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The Effect of Short–Selling on the Aggregation of Information in an Experimental Asset Market

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Abstract

We show by means of a laboratory experiment that the relaxation of short–selling constraints causes the price of both an overvalued and an undervalued asset to decrease. Hence, the aggregation of information by the market price becomes better in case the asset is overvalued but worse if the asset is undervalued. With respect to payoffs, we find that not only uninformed but also some of the imperfectly informed traders suffer from the weakening of short–selling constraints.

Keywords: Asset Market, Experiment, Rational Expectations, Short Sales.

JEL-Classifications: C90, G12, G14.

1 Introduction

The Capital Asset Pricing Model (CAPM) constitutes the standard finance paradigm for the market equilibrium under uncertainty. One of its key assumption is that individuals have homogenous beliefs about the future return distribution, which implies directly that all traders divide their wealth between the risk–free asset and the market portfolio. Consequently, all

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investors hold the same portfolio and no investor will ever engage in short sales. To come up with a more realistic model of portfolio selection, either the assumption of homogenous beliefs has been dropped and/or some kind of market segmentation such as different capacities to short sell has been introduced.

Using both heterogenous beliefs and market segmentation, Miller (1977) shows that pessimistic investors will often not engage in short–selling because they find it too costly. Since these negative opinions about the stock price development are not taken into account, prices are too high and the efficient market hypothesis of Hayek (1945), operationalized by Muth (1961), must fail. This view has above all been contested by Diamond and Verrecchia (1987) who claim that rational investors will take into account that some of the more negative views are not collected by prices. Thus, the more optimistic investors will revise their beliefs downwards reestablishing the full aggregation of private information through prices.

Indeed there is a lot of laboratory evidence showing that markets are generally able to aggregate private information. Prominent examples include the studies of Forsythe et al. (1982), Plott and Sunder (1982, 1988), Forsythe and Lundholm (1990), Lundholm (1991), and Sunder (1992). However, in a variety of situations the market may actually fail to aggregate information correctly. Salient reasons are information mirages (see Camerer and Weigelt, 1991), information traps (see Nöth et al., 1999), and price manipulations (see Veiga and Vorsatz, 2008). It is therefore the main objective of this paper to study in a laboratory experiment whether the relaxation of short–selling constraints can improve the aggregation of information. To do this, we consider a setup in which the market aggregates information rather poorly in the presence of short–selling constraints meaning that the asset tends to be overpriced in some and underpriced in other situations. This provides sufficient room to study how the weakening of the short–selling constraints affects market prices.

To be more specific, we compare the market statistics of two different asset markets. In the *baseline treatment*, which is borrowed from Plott and Sunder (1988), twelve subjects trade a common value asset that takes the values of 125, 375, and 525 ECU (Experimental Currency Units) with equal probability for ten rounds in a short–selling constrained double auction market. Every trading period, subjects receive four shares of the asset and an interest free loan. Six subjects receive imperfect information about the true value of the asset before trading starts in such a way that there is no aggregate uncertainty in the market. The *short–selling treatment* is identical to the baseline treatment, only that subjects are now allowed to short sell up to ten shares of the asset.

We find that if the value of the asset is 125 ECU, then, as expected, prices are significantly lower in the short–selling treatment (the average final contract price is 346 ECU in the baseline and 283 ECU in the short–selling treatment). Thus, the relaxation of short–selling constraints helps to improve the aggregation of information in this state. If the value of the asset is 375 ECU, information is very well aggregated in both treatments. Finally, if the value of the asset is 525 ECU, prices are significantly lower in the short–selling treatment (the average final contract price is 423 ECU in the baseline and 389 ECU in the short–selling treatment). Hence, allowing for short sales drives the price of an undervalued asset even lower. This is perhaps surprising because one might have conjectured that the improved aggregation of information in the low value scenario has positive spillovers on the case when the asset is worth 525 ECU.

Regarding payoffs we may conclude that the group of uninformed traders is the one that suffers most from the weakening of short–selling constraints. In fact, the average per–round payoff of the typical uninformed trader decreases from 1317 to 1174 ECU. With respect to the group of informed traders, we condition the analysis on the type of information received.

The informed traders who receive the information that the value of the asset is not 125 ECU earn significantly more in the short–selling treatment. This is because this group of traders holds long positions and profits from the lower prices and the extensive short–selling of other subjects when the asset is actually worth 525 ECU. On the other hand, the other two groups of insiders –the ones that receive the information that the asset is not worth 375 ECU and the ones with the signal that the value of the asset is not 525 ECU– earn less in the short–selling treatment, but not significantly so. Consequently, only one particular group of traders gains from the relaxation of short–selling constraints.

We proceed as follows. In the next section, we describe our experimental design and procedures. Afterwards, we present our results with the corresponding econometrical/statistical analysis. Finally, we conclude. The experimental instructions together with the control questions are relegated to the Appendix.

2 Experimental Design and Procedures

2.1 Setting

We compare two different experimental treatments. In the *baseline treatment*, twelve subjects trade a common value asset, which takes the values 125, 375, and 525 ECU (Experimental Currency Units) with equal probability, for ten rounds in an electronic double auction market. We fixed one series of values similar to the one applied by Plott and Sunder (1988) in their market number 8 before conducting the experiment.

In every round of an experimental session, subjects receive four shares of the asset and an interest free loan of 25.000 ECU that has to be returned at the end of the trading period. Using these endowments, the asset is traded for five minutes in an electronic double auction

market by submitting bid and ask prices. A trade takes place whenever a subject accepts a standing buy or sell offer. It is not possible to trade multiple units of the asset at the same time and short sales are not permitted.

It is common knowledge that no subject has information about the asset's value before the market closes in the first round of the experiment and that from round two on, some subjects are privately informed before the market opens. In particular, if the actual value of the asset is 525 ECU, three subjects get to know that the value is not 125 ECU and three subjects learn that the value is not 375 ECU. The remaining six subjects stay uninformed. In general, we can describe the assignment of information as follows: if the state space is denoted by $S = \{x, y, z\}$ and the actually selected state is x, then three traders get to know that the state is not y and three traders learn that it is not z. Hence, private information is imperfect and there is no aggregate uncertainty. The probability to be privately informed is the same for all subjects in all rounds, and traders are fully aware about how information is allocated. Finally, the first round has only been included in our design to make subjects familiar with the trading platform and therefore, it is excluded from our analysis later on.

The *short–selling treatment* is identical to the baseline treatment apart from the fact that subjects are now allowed to short sell up to ten shares of the asset. Hence, a subject who holds a negative number of shares at the end of the trading period has to pay the actual value of the asset for each of them. We also pre–fixed a different series of values maintaining the initial feature that each value of the asset occurred three times over the last nine rounds.

2.2 Implementation

We conducted the experiment, which was programmed within the z–Tree toolbox (see Fischbacher, 2007), in the computer laboratory at Maastricht University in June 2007 (baseline

treatment) and April 2008 (short–selling treatment). Since all students from the Faculty of Economics and Business Administration have an e–mail account associated with their student–ID, we promoted the experiment mainly via electronic newsletters and gave students the opportunity to register online for their preferred session. In total, 144 unexperienced undergraduates participated in one of the 12 experimental sessions (six sessions per treatment). No student took part twice and within a given session, subjects did not know each other.

At the beginning of a session, students met outside the laboratory. We prepared cards with the numbers from one to twelve and let each student draw one card. If more than twelve students showed up for a particular session, we offered three Euros in case somebody was willing to leave. If an insufficient number of students decided to leave, we put additional empty cards into the deck and determined the participating students randomly. Students with an empty card received also a compensation of three Euros but were excluded from the experiment. We also reminded everybody that any kind of communication inside the laboratory would lead to an immediate cancellation of the session.

Students then entered the laboratory and took seat in front of the computer corresponding to their card. The computers were distributed in such a way that subjects could not see each other, and next to each computer, we placed the instructions, an official payment receipt, and a set of control questions (see the Appendix). Subjects could study the instructions at their own pace and eventual doubts were privately answered. The experiment started once everybody answered all control questions correctly.

At the end of a session, subjects were paid privately one–by–one. In addition to the three Euro show–up fee, we offered 90 Euro–cents in the baseline and 1 Euro in the short–selling treatment for every 1000 ECU obtained in the course of a session. The difference stems from the fact that the value of the asset was 375 ECU in round 1 of the baseline treatment but

only 125 ECU in round 1 of the short–selling treatment and we wanted to induce the same expected payoffs (15.8 Euros). A typical session lasted about 90 minutes.

3 Results

In this section, we present the results of our experiments. Figure 1 shows the average sequence of contract prices for all possible situations. In each of the two panels, the continuous line corresponds to the case when the value of the asset is 525 ECU, the dotted line to the case when the value is 375 ECU, and the dashed line to the case when the value is 125 ECU.

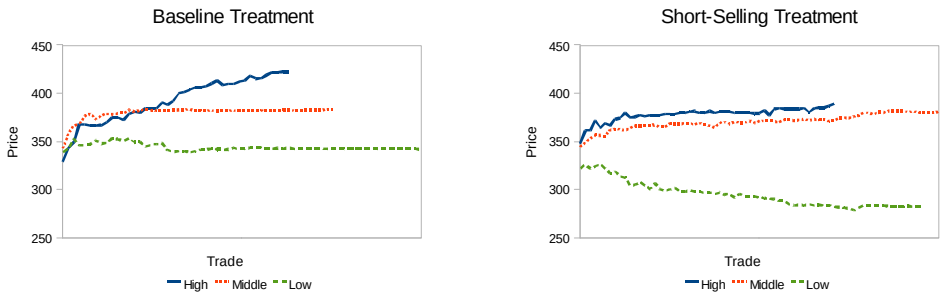

Figure 1: Average price paths.

Looking at Figure 1, we first observe that if the value of the asset is 375 ECU, the average price paths of the two treatments almost coincide. In particular, the two paths converge to prices close to the actual value of the asset. But this is the only similarity found. If the value of the asset is 125 ECU, the average price path for the baseline treatment is flat, whereas the one for the short–selling treatment decreases constantly over time. Consequently, and as expected, the average last contract price is considerably lower in the short–selling treatment. Finally, and most importantly, if the fundamental value of the asset is 525 ECU, the reversed relationship is found: the average price path increases in the baseline treatment, whereas it flattens quickly after an initial increase in the short–selling treatment. As a result, the

average last contract price is again considerably lower in the short–selling treatment. This is a first hint that the weakening of short–selling constraints leads to a worse aggregation of information if the value of the asset is high.

Since the data presented so far is aggregated over all rounds and may be subject to learning through repetition, we present next the price paths of all sessions. The rational expectations equilibrium for a given round, the expected value in the absence of private information and the actual value of the asset otherwise, is always indicated by a straight line.

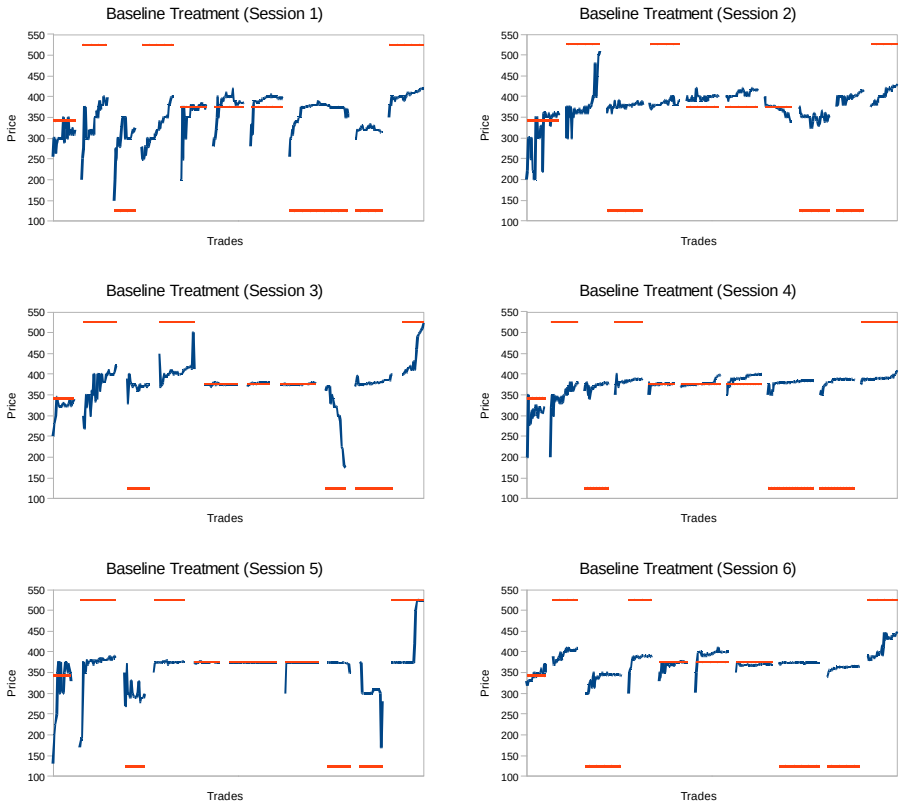

Figure 2: Price paths for the baseline treatment.

It can be observed from Figure 2 that in all six baseline sessions, the market aggregates information very well whenever the value of the asset is 375 ECU. Things are different in the other two states. If the fundamental value is 525 ECU, prices tend to be higher than

375 ECU, but a clear convergence to the actual value can only be observed in five rounds (in round 2 of session 2, in rounds 4 and 10 of session 3, and in round 10 of sessions 5 and 6). In these cases, learning through repetition seems to improve the convergence to the fundamental value of the asset. On the other hand, if the value of the asset is 125 ECU, a clear convergence pattern to the rational expectations equilibrium can only be identified for round 8 of session 3 and round 9 of session 5. In fact, the price of the asset is rather often higher than 300 ECU (in rounds 3, 8, and 9 of sessions 1, 2, 4, and 6, in rounds 2 and 9 of session 3, and in round 8 of session 5). This leads to the conclusion that learning only plays a minor role if the fundamental value of the asset is low.

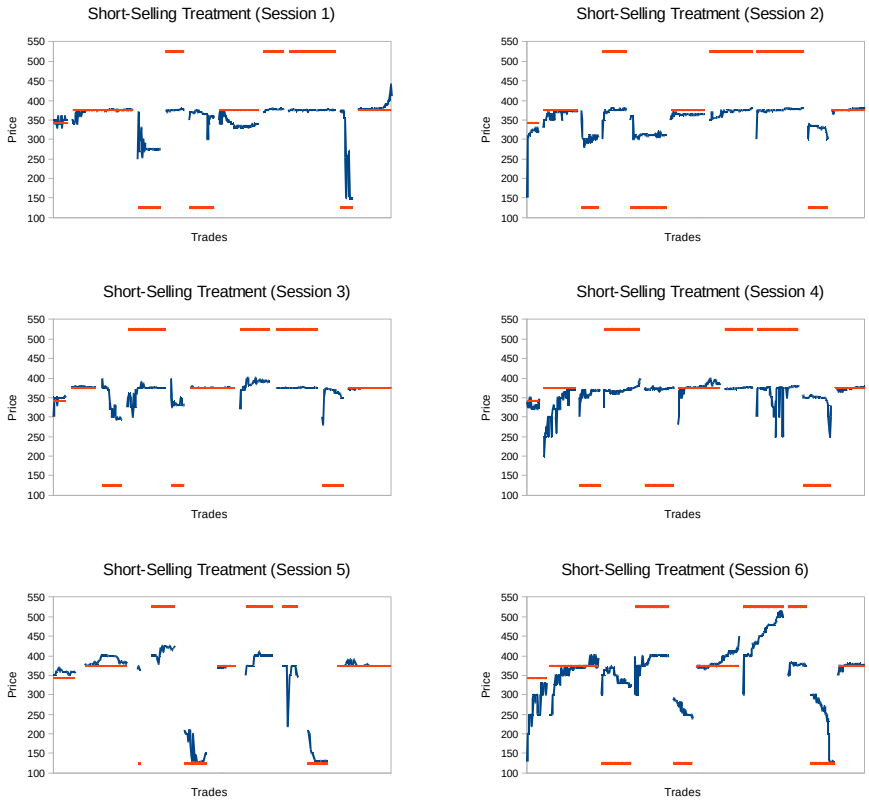

Figure 3: Price paths for the short–selling treatment.

As it is shown in Figure 3, the price paths in the short–selling treatment exhibit similarities

and differences. First, information is again very well aggregated in all sessions when the actual value of the asset is 375 ECU. Second, in comparison to the baseline treatment, information seems to be better aggregated if the asset is worth 125 ECU. Now, the final contract price is lower in some of the earlier rounds of a session (*i.e.*, round 3 of session 1, rounds 3, 5, and of session 2, and round 5 of session 6) and, in the later rounds of a session, the price converges even four times to the rational expectations equilibrium (in round 9 of session 1, in rounds 5 and 9 of session 5, and in round 9 of session 6). Hence, contrary to the baseline treatment, repetition seems to have a clearer impact. Finally, if the value of the asset is 525 ECU, the price does not converge to the rational expectations equilibrium even in later rounds of a session (the only exception is round 8 of session 6). In fact, the price paths resemble in most sessions the case when the value of the asset is 375 ECU, thereby clearly suggesting that the aggregation of information gets worse in comparison to the baseline treatment.

3.1 Econometrical and Statistical Analysis: Prices

We specify an econometric model with random effects for the last contract price P in order to enquire how the market statistics are affected by the weakening of short–selling constraints. Let P_{ij} be the last contract price in round i, $i = 2, ..., 10$, of session j (the six sessions corresponding to the short–selling treatment are indicated by $j = 1, ..., 6$, whereas the six sessions of the baseline treatment are indicated by $j = 7, ..., 12$). We consider four different regressors: the first two variables combine the fundamental value of the asset with an indicator for learning, while the final two variables capture the additional impact when a session belongs to the short–selling treatment. Formally, the variable H_{ij} (an abbreviation for High) equals k, $k \in \{1, 2, 3\}$, if the value of the asset in round i of session j is for the k'th time 525 ECU. Otherwise, $H_{ij} = 0$. The difference between L_{ij} (an abbreviation for Low) and H_{ij} is that

the former variable takes strictly positive values if, and only if, the fundamental value is 125 ECU. These are the first two regressors. Next, consider the dummy variable S_j that equals 1 if, and only if, session j belongs to the short–selling treatment. The final two regressors, $S_j \cdot H_{ij}$ and $S_j \cdot L_{ij}$, measure therefore the additional impact of H_{ij} and L_{ij} whenever a session belongs to the short–selling treatment. Finally, γ_j denotes the random effect of session j and ε_{ij} is the error term for round i of session j. The random effect (error term) is assumed to be distributed normally and independently with mean zero. We have then that[1]

$$P_{ij} = (\beta_0 + \gamma_j) + \beta_1 \cdot H_{ij} + \beta_2 \cdot L_{ij} + \beta_3 \cdot (S_j \cdot H_{ij}) + \beta_4 \cdot (S_j \cdot L_{ij}) + \varepsilon_{ij}. \tag{1}$$

In equation (1), the parameters β_3 and β_4 measure how the relaxation of the short–selling constraints affects prices when the actual values of the asset are 525 ECU and 125 ECU, respectively.

Variable	Coefficient	Std. Error	z–Statistic	p–Value
Constant	380.917	4.8620	78.3	0.000
High	21.2143	5.6557	3.75	0.000
Low	-14.1905	4.96936	-3.56	0.004
Short–Selling · High	-19.1548	5.3747	-2.52	0.012
Short–Selling · Low	-34.3927	13.649	-3.56	0.000
$R^2 = 0.513969$				

Table 1: Panel–GLS regression.

Table 1 reports the parameter estimates of the Panel–GLS estimation procedure. The standard errors are clustered on sessions and are robust to heteroscedasticity and serial autocorrelation. We employed the computer software Stata 9.2 for this purpose. It can be observed

[1] In different estimations, the value of the asset, the dummy variable S_j on its own, and/or variables for the case when the fundamental value of the asset was 375 ECU were either insignificant or led to a considerably lower R^2. Therefore, these regressors were excluded from our final specification.

that all parameter estimates are statistically significant and that the estimated model captures more than 51% of the price variation.[2]

The signs of the parameters are the expected ones. In the baseline treatment, the convergence to the rational expectations equilibrium improves thanks to repetition (the sign of the estimated coefficient of H is positive and the one of L is negative) and prices are lower in the short–selling treatment (the signs of the estimated coefficients of $S \cdot H$ and $S \cdot L$ are both negative). The constant is also very close to 375, showing that, on average, information is very well aggregated if the fundamental value of the asset is 375 ECU. Finally, the estimated coefficients of H and $S \cdot H$ almost cancel out. This confirms that even in later rounds of an experimental session, prices in the short–selling treatment tend to be rather low whenever the fundamental value of the asset is 525 ECU. Table 2 below summarizes the estimated last contract prices.

	Baseline			*Short–Selling*		
Occurrence	High	Middle	Low	High	Middle	Low
1^{st}–time	402.14	380.92	366.73	382.99	380.92	332.34
2^{nd}–time	423.36	380.92	352.54	385.06	380.92	283.76
3^{rd}–time	444.48	380.92	338.35	388.13	380.92	235.18

Table 2: Estimated prices.

To provide additional support for our findings, we perform non–parametric tests on the average last contract price per session. To be more specific, we consider the last contract price of each round. We calculate then, for each session, the average last contract price over

[2]The model is correctly specified in the sense that the residuals are normal *i.i.d.* with mean zero. In particular, all autocorrelation functions of the residuals (total and partial) are smaller than 0.2 and individually insignificant, the Ljung–Box reveals that autocorrelations are jointly insignificant, and the Jarque–Bera test establishes that the residuals are normally distributed with mean zero. The average random effect is also close to zero.

rounds conditional on the value of the asset. Thus, for each treatment and for each possible value of the asset, there are six independent observations (one per session). The entries in Table 3 are then obtained by averaging over all independent observations and, therefore, they coincide with the last points of the average price paths depicted in Figure 1. The p–values suggest that prices are lower in the short–selling treatment if the value of the asset is either 125 or 525 ECU and that there is no difference in prices if the asset is worth 375 ECU.

	Baseline		Short–Selling
Value of 525 ECU	423	[0.0100]	389
Value of 375 ECU	384	[0.1308]	381
Value of 125 ECU	346	[0.0227]	283

Table 3: Average last contract prices. The one–sided p–value of the Mann–Whitney U test on the equality of the two values is displayed in squared brackets.

3.2 Statistical Analysis: Payoffs

We investigate next how the per round payoffs change due to the relaxation of short–selling constraints. In total, four different groups of traders can be identified: the group of uninformed traders and, depending on the type of information received, three groups of informed traders. For each of the four groups, the average per round payoff in a given session is calculated. For example, we sum up the per round payoffs of all uninformed traders over the whole session and divide it by the product of the number of uninformed traders (six) and the number of rounds per session (nine). Consequently, for each representative trader, we have six independent observations per treatment. The entries in the following table are then obtained by averaging over all independent observations. Finally, note that the average payoff per round is equal to $\frac{(125+375+525)\cdot 3}{9} \cdot 4 = 1366.67$ ECU. This is the payoff any subject can insure herself/himself by not trading.

	Baseline		Short–Selling
Uninformed	1322	[0.0153]	1167
Insider (Not 125)	1885	[0.0066]	2498
Insider (Not 375)	1143	[0.1893]	1045
Insider (Not 525)	1207	[0.2876]	1158

Table 4: Average per–round payoffs. The one–sided p–value of the Mann–Whitney U test on the equality of the two values is displayed in squared brackets.

Table 4 presents the average per–round payoffs of the four groups of traders. Information is valuable in the sense that the representative uninformed trader earns in both treatments less than the average payoff of 1367 ECU. It can also be seen that this group suffers significantly from the relaxing of the short–selling restrictions (p=0.0153). In fact, the uninformed traders earn less in the short–selling treatment independently of the value of the asset: if the value of the asset is 525 ECU, they earn 1652 ECU (versus 1957 ECU); if the value of the asset is 375 ECU, they earn 1486 ECU (versus 1500 ECU); and if the value of the asset is 125 ECU, they earn 363 ECU (versus 508 ECU). Mann–Whitney U tests provide evidence that the difference is significant if the value of the asset is 525 ECU (p=0.0101, one–sided) and insignificant if the value of the asset is either 375 ECU (p=0.1893, one–sided) or 125 ECU (p=0.1890, one–sided).

The discussion above establishes directly that the group of informed traders as a whole profits from the introduction of short–selling opportunities, however important distinctions have to be made among the insiders. Table 4 reveals that traders with the signal that the value of the asset is not 125 ECU earn significantly more in the short–selling treatment. To be more precise, they earn on average 3476 ECU (1520 ECU) when the value of the asset is 525 ECU (375 ECU), while the associated average per–round payoff in the baseline treatment is "only" 2284 ECU (1485 ECU). It is therefore not surprising that the per–round payoff of this group of traders in the short–selling treatment is not significantly different from the one

in the baseline treatment whenever the value of the asset is 375 ECU (p=0.1490, one–sided), but that payoffs are significantly higher in the short–selling treatment if the value of the asset is 525 ECU (p=0.0041, one–sided). The latter happens because in comparison to the baseline treatment, these insiders can buy more shares at cheaper prices. On the other hand, both markets aggregate information similarly if the value of the asset is 375 ECU and, therefore, there are no additional opportunities to be exploited in this state.

The average per–round payoffs of the other two groups of informed traders is lower in the short–selling treatment. Even though it follows from Table 4 that the difference is not significant for either of the two groups, it is possible to say something more by looking at every state separately. In particular, traders with the signal that the value of the asset is not 375 ECU earn less in the presence of short–selling opportunities when the value of the asset is high (1526 vs. 2089 ECU) and they earn more if the value of the asset is low (564 vs. 196 ECU). Mann–Whitney U tests show that the former difference is significant (p=0.0025, one–sided), while the latter is not (p=0.4051, one–sided). The lower overall payoff of this group of traders is therefore caused by a sharp decrease in case the value of the asset is high. This also means that these traders engages in extensive short–selling.

Regarding the traders who receive the signal that the asset is not worth 525 ECU, we observe that their payoff is not only lower in the short–selling treatment if the value of the asset is 375 ECU (1422 vs. 1512 ECU), but also if the fundamental value is 125 ECU (893 vs. 901 ECU). Mann–Whitney U tests provide statistic evidence that the former difference is significant (p=0.0226, one–sided), while the latter is not (p=0.4681, one–sided). This second result may be interpreted as follows: short–selling opportunities allow these traders to make additional profitable trades if the value of the asset is 125 ECU. However, since prices are lower in the short–selling treatment, their gain per trade decreases in such a way that the

positive and negative effect cancel out.

4 Concluding Remarks

In this paper, we studied by means of an experiment whether the weakening of short–selling constraints leads to a better aggregation of information through prices and how the payoff of different groups of traders is affected by this. Regarding payoffs we find evidence that not only uninformed but also some of the informed traders suffer from the relaxation of the short–selling constraints. In particular, only the group of traders with the signal that the value of the asset is not 125 ECU earns more in the short–selling treatment. But in our opinion the most important finding is that prices are lower in the short–selling treatment independently on whether or not the asset is over– or undervalued in the baseline treatment. This result is perhaps surprising because one would conjecture from a rational expectations point of view that a better aggregation of information for the overvalued asset (when the value of the asset is low) helps the traders to better identify the state when the value of the asset is high (where the asset is typically undervalued). Consequently, we may conclude that short–selling opportunities do not necessarily improve the transmission of information through prices.

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Appendix: Instructions (Short–Selling)

Dear participant, thank you for taking part in this experiment. It will last about 90 minutes. If you read the following instructions carefully, you can – depending on your decisions – earn some more money in addition to the 3 Euro show-up fee, which you can keep in any case. The money you earn with your decisions during the session will be added up and paid to you in cash at the end of the experiment. These instructions are solely for your private information.

We will not speak of Euros during the experiment, but rather of ECU (Experimental Currency Units). Your whole income will first be calculated in ECU. At the end of the experiment, the total amount you have earned will be converted to Euros at the following rate:

1000 ECU = 1 Euro.

In order to ensure that the experiment takes place in an optimal setting, we would like to ask you to abide by the following rules. If you do not obey them, we will have to exclude you from this experiment and you will not receive any compensation.

- Do not communicate with your fellow students. If you have any doubts, raise your hand and one of the experimenters will clarify them privately.
- do not forget to switch off your mobile phone!
- you may take notes on this instruction sheet if you wish.
- when the experiment finishes, remain seated till we pay you off.

Environment

First we introduce you the basic situation of the experiment. Later on, you will learn how the experiment will be conducted. You will find control questions at the end of the description that help you to understand it better.

The Asset Market

In this experiment, you have the possibility to trade a financial asset in a stock exchange market for a total of ten rounds. Your final income (in Euro) will be determined by the sum of your per-round payoffs (in ECU). Every round, before the market opens for trade, the actual liquidation value of the asset is determined. It is either 125, 375, or 525 ECU and all values are equally likely to occur. The liquidation value is also common; that is, it is the same for all traders. Once the market closes, you receive the liquidation value for every share of the asset in your portfolio. For example, if the actual liquidation value of the asset is 125 ECU and you have a total of six shares of the asset, then you receive 900 ECU.

In the beginning of every round, every trader is endowed with 3 shares of the asset and 25000 ECU. Yet, the 25000 ECU are an interest free loan from a bank; that is, you will have to pay them back at the end of the very same round.

It is allowed that you sell shares of the assets you do not possess; that is, you can have a negative number of shares during and at the end of the trading period. This is called short–selling. In particular, you can have up to -10 shares of the asset. If you have a negative number of shares at the end of the trading period, you have to pay the liquidation value for each of the shares. For example, if the actual liquidation value of the asset is 375 ECU and you have a total of minus two shares, then you have to pay 750 ECU. Remember that you receive some ECU from another trader when you sell the share. So, the practice of short–selling is profitable to you whenever the price at which you sell the asset is higher than the actual liquidation value. Otherwise, it results in losses. For instance, if you sold two shares at 425 ECU each, the total profit from these trades is 100 ECU when the actual liquidation value is 375 ECU. If you had sold the shares at a price of 250 ECU each, you would have lost a total of 250 ECU from these trades.

The Traders

Before the first round of the experiment, all participants are randomly divided into groups of 12. Apart from us – the experimenters – nobody else knows the group composition. The group composition does not change during the course of the experiment; that is, you will always face the same traders.

Information Structure

No trader receives any information regarding the actual liquidation value before the trading stops in the first round of the experiment. From round two on, 6 traders (which are determined every round randomly anew) receive some information about the liquidation value before the market opens. In particular, each of them gets to know one of the two values the asset **does not take**. Three of the six informed traders learn one value the asset does not have and three the other. As an example consider a situation when the actual liquidation value is 525 ECU. In this case, three traders learn that the actual liquidation value is not 125 ECU and the other three traders learn that it is not 375 ECU.

Control Questions

Please answer the following control questions before you continue reading the instructions. Once you have written down all your answers, please raise your hand so that one of the experimenters can check them.

1. How many traders participate in the same market?

2. Does the composition of the traders participating in the same market change during the experiment?

3. What is the minimal number of shares you must have at the end of the trading period (hint: think of short–selling)?

4. How many shares of the asset do you receive in the beginning of round 5?

5. Do you have to return your monetary endowment of 25000 ECU at the end of the very same round?

6. How many traders receive information with respect to the liquidation value in round 1 of the experiment?

7. How many traders receive information with respect to the liquidation value in round 9 of the experiment?

8. Imagine that you learn in round 6 that the liquidation value is not 375 ECU? Which are the possible liquidation values of the asset?

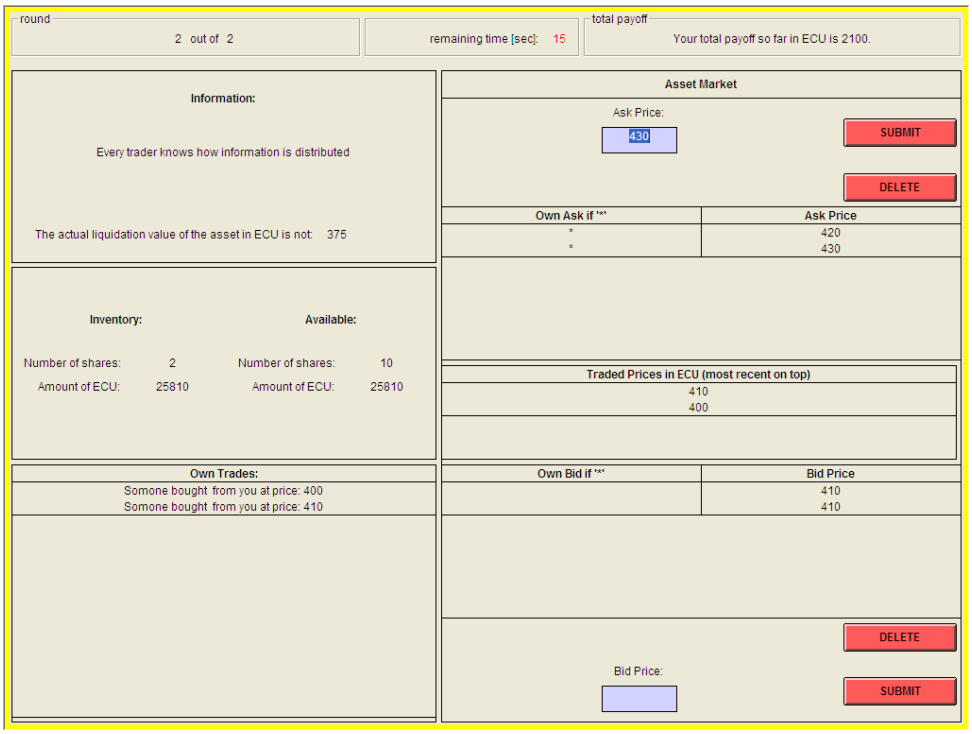
9. Imagine that you are informed in round 3 that the liquidation value is not 375 ECU. How many traders receive the same information as you?

The Experiment

In the next step, we will now go over a brief instruction period so that you get used to the computer interfaces.

The Trading Mechanism

After the determination of the liquidation value, a stock exchange market opens for 300 seconds. On the top of the corresponding computer screen you can identify the current trading round, how long the market remains to be open, and the total amount of ECU you have gained so far. In our example, we are in the second out of ten trading rounds, the market remains to be open for 15 seconds, and the trader has earned 2100 ECU so far.



The screen is further divided into two main parts, the boxes on left hand side and the boxes on the right hand side. The boxes on the left hand side provide different pieces of information whereas the boxes on the right hand side are needed to trade the asset. First, we introduce the purposes of the boxes on the left hand side.

1. The box on the top is entitled **Information**. As it had been said before, in round 1 of the experiment no trader has information about the liquidation value of the asset. From round two onwards, six randomly determined traders get to know some information about the liquidation value. In our example, you get to know that the value of the asset is not 375 ECU.

2. The box in the middle gives you an overview about your portfolio and your cash account. In the left part of this box, the **Inventory**, you find how many shares of the asset you possess (in our example you possess 2) and how many ECU you have in your cash account (in our example you have 25810 ECU). The right part of the box, which is denominated **Available**, has the following aim:

   Any sell offer you make is binding. So, if you want to sell one share of the asset, then you must be able to deliver it at any time in the future once the offer is accepted. To insure this, we reduce the number of shares available to you by one whenever you place a new sell offer. Since we allow that you short–sell up to 10 shares of the asset, the number of standing sell offers you can have at most is equal to the number of shares you possess plus 10. In our example, you see on the right hand side of the screen that the trader has 2 standing sell offers, which are the ones marked with a star at the prices of 420 and 430 ECU. Moreover, the trader has already sold two of the four shares s/he received as an endowment (one at a price of 400 and another at a price of 410 ECU as you can see in the box at the bottom left of the screen). Hence, a total of 2 is subtracted from the 12 shares you could sell at most (2 shares in the inventory plus 10 shares because of short–selling). Consequently, at this point, you can still post 10 additional sell offers.

   A similar approach applies to the available ECU. If you want to buy one share of the asset, then you must be able to pay for it in the future. To insure this, we reduce the available ECU by the amount you are willing to pay whenever you place a new buy offer. As the available ECU is not allowed to be negative, the total value of your buy offers cannot exceed the amount of ECU in the inventory. In our example, you see on the right hand side of the screen that the trader has no standing buy offers. Consequently, the available ECU is equal to the ECU in the inventory.

3. The box at the bottom is called **Own Trades**. This box contains a list of your own trades during a round. The most recent trade is on the top of the list. In our example, the individual made so far two trade in this round. S/he sold two shares of the asset, one at a price of 400 and another at a price of 410 ECU.

The boxes on the right hand side of the screen are denoted **Asset Market**. We are going to explain next how the asset is bought and sold using these boxes.

1. If you want to sell one share of the asset, enter the minimum amount of ECU you want to obtain in the field denominated **Ask Price**. You have to confirm your decision by pressing the button **Submit**. Your offer appears immediately in the column **Ask Prices** where all open sell offers are collected. The open sell offers are ordered with the lowest ask price being on the top of the list. You can easily identify your own open sell offers; they are marked with the symbol *****. We want to remind you that any additional sell offer decreases the amount of available shares by one. You are allowed to withdraw

a sell offer that has not found a buyer. To do so, you only have to select the sell offer you want to eliminate from the list and to click on the button **Delete**. As a consequence, the amount of available shares goes up again.

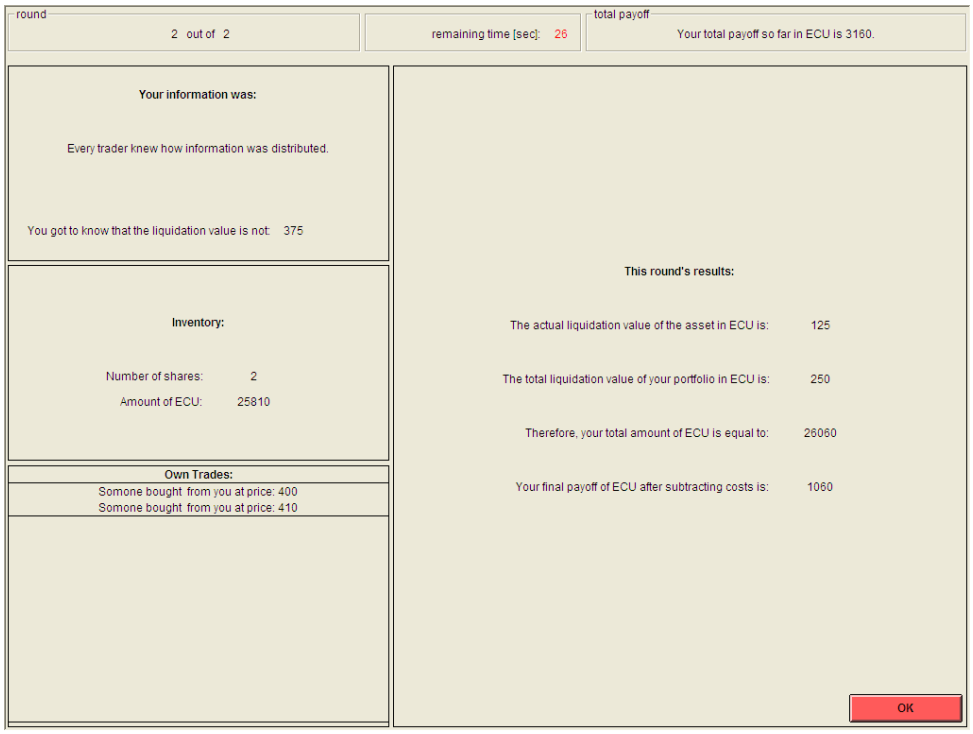
2. If you want to buy one share of the asset, enter the maximum amount of ECU you are willing to pay in the field denominated **Bid Price**. You have to confirm your decision by pressing the button **Submit**. Your offer appears immediately in the column **Bid Prices** where all open buy offers are collected. The open buy offers are ordered with the highest bid price being on the top of the list. You can easily identify your open buy offers; they are marked with the symbol *****. We remind you that any additional buy offer decreases the amount of available ECU by the value of your bid. You are allowed to withdraw a buy offer that has not found a seller. To do so, you only have to select the buy offer you want to eliminate from the list and to click on the button **Delete**. As a consequence, the available ECU goes up again.

3. **When and how does a trade take place?** A trade is possible if the **highest bid price** is at least as high as the **lowest ask price**. In this situation, one bidder is willing to pay for the asset at least as much as one seller asks for it. These situations are recognized by the software and trade takes place automatically. The traded price will be equal to the one proposed by the first of the two parties. One simple example clarifies this: Suppose that in a certain situation the lowest ask price is 170 ECU and that the highest bid price is 169 ECU. Then, no trade is possible. If another bidder is willing to pay 177 ECU for the share, the only thing s/he needs to do is to enter a bid of 177 ECU into the system following the procedure of point (2) above. The system recognizes that a trade is possible; that is, the seller receives 170 ECU from the buyer's inventory (because the seller was first in the market) and the buyer receives one share of the asset from the seller's inventory.

   An important box on the right hand side is called **Traded Prices**. In it, you find a list of all prices at which a trade took place. The most recent trade price is on the top of the list. In our example, the most recent price is 410 ECU.

Round Summary

Once the market closes, the asset is liquidated. In the corresponding computer screen you find different pieces of information. On the left hand side of the screen you find (a) your particular information with respect to the actual liquidation value of the asset, (b) how many shares and how many ECU you have in your inventory, and (c) a history of your trades.
On the right hand side you find the summary statistics of this round. We inform you about the actual liquidation value of the asset (in our example it is 125 ECU). This value is multiplied with the number of shares in your inventory to determine the liquidation value of your portfolio



(since the trader has two shares in her/his portfolio, the value of the portfolio is in our example equal to 250 ECU). Afterwards, we add the amount of ECU in your inventory to it (the sum is in our example equal to 26060 ECU). Finally, we subtract the 25000 ECU that have been given to you in the beginning of the round as an interest free loan. As a result, we obtain the final payoff of the round (in our example it is 1060 ECU). This amount is added to your earlier payoffs. For example, in the top right corner of the screen you see now that your total current payoff is 3160 ECU (2100 ECU from the first plus 1060 ECU from the second round).

Click on the button **OK** to proceed to the next trading round. Note that every trader starts again with 25000 ECU from an interest free loan and four shares of the asset. At the end of the last round, you will get a short electronic questionnaire regarding your personal background. This data will only be used for statistical purposes.

FINAL QUESTION: Suppose you want to sell the asset at a price of 400 ECU. In which field do you have to enter the price, in the ASK or in the BID cell? Once you have written down the answer, please raise your hand.