10.9	5	121	5.5
	N21	1.37	12	0.10	137	9.5	9	132	6.0
	N31	1.33	5	0.59	134	13.2	5	143	6.5
House Money	Average	0.84	9	0.54	77	6.5	6	315	7.0
	Median	0.85	9	0.48	59	4.7	4	334	7.4
Corgnet et al.	Average	1.26	9	0.34	130	11.2	6	132	6.0
	Median	1.33	9	0.33	134	10.9	5	132	6.0
MWW† (p-values)		0.05	1.00	0.18	0.05	0.18	0.55	–	0.65

†MWW stands for the Mann-Whitney-Wilcoxon test.

Bubble measures in our HM treatment and those reported by Corgnet al. (2010) are not significantly different when using a multivariate test (p-value=0.33)[17]

[17] We used command sr.loc.test in R to do these spatial rank tests of multivariate location. We obtained similar values using a Hotelling's T^2 test (p-value=0.42).

Appendix B: Instructions Part I (Task)

Instructions:

- This is a study in decision-making. Funding for this project has been provided by several funding agencies.
- You will be taking part in an experiment that consists of two parts. In the first part, you will be required to perform a task related to a Research Institute database.
- The amount earned in the first task is credited to your account and will be used in the second part. In the second part, you will be participating in an economic experiment.
- The amount you will earn in the first task will be carried over to the experiment you will take part in the second part. You will be paid **IN CASH for the entire experiment** at the end of the second part that will take place at the end of this week.

Today's Task:

- In this part you will be performing a task for a Research Institute database.
    - You have a list of academic articles on your desk.
    - You are expected to search a minimum of 20 articles in a JSTOR database and download them to a folder (that will be identified later).
- You will be credited $31.50 for this task.

Where to save the articles?

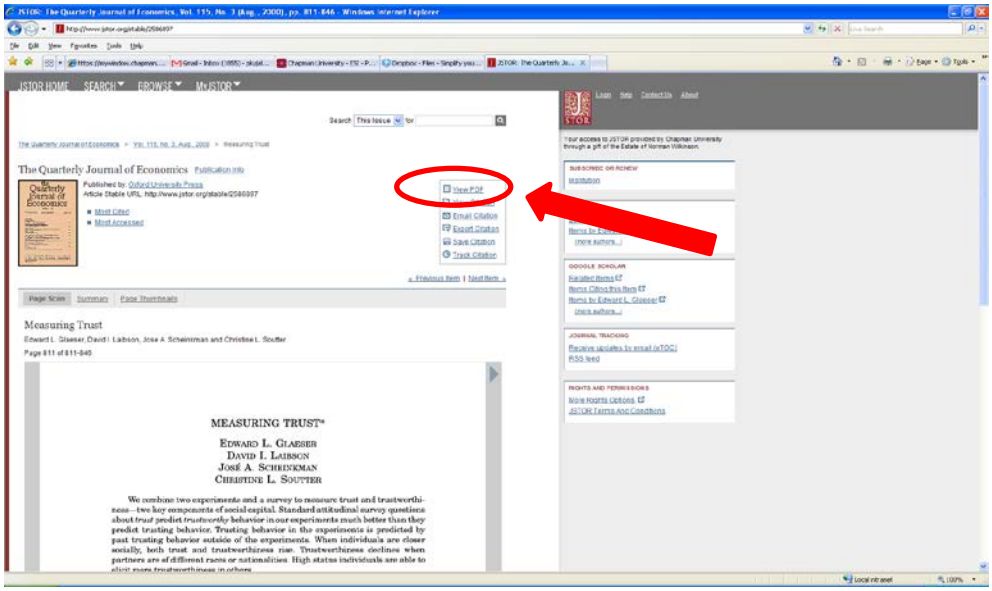
- Please, right click on the mouse and create a new folder on the desktop.
- Please, **name the folder** now using your own complete name.
- You will be saving the articles into this folder.

How to save an article?

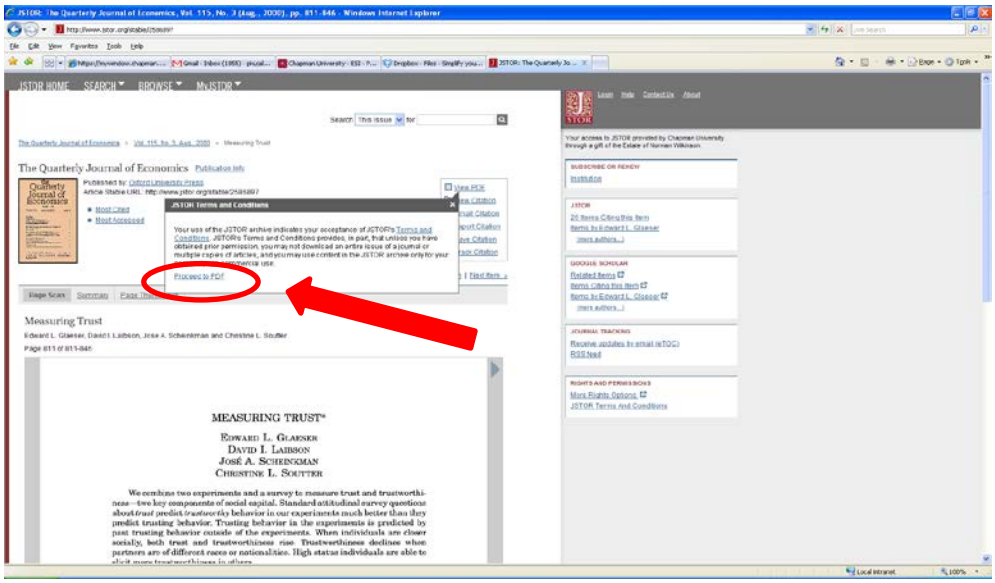
- For example, the article:
    - Edward L. Glaeser, David I. Laibson, Jose A. Scheinkman, Christine L. Soutter, 2000, Measuring Trust, The Quarterly Journal of Economics, Vol. 115, pp. 811-846.
- Go to, http://www.jstor.org/
- Then select Economics.
- Type in the **name** of the journal, e.g., "Quarterly Journal of Economics"
- Go to the corresponding year and page numbers
- Click on the article and save it to your folder.

How do I download the article from JSTOR?

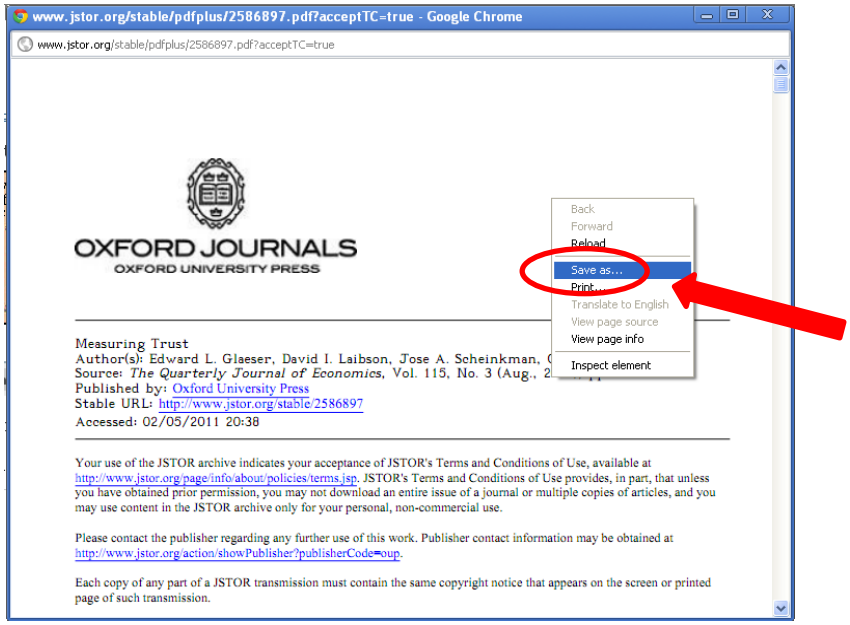
- Once you find the article you will find a screen similar to the one below
    - click on **View pdf** on the right hand side.



- Then click on **proceed to pdf**.



- Then right-click on the article to **save as** in your folder in the format mentioned earlier.



Format of the saved article

Author1&Author2_TitleofPaper_JournalInitialsYear.pdf

- For example, the article:
  - Edward L. Glaeser, David I. Laibson, Jose A. Scheinkman, Christine L. Soutter, 2000, Measuring Trust, The Quarterly Journal of Economics, Vol. 115, pp. 811-846.
- Will be saved as,

Glaeser&Laibson&Scheinkman&Soutter_Measuring Trust_ QJE2000.pdf

- Note: Journal initials are the first letters of the journal title.
  - For example, for **Q**uarterly **J**ournal of **E**conomics the initials are **QJE**, for **E**conomic **J**ournal the initials are **EJ,** for **A**merican **E**conomic **R**eview the initials are **AER** etc…

What if you do not find the article on JSTOR?

- Move on to the next article on the list.
- Please state on the handout that the article was not available.

What if the journal is not available on JSTOR?

- State on the handout that the journal is not available on JSTOR and move on to the next article on your list.
- Please make sure that all articles are saved using the naming format we provide above.

Appendix C: Instructions Part II (Asset Markets)

INSTRUCTIONS (1/14)

This is an experiment in market decision making. You will be paid in cash for your participation at the end of the experiment. Different participants may earn different amounts. What you earn depends on your decisions and the decisions of others.

[(Only EM treatment) Before participating in this experiment, you earned $31.50 by working on the ESI database during 2.5 hours. This full amount of cash will be used to pay for your initial portfolio in the current experiment.]

The experiment will take place through computer terminals at which you are seated. If you have any questions during the instruction round, raise your hand and a monitor will come by to answer your question. If any difficulties arise after the experiment has begun, raise your hand, and someone will assist you.

INSTRUCTIONS (2/14)

In this experiment you will be able to buy and sell a commodity, called **Shares**, from one another.

At the start of the experiment, every participant will be given some Cash and Shares.

The shares last for EXACTLY **15** periods of trading. After each trading period the share will earn a dividend of **24** cents. Thus, if you had a share at the end of period 1, you would get a return of **24** cents for that period.

If you held a share from period 1 until the end of period 15, then that share would return to you a total of **$3.60** (15 × 24 cents) over the 15 periods. Similarly, if you bought a share in period 2 and held it from period 2 until the 15th period, the accumulated dividends would be **$3.36** (14 × 24 cents).

INSTRUCTIONS (3/14)[18]

You will start the experiment with six shares and 990 cents in cash. The initial value of your portfolio is identical and equal to $**31.50**. This is the case because the total dividend value of each share over the 15 periods is equal to **$3.60** (15 × 24 cents):

990 cents + 6 × $3.60 = $**31.50**.

[(Only EM treatment) Notice that the value of your initial portfolio corresponds to the earnings in the 2.5 hours you spent working on the ESI database.]

[18] This part of the instructions was specific to each subject's initial portfolio. The initial endowment of cash and number of shares were 990, 1350 or 1710 cents and 6, 5 or 4 shares, respectively.

INSTRUCTIONS (4/14)

During every period, traders can buy or sell shares from one another by making offers to buy or to sell.

Every time a trade is made, it will be shown as a dark **GREEN** dot in the graph located on the left of the lower part of your screen. Transactions are also listed on the **Market Book** located on the right of the graph. If you buy a share (or somebody sold it to you), the cell in the Market Book will be shown in light **BLUE**. The cell will be shown in **RED** if you sell a share (or somebody buys it from you). The cells that are shown without colors correspond to transactions in which you are not involved either as a buyer or as a seller.

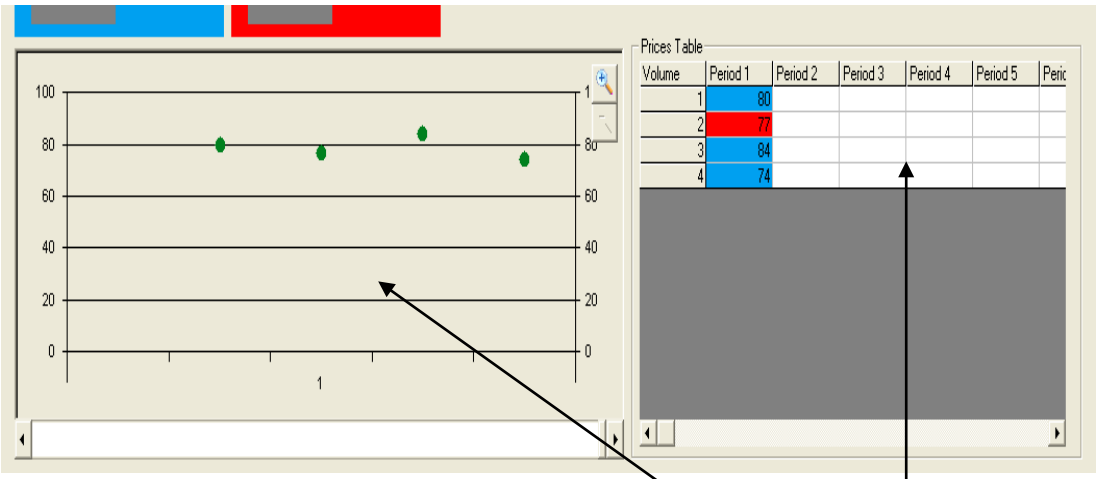


Figure 1: Lower part of your trading screen (graph and market book)

INSTRUCTIONS (5/14)

To enter a new order to buy or to sell a share, type in the price at which you would like to buy, or sell, in the appropriate **Add order to Buy** box or **Add order to Sell** box. Click the **Add order to Buy** or **Add order to Sell** button to submit your order.

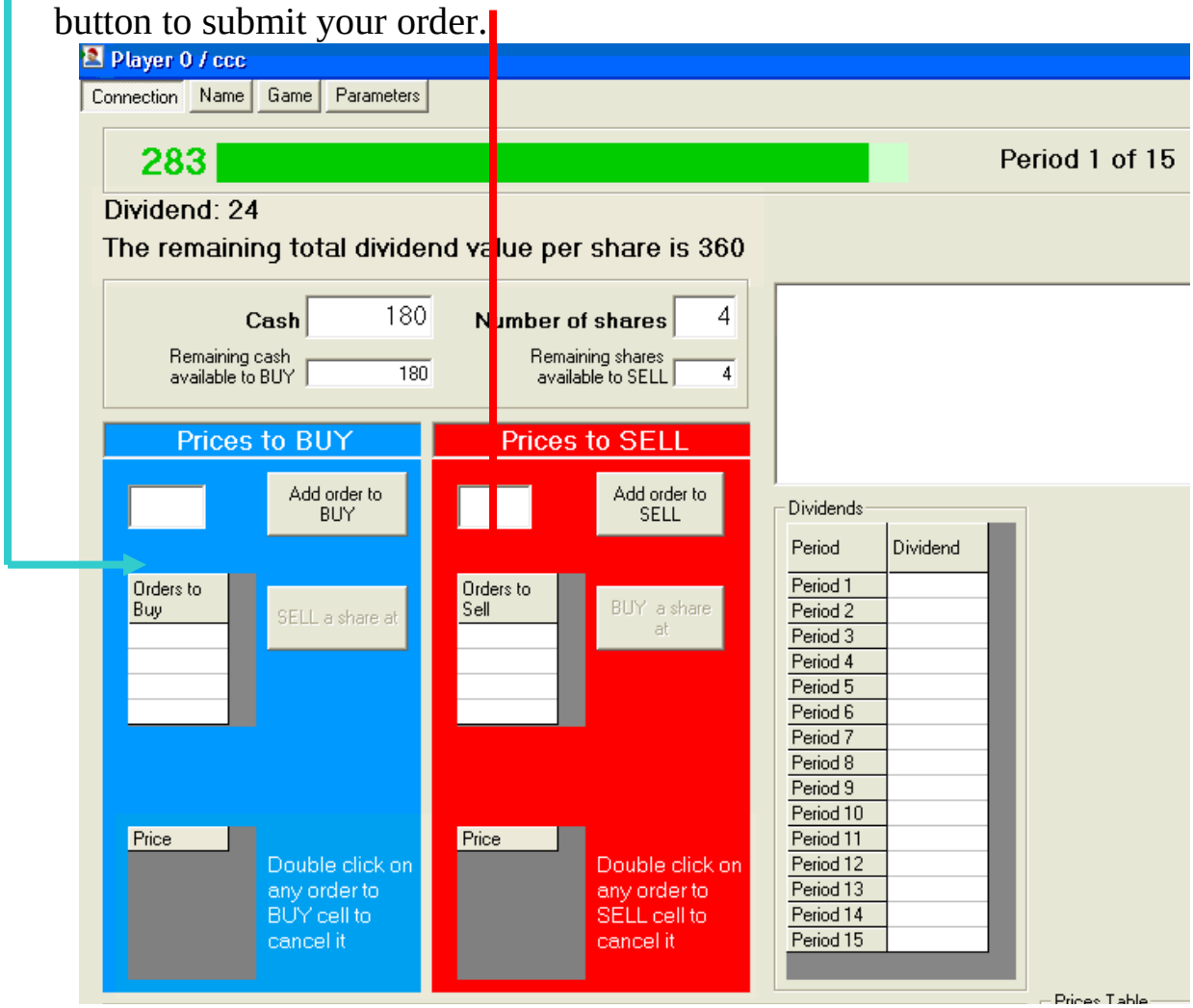


Figure 2: Upper part of your screen (Buy and Sell)

INSTRUCTIONS (6/14)

Every time someone posts an order to buy a share, it will be added to the list of best orders to buy (in the **BLUE** quadrant). This list shows only the best **FOUR** orders. Every time someone makes an offer to sell a share, it will be added to the list of the best orders to sell (in the **RED** quadrant). This list shows only the best **FOUR** orders.

The orders to buy will be listed from the highest price to the lowest price, while the orders to sell will be listed from the lowest price to the highest price.

Your own orders in this list will be highlighted in **ORANGE**. For example, you have just posted an order to sell at a price equal to 202 and this corresponds to the third best order in the market (that is, the third lowest order to sell). This order will appear in the third place in the list of orders to sell.

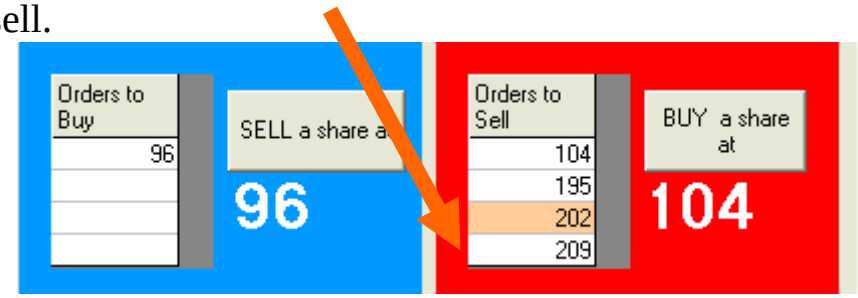


Figure 3: Upper part of your screen (Orders to buy and to sell)

INSTRUCTIONS (7/14)

To accept an existing order from another participant, click the **Buy a share at** or **Sell at share at** buttons located on the right of the list of orders to sell and orders to buy, respectively. The list of orders to buy shows you the four highest orders to buy that are currently available on the market, while the list of orders to sell shows you the four lowest orders to sell. By clicking on the **Buy a share at** button, you buy at the listed price of 104 in the current example; by clicking on the **Sell at share at** button, you sell at the listed price of 96 in the current example. Your own existing orders to buy or sell are highlighted in **ORANGE**.

In the situation illustrated in the following screen shot, the best order to sell corresponds to a price of 104 (the lowest value in the list of orders to sell). This is the price at which you can currently buy the share. The best order to buy corresponds to a price of 96 (the highest value in the list of orders to buy since this is the only order to buy currently available). This is the price at which you can currently sell the share.

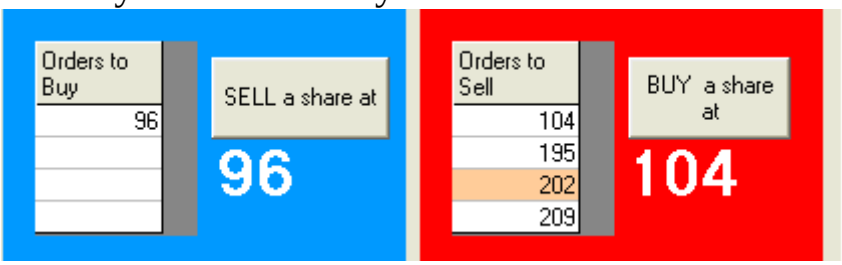


Figure 4: Upper part of your screen (Orders to buy and to sell)

INSTRUCTIONS (8/14)

Whenever you enter new orders to buy, or sell, you will have those orders listed in a table below the list of orders to buy and sell. By double clicking on any cell in the table, you can cancel your own orders.

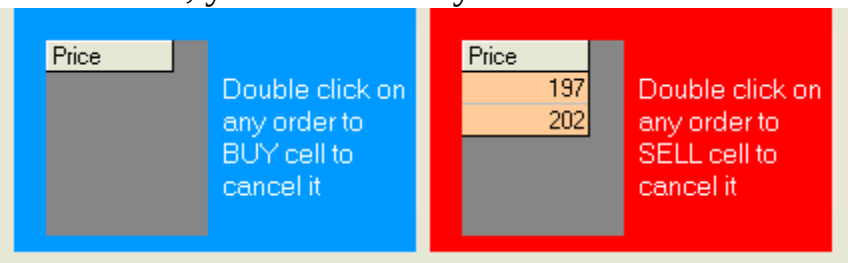


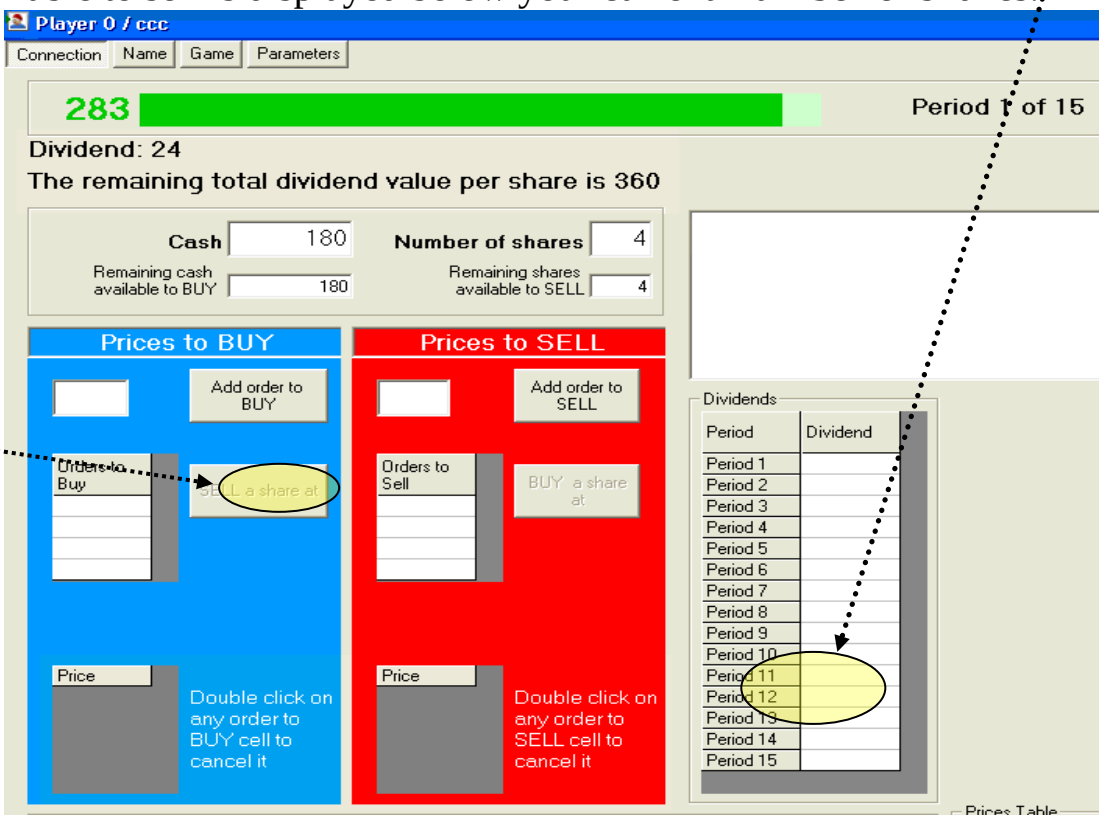
Figure 5: Upper part of your screen (Orders to buy and to sell)

INSTRUCTIONS (9/14)

At the end of every period, each share will pay a dividend of 24 cents. The dividend for each period will appear in the Dividends Table.

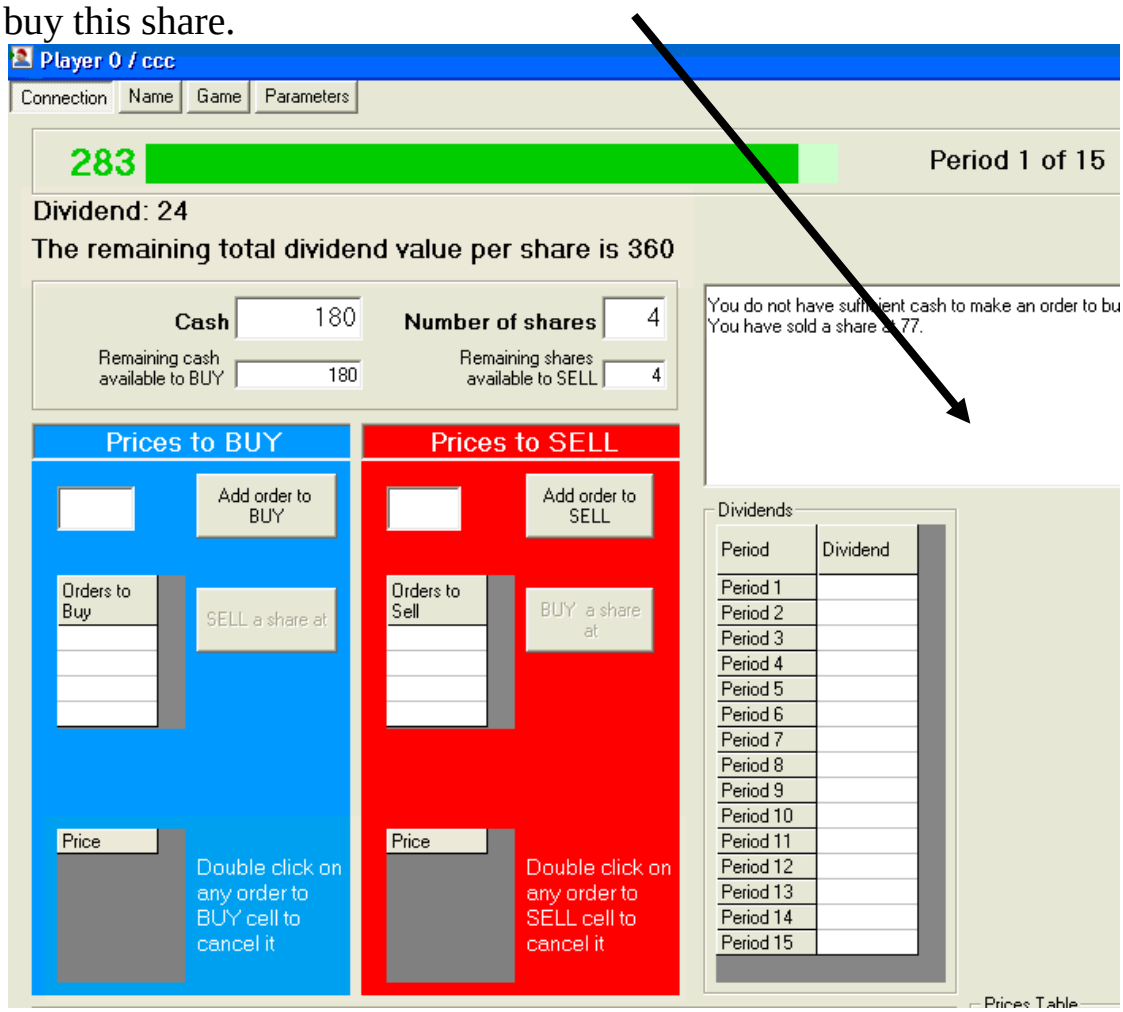
The earned dividends (for shares) of each period will be added to the cash account of the holder.

The number of your shares will change, only when you buy, or sell, shares. Notice that you cannot place orders to buy for an amount that is greater than your current **Cash**. The information regarding the remaining cash available to buy is displayed in the box below your current **Cash**. Also, you cannot place more orders to sell shares than the **Number of shares** you currently hold. The information regarding the remaining shares available to sell is displayed below your current **Number of shares**.



INSTRUCTIONS (10/14)

During a period and each time you place an order or complete a transaction a message will appear in the box above the dividends table. This message box provides indications on whether your order or transaction has been completed successfully. For example, if you attempt to buy a share at a price that is higher than your current cash holdings, a message will appear in the box stating that you do not have sufficient cash to buy this share.



INSTRUCTIONS (11/14)

An example:

Suppose you have 6 shares and 150 in Cash at the start of a period, and you make one transaction during the period purchasing a share for 110 cents within the period, and the dividend for the period is 24 cents, then:

Your Cash holdings will increase by 34 cents (Dividends of 24 times 6 shares minus a purchase at 110). Your new cash holding will thus be 150+34=184 cents.

Your share holdings will increase from 6 to 7 units.

INSTRUCTIONS (12/14)

Another example:

At the end of the previous period, you had 4 shares and 242 in Cash.

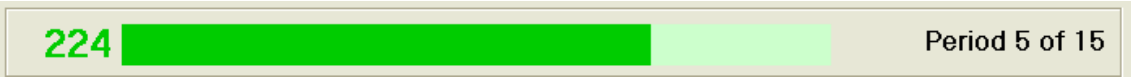
Suppose in the next period you make two transactions. You sell one share for 130 and another share for 110, and the dividend for the period is 24, then:

Your Cash holdings will increase by 288 cents (Dividends of 24 times 2 shares plus sales of 130 plus 110). Your new cash holding will thus be 242+288=530 cents.

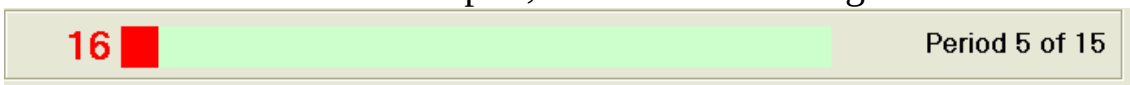
Your share holdings will, however, decrease from 4 to 2 units.

INSTRUCTIONS (13/14)

This experiment will last for **15 periods**. Each period will last for several minutes. The remaining time (in seconds) will appear on the top of your screen.



When the time is about to expire, the color will change to RED.



We will have a short practice period to allow you to become familiar with entering orders and making trades.

INSTRUCTIONS SUMMARY (14/14)

1. You will be given an initial amount of Cash and Shares.
2. Every share generates a dividend of 24 cents at the end of each of 15 trading periods.
3. You can submit orders to BUY shares and orders to SELL shares.
4. You make trades by buying at the current lowest order to sell or selling at the current highest order to buy.
5. The market lasts for 15 periods. At the end of period 15, there will be one last dividend draw. After that the share expires and is worth nothing to you.
6. The initial value of your portfolio is equal to $31.50 (= 990 cents + 6 shares × $3.60)[19]. **[(Only EM treatment)This amount corresponds to the earnings you obtained in the 2.5 hours you spent working on the ESI database.]**

Click "Ready" to start the experiment

[19] Again, this paragraph was specific to each subject's initial portfolio.

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