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Two heads are less bubbly than one: Team decision-making in an experimental asset market

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Abstract: In the world of mutual funds management, responsibility for investment decisions is increasingly entrusted to small teams instead of individuals. Yet the effect of team decision-making in a market environment has never been studied in a controlled experiment. In this paper, we investigate the effect of team decision-making in an asset market experiment that has long been known to reliably generate price bubbles and crashes in markets populated by individuals. We find that this tendency is substantially reduced when each decision-making unit is instead a team of two. This holds across a broad spectrum of measures of the severity of mispricing, both under a continuous double-auction institution and in a call market. The result is not driven by reduced turnover due to time required for deliberation by teams, and continues to hold even when subjects are experienced. Our result also holds not only when our teams treatments are compared to the 'narrow' baseline provided by the corresponding individuals treatments, but also when compared more broadly to the results of the large body of previous research on markets of this kind.

Keywords: *group decision-making, price bubbles, asset market experiments.*

JEL codes: *C92, D70, G12.*

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1 Introduction

Many important decisions in both business and government – including funds management (Bär, Kempf and Ruenzi 2011) and monetary policy (Blinder and Morgan 2005) – are increasingly being entrusted to small groups as opposed to individuals. Yet, with the exception of the fields of public choice and organization theory, economics has remained largely silent on the question of group decision-making, treating the decisions of households and firms as though they were made by unitary decision-makers. In this paper we examine the effect of team decision-making upon the propensity for asset markets to bubble and crash. We make this comparison in the setting of an experiment, in which the intrinsic value of the asset that is bought and sold – as well as other features such as the size of the decision-making unit – is under the control of the experimenter. Our experiments thus isolate the effect of team decision-making, holding other features of the market environment constant.

Our paper sets out to make two distinct contributions. Firstly, we contribute to experimental research on teams by reporting, to the best of our knowledge, the first study to compare the behavior of individuals and teams in a fully-fledged double-sided market environment. We make this comparison using both a continuous double-auction institution and a call market institution, in the setting of a market for a long-lived asset. Secondly, whereas almost all existing research on asset market experiments has examined the robustness of bubbles and crashes to *institutional features of the market environment*, our focus in this paper is on the *characteristics of the traders themselves*, in particular the effect of populating a market with teams of size two instead of individuals. Across a broad range of measures of the severity of mispricing, we find strong support for the proposition that team decision-making results in substantially smaller price bubbles when compared to baseline markets populated by individuals drawn from the same subject pool and using the same procedures. This is the case in both our double-auction and call market treatments. This is also the case when we compare our teams markets to a broader database of results from previous research on markets of this type.

2. Related literature

2.1 Decision-making by individuals and teams

To date, the limited economic literature on team decision-making can be divided into studies of preferences or decision-making in non-strategic settings, and studies involving strategic games. Studies of non-strategic environments are dominated by experiments on decision-

making under risk. Baker, Laury and Williams (2008) and Shupp and Williams (2008) compare experimentally-elicited measures of risk preferences between individuals and teams of size three. Baker, Laury and Williams do this using the paired lottery choice procedure of Holt and Laury (2002). Shupp and Williams elicit certainty equivalents for lotteries with different probabilities of winning, using a procedure based upon Kachelmeier and Shehata (1992). Baker, Laury and Williams find no significant difference between the risk preferences of individuals and teams, while Shupp and Williams find that teams are significantly more risk averse when the probability of winning is low, but less risk averse when it is high.

Bone, Hey and Suckling (1999) and Rockenbach, Sadrieh and Mathauschek (2007) examine whether teams (of size two and three, respectively) are more or less likely than individuals to exhibit violations of expected utility theory such as the common ratio effect. Both papers report almost no difference; however Rockenbach, Sadrieh and Mathauschek observe that teams accumulate significantly more expected value than individuals, and at a significantly lower risk, a result they attribute to teams' avoidance of excess risk. Charness, Karni and Levin (2007) study violations of first-order stochastic dominance and Bayes' rule by individuals and teams. They find that teams commit fewer violations than individuals, and that the incidence of violations further decreases as team size increases from two to three. Blinder and Morgan (2005) study two experiments designed to test the hypothesis that teams make decisions more slowly than individuals. They find no significant difference between individuals and teams of size five in the amount of data that is accumulated before a decision is made, but report that teams make significantly better decisions.

Turning to studies of strategic interaction, Kocher and Sutter (2005) find no difference between the decisions of individuals and teams of three in the first round of a beauty-contest experiment. However as the game is repeated, teams converge significantly faster toward the game-theoretic equilibrium, indicating that teams learn faster than individuals. Cooper and Kagel (2005) compare individuals to teams of two in three entry-deterrence signaling games. They find that teams learn strategic play more rapidly than individuals in all three treatments, and that teams' superior performance increases with the difficulty of the games.

We are also aware of studies that experimentally examine bidding behavior by teams. Cox and Hayne (2006) compare individuals to teams of five in common-value auctions in which the number of bidders is either three or seven. When both individuals and teams receive a single signal of value, they find no evidence that the winning bids of teams are either more or less rational than those of individuals. However, when each member of a team receives their

own signal, they find that winning teams bid less rationally than individuals, in that they fail to discount their bids sufficiently to avoid the winner's curse. Casari, Zhang and Jackson (2010) study bidding by individuals and teams of size three in the company takeover game of Bazerman and Samuelson (1985), in which there is only a single buyer and a robot seller. They report that teams make significantly fewer winner's curse offers because they learn faster and because 75% of team decisions coincide with the choice of the median member, in a task in which the majority of subjects make the correct decision when deciding in isolation.

Finally, there are some empirical studies that are pertinent to our research. Bär, Ciccotello and Ruenzi (2010) and Bär, Kempf and Ruenzi (2011) analyze data on US mutual funds and find that, controlling for differences in size, age and other characteristics, team-managed funds take on less risk than individually-managed funds, and adjust their risk profile less in response to prior performance. Team-managed funds follow an investment style that is less extreme and more consistent over time. Bliss, Potter and Schwartz (2008) similarly find that team-managed funds take on less risk, and that they have lower expenses than individually-managed funds. However, an inherent difficulty with this type of research is that since the intrinsic value of funds' assets is unobservable, it is not possible to evaluate the effect of team management upon the overall performance of the market as a whole.

2.2 Price bubbles in experimental asset markets

The second body of literature to which we seek to contribute relates to experimental asset markets. The tendency for such markets to bubble and crash, even when the dividend process is common knowledge, was first documented by Smith, Suchanek and Williams (1988), hereinafter SSW. They found that with inexperienced subjects, prices follow a consistent pattern of starting out below intrinsic value before rising steeply above it and then crashing.

An extensive body of subsequent research has shown that this pattern is robust to numerous extensions and modifications to SSW's original design. However we are aware of only three studies that consider the effect of trader characteristics upon the bubble-and-crash phenomenon. SSW populate one of their markets (Experiment 10) with professional and business people from Tucson. They conclude from this that their results are not an artifact of the use of student subjects. Similarly, King et al (1993) report two markets in which the subjects were corporate executives and stock market dealers, respectively. They likewise conclude that this did not alter the general pattern of trade typically observed with inexperienced student subjects. Finally, Ackert and Church (2001) compared markets

populated with business students with markets made up of non-business students. They observe the same familiar bubble-and-crash pattern with both inexperienced non-business subjects (Markets 1–3) as with inexperienced business subjects (Markets 4–6).

3. Design and procedures

We compare the performance of experimental asset markets populated by individuals to ones in which each decision-making unit is a team of size two. We make this comparison in both continuous double-auction and call market institutions. Our experiments were conducted in the CentERlab at Tilburg University in the Netherlands. This facility comprises both a conventional laboratory with 24 partitioned workstations (the 'A Lab') and ten soundproofed cubicles, each large enough to seat two subjects side-by-side in front of the computer (the 'B Lab').[1] All sessions were conducted in English, and all treatments were fully computerized and programmed in z-Tree (Fischbacher 2007).

The experimental asset has a life of fifteen trading periods, and pays a stochastic dividend to its current owner at the end of each period. This dividend may be 0, 8, 28 or 60 units of experimental currency ('francs') per unit of stock ('share'), each with equal probability, such that the expected dividend is 24 francs in each period. A trader's holdings of experimental money and stock carry over from one trading period to the next. At the conclusion of fifteen periods, all shares expire without any terminal value. The intrinsic value of a unit of stock is thus 24 multiplied by the number of remaining periods, and in particular it is 360 in the first period. The dividend structure of the asset was clearly explained as part of the instructions that were read aloud at the start of the experiment, and in addition information on the intrinsic value in each period was provided in the form of an average holding value table.

Each market consists of nine traders. At the beginning of the first trading period, three traders are endowed with an initial portfolio of 450 francs and six shares. A further three traders are endowed with 1,170 francs and four shares, and the remaining three traders are endowed with 1,890 francs and two shares. The intrinsic value of each trader's initial endowment is thus identical and equal to 2,610 francs.[2] The rules of the market do not allow traders to buy on margin or to sell short. Each trader's earnings from the experiment are derived from the

[1] A photo of one of the cubicles in the B Lab is included in the supplementary material. A floor plan of the CentERlab can be found online at http://center.uvt.nl/lab/map1.doc.

[2] No trader is aware of the endowments of the other traders. They only know of their own, which they learn of at the commencement of the first trading period.

amount of experimental money they hold at the end of the fifteenth period, after the dividend for that period has been paid. At the conclusion of the experiment, this amount was converted into Euros at a fixed and pre-announced exchange rate, and paid to the subjects in cash.

In each of our teams markets, each of the nine traders was a randomly-matched team of two. At the conclusion of the session we paid out the value of a team's earnings to *each* of its two members, using the same exchange rate as in the corresponding individuals treatment. In other words, each team member received the same earnings as they would have had they executed the same transactions as individuals in the corresponding individuals treatment (and faced the same random realizations of the dividends). Upon completion of the experiment, but prior to receiving their payments, all subjects were also asked to complete a post-experiment questionnaire. This was completed individually in both the individuals and teams treatments.[3]

3.1 Double-auction sessions

Our individual double-auction data are from the baseline condition in Haruvy, Noussair and Powell (2009), hereinafter HNP, who report six baseline markets conducted between 10 December 2007 and 28 March 2008.[4] A total of 51 subjects took part in these markets, since not all sessions had the full complement of nine traders. We compare these to six team double-auction markets which we conducted under identical parameters using the same laboratory and subject pool in Tilburg between 5 and 13 February 2009. We oversubscribed our sessions to ensure that there were eighteen subjects (nine teams of two) in each session, for a total of 108. We used the same computer program as HNP,[5] and paid our subjects using the same exchange rate as they used (100 francs to one Euro). Each session ran for an average of 2.5 hours, and no individual was allowed to participate in more than one session. Table 1 provides summary demographic and earnings statistics for each of the treatments, while a more detailed subject pool analysis is reported in the supplementary material.

[Table 1 about here.]

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[3] Refer to the supplementary material for the post-experiment questionnaire for our teams treatments. In all treatments other than the individual double auctions, the questionnaires also included a ten-item test of financial literacy derived from van Rooij, Lusardi and Alessie (2011).

[4] In addition to their baseline condition, HNP consider additional treatments involving the buyback or float of shares. We do not utilise the data from these other treatments in this study.

[5] Refer to the supplementary material for sample screen shots. During the course of a trading period, each trader's screen displayed their current holdings of experimental money and stock, the history of prices in the current period, and the open order book of bids and asks. At the conclusion of each period, the screen displayed summary information including the dividend realization for the period just ended.

After subjects had signed in, we directed them to sit at any available terminal in the A Lab. We then distributed and read aloud the first section of the instructions, dealing with the mechanics of using the trading interface to post offers and to buy and sell shares.[6] These were identical to the corresponding instructions used by HNP. Following the same procedure adopted by HNP, subjects were then given ten minutes in which to practice trading using the interface. They completed this practice period individually, and it did not count toward their earnings. It is worth emphasizing that they completed the practice task before they had been told about the dividend structure of the asset, how their earnings would be determined, or that they would undertake the main part of the experiment in teams.

We next circulated and read aloud the remaining sections of the instructions, dealing with the team nature of the experiment, dividend structure of the asset, average holding value table and calculation of earnings. These were adapted from the corresponding instructions from HNP by emphasizing that all dividends and cash balances would accrue to *both* members of each team. After the subjects had been assigned into their teams, each team was then escorted to its own separate cubicle in the B Lab. When all teams were ready, the doors to the cubicles were closed and the experiment commenced.[7] In order to facilitate team deliberation, we increased the length of each double-auction trading period from four minutes in the HNP baseline condition to five minutes in our teams markets. Upon completion of the experiment, the subjects returned to their original seats in the A Lab, where they completed a post-experiment questionnaire individually. Finally, given that both members of each team received the same earnings, we paid them in teams, in privacy from the others, in an adjoining office.

3.2 Call market sessions

We ran our call market treatments to address the concern, discussed at length in Section 5.1 below, that the time required for deliberation by teams might account for the lower turnover that we observe in our team double auctions, and this might in turn account for our finding that these markets are less prone to bubble.[8] For this reason, we did not impose any time

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[6] The complete text of the instructions for the team double auctions is contained in the supplementary material. The same experimenter (Author 1) read out the instructions in all six sessions.

[7] There was a call button in each cubicle, which subjects could use to alert the experimenters in the event of any questions or other difficulties.

[8] We thank an anonymous referee for suggesting these treatments. This referee also suggested the use of recording devices for teams markets. We decided against pursuing this for several reasons. Firstly, the experiment was conducted in a non-native language for many of the subjects. Had we attempted to regulate the language in which they conversed, this might itself have interfered with the speed and efficacy of their deliberations. Moreover, the mere fact that they would have been aware that their conversations were being recorded might alone have influenced the nature of their deliberations. Secondly, we lack any comparable

constraints upon the submission of limit orders in the call markets, thereby allowing unlimited time for deliberation by both individuals and teams.

Our call market data consist of four individuals sessions and three teams sessions, conducted between 21 and 25 March 2011, using the same laboratory and subject pool in Tilburg as the double-auction sessions.[9] We use a call market institution similar to Haruvy, Lahav and Noussair (2007), while retaining the same parameters as the double-auction treatments. In each period, each trader submits the maximum quantity of shares they are willing to buy and the highest price they are willing to pay, as well as the maximum quantity they are willing to sell and the lowest price that they will accept. The period is concluded when all traders have submitted their orders. At this point, the computer screen displays summary information including the market price and the dividend realization for the period just ended.[10]

To preclude the possibility of a selection effect, we recruited subjects for a session with an advertised length of 2.5 hours (the same as our team double auctions) in both the individuals and teams treatments. Because we did not limit the time for deliberation in call markets, we could not be certain in advance how quickly or slowly the session would progress. However, we anticipated that it might be possible to complete more than one market repetition within the allotted time, and so we adjusted the exchange rate to 260 francs to one Euro.

As it turns out, in each of our sessions we had sufficient time to conduct at least one additional repetition of the market using the same parameters as before. For our call market treatments, we are thus able to report results for both inexperienced and once-experienced markets.[11] In the individuals sessions, the average length of time required to complete two market repetitions was 77 minutes, while in the teams sessions it was 147 minutes. We over-subscribed sessions to ensure that there would be 9 (18) subjects in each individuals (teams) session, for a total of 36 (54). No subject was allowed to take part in more than one session.

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protocol for individuals that would allow us to 'listen in' on their deliberative processes. Thirdly, in spite of being quite laborious to analyze, the resulting evidence would only be of an anecdotal nature in any case.

[9] The reason for this unbalanced number of observations is that we experienced a software crash at the end of the first individuals session, due to programming problems. Since we were subsequently able to recover the data from this first session essentially intact, we include it in the analysis.

[10] Refer to the supplementary material for sample screen shots.

[11] In some sessions we also completed a third repetition, which we do not report here. Since markets populated by individuals typically converge to intrinsic value by the third repetition (SSW; van Boening, Williams and LaMaster 1993), there is little scope in this setting for teams to improve on the performance of individuals.

Since we did not have access to the A Lab for the entire duration of the sessions, we had to modify our procedures relative to the team double auctions. After subjects had signed in, we assigned them to, and seated them in, the cubicles in the B Lab, keeping the doors open. We then read aloud the instructions, copies of which lay ready in the cubicles.[12] There was no practice period, as the task of entering quantity and price offers was straightforward. When all individuals (teams) were ready, the doors to the cubicles were closed and the experiment commenced. Upon completion of the experiment, the subjects were asked to seat themselves in the A Lab, where they completed the post-experiment questionnaire individually. Finally, we paid them individually, in privacy from the others, in the adjoining office.

4. Bubble measures

To facilitate a formal comparison of individual and team markets, we follow previous studies in computing a range of well-established measures of the severity of mispriced transactions. These bubble measures allow us to compare our teams treatments not only against the 'narrow' baseline provided by the corresponding individuals treatments, but also against the broader literature on SSW-style markets, since the measures normalize for differences in parameterization across studies. For each of the measures, which we define below, a larger value indicates a more pronounced price bubble.[13]

Turnover (King et al. 1993) is a measure of the volume of share transactions relative to the number of shares on issue in the market:

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

where T is the number of trading periods, q_t is the number of shares transacted in period t and *TSU* (Total Stock of Units) is the total number of shares on issue.

Amplitude is a measure of the overall magnitude of peak-to-trough deviations in the mean transaction price in a period from intrinsic value. In the version of this measure defined by Haruvy and Noussair (2006), the maximum and minimum price deviations are evaluated relative to intrinsic value in the current period, such that:

$$Amplitude = \max_t \left[\left(\overline{P}_t - f_t \right) / f_t \right] - \min_t \left[\left(\overline{P}_t - f_t \right) / f_t \right]$$

[12] The complete text of the instructions for the team call markets is contained in the supplementary material. The same experimenter (Author 2) read out the instructions in all seven call market sessions.

[13] For *Average Bias*, negative values indicate a negative bubble, i.e. prices below intrinsic value.

where $\overline{P}_t$ is the mean transaction price in period t in a double-auction market, or simply the market-clearing price in period t in a call market, and f_t is intrinsic value in period t. A high value of this measure indicates large price swings relative to intrinsic value.

Duration (Porter and Smith 1995) is defined as the length of the longest sequence of periods over which the difference between the (mean) transaction price and the intrinsic value increases consecutively from one period to the next:

$$Duration = \max\left(m : \overline{P}_t - f_t < \overline{P}_{t+1} - f_{t+1} < \ldots < \overline{P}_{t+m} - f_{t+m}\right)$$

Average Bias (Haruvy and Noussair 2006) is a measure of the average strength and direction of the deviation of the (median) price in a period from intrinsic value in that period:

$$Average\ Bias = \sum_{t=1}^{T}\left(\tilde{P}_t - f_t\right)\Big/T$$

where $\tilde{P}_t$ is the median transaction price in period t in a double-auction market, or simply the market-clearing price in period t in a call market.

Average Dispersion (Palan 2009) measures the average *absolute* discrepancy between the (median) transaction price in a period and intrinsic value.[14] It differs from *Average Bias* in that it penalizes both positive and negative deviations, where these may potentially cancel each other out in the expression for *Average Bias*. The *Average Dispersion* is defined as:

$$Average\ Dispersion = \sum_{t=1}^{T}\left|\tilde{P}_t - f_t\right|\Big/T$$

Overpriced Transactions (Palan 2009) is the percentage of all transactions that occur at prices in excess of the maximum remaining dividend value of a share. It is defined as:

$$Overpriced\ Transactions = 100\times\sum_{t=1}^{T}\sum_{i=1}^{q_t} I_{it}^{\max}\Big/\sum_{t=1}^{T} q_t$$

where $I_{it}^{\max}$ is an indicator variable that takes the value 1 if $P_{it} > f_t^{\max}$ (where P_{it} is the price of the ith share transacted in period t and $f_t^{\max}$ is the maximum dividend stream that could possibly accrue from holding a share from period t until the end of the market), and $I_{it}^{\max} = 0$ otherwise. Thus under our parameters, $f_t^{\max}$ is simply the maximum dividend realization of 60 multiplied by the number of remaining trading periods. This measure provides a strong

[14] A measure of *Total Dispersion* was introduced by Haruvy and Noussair (2006). We follow Palan (2009) in normalizing for the number of trading periods.

indication of speculative trade, since speculation is the only rationale (short of irrationality) that can explain why a trader would be willing to purchase shares at a price in excess of $f_t^{\max}$.

Normalized Deviation (King et al. 1993) measures the aggregate absolute deviation of individual transaction prices from intrinsic value, normalized by the Total Stock of Units:[15]

$$Normalised\ Deviation = \sum_{t=1}^{T} \sum_{i=1}^{q_t} \left| P_{it} - f_t \right| \Big/ \left(100 \times TSU \right)$$

Finally, for double-auction markets only, we report the *Dispersion Ratio* (Palan 2009). This is a measure of price volatility designed to normalize for differences in the level and change over time in the variability of the outstanding dividend stream on a share. It is defined as:

$$Dispersion\ Ratio = \frac{1}{T} \sum_{t=1}^{T} \frac{\hat{\sigma}_{P_{it}}}{\sigma_{f_t}}$$

where $\hat{\sigma}_{P_{it}}$ is the sample standard deviation of transaction prices in period *t*, and σ_{f_t} is the population standard deviation of the remaining dividend stream on a share in period *t*. A *Dispersion Ratio* equal to unity thus indicates that transaction prices are on average exactly as variable as the dividend stream on a share.

5. Results

5.1 Double-auction treatments

Figure 1 presents an initial impression of the trajectory of market prices in the team double-auction markets, by showing the median transaction price in each trading period for each of the six markets. In this figure the lower, dark, stepped line represents the time path of intrinsic value while the upper, light, stepped line represents the maximum dividend value of a share in the event that it pays the highest possible dividend realization in all remaining periods. It can be seen that price bubbles are not completely eliminated in the teams markets: Market 3 in particular, and Market 6 to a lesser extent, display a bubble-and-crash pattern broadly similar to what is observed in previous studies. In the remaining four markets, prices briefly rise above intrinsic value, but the magnitude of the discrepancy is comparatively small and prices track intrinsic values closely over the final third of the experiment.

[15] The reason for dividing by 100 in the expression for *Normalized Deviation* is to make the results of our study, in which the dividends are expressed as 0, 8, 28 or 60 experimental 'cents' comparable to earlier studies in which the dividends were expressed as 0.00, 0.08, 0.28 or 0.60 experimental 'dollars'.

To provide an initial comparison, Figure 2 plots corresponding price trajectories for the HNP baseline markets. Four of the markets exhibit the bubble-and-crash pattern, and a pronounced 'negative bubble' is observed in a fifth market. In only one of the markets do we observe prices broadly in line with intrinsic value through the middle to later stages of the experiment.

[Figures 1 and 2 about here.]

Table 2 reports our analysis of the summary bubble measures for the double-auction markets. The first two sections of the table report values of each of the measures in each of the six team double-auction and HNP baseline markets respectively, along with treatment means. The next two rows report *p*-values for tests of the null hypothesis of equality of central tendency between individual and team double-auction markets, in parametric and nonparametric tests respectively. The final row of the table is derived from a database of bubble measure observations that the second author has compiled for another paper. We report the mean values of each measure for all available observations in the database for which the subjects were inexperienced, and which conform particularly closely to the standard SSW design.[16]

[Table 2 about here.]

The mean bubble measures reported in Table 2 indicate that on average we attain smaller values of all but one of the eight measures in our team double auctions compared to the HNP baseline data. Moreover, the formal tests reported in the table confirm that with one additional exception, these differences are at least marginally significant in both the parametric and nonparametric tests.[17] Although the significance levels of the individual test statistics are inhibited by the limited number of observations, the strength of our result is reinforced by the fact that it holds across a full spectrum of bubble measures that previous authors have devised to capture a broad range of characteristics of an experimental asset market.

Our strongest result is for *Duration*: in every one of our team double auctions, we observe *Duration* less than or equal to the lowest value observed in the HNP baseline markets. The measure for which we clearly fail to obtain a result is *Average Bias*. Recall however that the definition of this measure allows periods of positive and negative price deviations from intrinsic value to cancel one another out, and that the HNP baseline data includes markets

[16] These inexperienced baseline markets are limited to ones in which the intrinsic value of the experimental asset is declining over time, which employ a double-auction institution, and in which there is no short selling or futures market. The list of inexperienced baseline observations is itemized in the note to Table 2.

[17] The exception is *Amplitude*, for which we just fail to attain a conventional significance level in the nonparametric Wilcoxon rank-sum test ($p = 0.109$).

with both very large positive and negative deviations. By contrast, the measure of *Average Dispersion* penalizes all absolute deviations, both positive and negative. Given that we observe a lower *Average Dispersion* in our team double auctions ($p = 0.063$ in a *t*-test and $p = 0.078$ in a rank-sum test), we confirm that prices do indeed track intrinsic values more closely in an absolute sense in our teams markets.

In addition to observing prices that track more closely to intrinsic value, we also observe lower *Turnover* in our team double auctions ($p = 0.045$ in a *t*-test and $p = 0.055$ in a rank-sum test). Figure 3 sheds further light on this by plotting the turnover of shares disaggregated by trading period, averaged over the six markets of the teams and HNP baseline markets respectively. It shows that the most pronounced difference in turnover is observed in the first period of trade. In the six HNP baseline markets each share is transacted on average 1.56 times during the first period, compared to 0.56 times in the first period of the team double auctions (the difference is significant at $p = 0.029$ in a *t*-test and $p = 0.055$ in a rank-sum test). This difference in the first period is the main contributor to our finding of lower overall *Turnover* in the teams markets: while the direction of comparison indicates lower turnover under teams in all but one of the remaining periods, in only two periods does this attain statistical significance.[18] We discuss these observations further below.

[Figure 3 about here.]

The measure of *Normalized Deviation* penalizes both the number of mispriced transactions and the (absolute) severity of mispricing, effectively combining the information from *Turnover* and *Average Dispersion*. Since we observe lower values for both *Turnover* and *Average Dispersion* in our teams treatment, it comes as no surprise that we find significantly lower *Normalized Deviation* ($p = 0.030$ in a *t*-test and $p = 0.037$ in a rank-sum test).

We also observe lower price volatility under the team double auctions as measured by the *Dispersion Ratio* ($p = 0.071$ in a *t*-test and $p = 0.055$ in a rank-sum test). Figure 4 sheds further light on this result by plotting the mean of the sample standard deviation of transaction prices in each period for the six markets of the teams and HNP baseline treatments respectively. It shows that the average volatility in transaction prices in a period is lower in the teams markets for all but one out of fifteen trading periods.[19]

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[18] In period ten $p = 0.049$ in the *t*-test, but $p = 0.106$ in the rank-sum test. In period twelve $p = 0.036$ in the *t*-test and $p = 0.064$ in the rank-sum test.

[19] When we conduct period-wise comparisons of the standard deviation of prices between the two treatments, we find that the difference is at least marginally significant in periods one, two, four, thirteen and fourteen.

[Figure 4 about here.]

Finally, the bottom row in Table 2 shows that when compared to the average of all inexperienced baseline markets in the database of bubble measure observations from previous studies, our team double-auction markets on average yield smaller values of all six of the measures for which we have a base for comparison. This confirms that the mispricing that we observe in our team double auctions is also mild by the standards of the broader literature.

In the context of a continuous double-auction, one potential impediment to the execution of trades by teams is that the two team members must first agree upon the trades that they make, and this takes time. It was for this reason that we elected to increase the length of each trading period from four minutes in the HNP baseline markets to five minutes in our team double-auction markets. Nonetheless, it remains possible that the time needed for deliberation by teams might account for the lower volume of trade that we document in our team double-auction markets. Moreover, and although this does not follow automatically, it could also be argued that this reduced volume might in turn account mechanically for our main finding of diminished mispricing in the teams markets. In our call market treatments, we address this concern by allowing unlimited time for deliberation in each trading period in both individual and teams treatments. Before turning to those results, we first explore this issue further with respect to the data from the double-auction treatments.

As we pointed out in our discussion of Figure 3, our finding of lower *Turnover* in the team double auctions appears to be driven primarily by the significantly larger volume of trade in the first period of the HNP baseline markets. In these markets, the first trading period accounts for 25 percent of total share transactions. In the remaining trading periods, while the comparison generally points in the direction of lower volume in the team double auctions, the magnitude of the difference is much smaller than what we observe in the first period, and it is generally not statistically significant. Moreover, as can clearly be seen in Figures 1 and 2, in both the HNP baseline and teams treatments the median transaction price during the first period of trade is below intrinsic value in every market. For this reason, it seems *a priori* implausible that the considerably larger turnover that we observe in the first period of the HNP baseline markets would account for the greater propensity of those markets to bubble in later periods – when the differences in turnover are largely insignificant.

To reinforce this point, Appendix A examines the robustness of the analysis in Table 2 to omitting the data from the first period. For each market, we recalculate each of our bubble measures using the data from periods two through fifteen only. An inspection of the treatment

means indicates that each of the measures is on average smaller in the teams markets. Turning to the significance tests, we find that the difference in *Turnover* is only marginally significant in the *t*-test ($p = 0.079$), while it is insignificant in the rank-sum test ($p = 0.262$). Our results for the remaining measures are largely unaffected. The only notable change is that the effect for *Normalized Deviation* drops to marginal significance. Since this measure incorporates turnover information by design, that is to be expected. Thus when the abnormal volumes in the first period are set aside, we continue to observe significant differences in mispricing even under conditions in which the turnover by individuals and teams is comparable.

5.2 Call market treatments

Figures 5 and 6 present the trajectories of market prices in the team and individual call markets respectively. We again observe that price bubbles are much less pronounced in the teams treatment. In the individuals treatment, all markets exhibit pronounced bubbles, with the exception of the experienced repetition in Market 4. In two of the inexperienced individuals markets, we observe prices in excess of the maximum possible remaining dividend value. In the experienced repetition of individuals Market 1, this is the case in 7 out of 15 periods. By contrast, we never observe prices in excess of maximum dividend value in any of the teams markets, in either the inexperienced or once-experienced repetitions.

[Figures 5 and 6 about here.]

Table 3 reports our analysis of the summary bubble measures for the call market treatments. The first two sections of the table report values of each of the measures in each of the three team (four individual) inexperienced call markets, along with treatment means.[20] The next two sections report the corresponding data for once-experienced markets. Because of the limited number of observations in the call market treatments, we do not report formal significance tests of the treatment differences. Nonetheless, the results reported in Table 3 are striking. The individual call markets yield larger average bubble measures in 13 out of 14 instances (7 measures for each of the inexperienced and once-experienced conditions).

[Table 3 about here.]

The one exception is *Turnover* in inexperienced markets, which is indistinguishable between individual and team markets. This further reinforces our conclusion in Section 5.1 that

[20] We do not report the *Dispersion Ratio* measure of price volatility for the call market treatments, since it is by definition equal to zero in all markets under this institution.

differences in *Turnover* are not responsible for the differences in mispricing that we report between individual and team markets under the double-auction institution. Once again, we find that these differences in mispricing persist even under conditions in which share turnover is comparable between individual and team markets.

Furthermore, the average bubble measures for our team call markets are in every instance smaller than the corresponding average from a broad database of call market bubble measures from previous studies, in a pairwise comparison of markets of the same experience level. These averages are reported in the final two rows of Table 3, and the list of call market observations is itemized in the note to that table. By contrast, for our individual call markets only 2 of the 6 mean bubble measures are smaller than the corresponding database averages, in both inexperienced and once-experienced markets.

Thus the results of our call market treatments strongly reinforce our findings from the double-auction treatments. They establish, firstly, that differences in mispricing persist even when both individuals and teams are allowed unlimited time for deliberation, secondly, that these differences persist with experience, and thirdly, that they are robust to the market institution.

5.3 Subject pool analysis

A concern raised by a referee relates to the large number of Economics and Business majors who participated in the team double-auction sessions. Although subjects in all treatments were recruited from the same population using comparable procedures, it is possible that – as a result of random sampling variation – the set of subjects assigned to one treatment might not be representative of the broader subject population, or might differ in some salient respect from the subjects assigned to another treatment. To shed further light on this, in the supplementary material we report an analysis of observable subject characteristics in the individual and team treatments for both the double-auction and call market treatments.

We find no significant differences between individual and team subjects with respect to any observable demographic characteristics. However with respect to Economics and Business majors, our findings are mixed. In the double-auction treatments, we indeed find that the proportion of these majors is significantly larger in the teams markets compared to the HNP baseline. Yet in our call markets, we obtain a significant difference in the opposite direction. Therefore, if it is subjects' knowledge of Economics and Business that is responsible for their reduced propensity to bubble, then in our call market treatments we should observe smaller price bubbles in the individuals condition. As we have seen, this is not the case: in our call

market treatments, we again find that mispricing is diminished in markets that are populated by teams. In short, there is no consistent association between the proportion of Economics and Business majors and the direction of our treatment effects across the two market institutions.

In retrospect, we do not find this result surprising. As we observed in our literature review, the few previous studies to examine the effect of subjects' knowledge of business upon their propensity to bubble and crash all find no effect when subjects are inexperienced. In light of these findings, as well as our own subject pool analysis, we conclude that it is implausible to attribute our finding of diminished mispricing in team markets to the proportion of subjects who were Economics and Business majors.

6. Conclusion

In this paper, we investigate the effect of team decision-making in an asset market experiment that has long been known to reliably generate price bubbles and crashes in markets populated by individuals. We find that this phenomenon is substantially diminished when each decision-making unit is instead a team of two. This is the case, as measured by a full range of measures of the severity of mispricing, both under a continuous double-auction institution as well as a call market. The result holds even when there is unlimited time for deliberation, and when the subjects are experienced. It also holds not only when teams are compared to the 'narrow' baseline provided by the corresponding individuals treatments, but also when compared more broadly to the results of the large body of previous research on markets of this kind.

In designing our study, we sought to give any effect of team decision-making the greatest opportunity to express itself by maximizing the team interaction. To this end, we allowed teams to communicate in the most natural way possible, choosing a protocol of direct, face-to-face interaction, over alternatives such as computer chat or simple voting protocols. We believe that this freedom of communication also more closely reflects the most common type of team interaction in a business context. At the same time, it involves a tradeoff in that we relinquish control over how team decisions are formed and thus the exact mechanisms by which the teams attain superior outcomes. Thus while we succeed in our original research objective of documenting an effect of team decision-making in a market setting, it remains an open question for future research to determine precisely how and why this effect occurs.

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Fig. 1 Median price trajectories in team double-auction markets. The black step-wise decreasing function shows the remaining expected dividend holding value of a share, the grey step-wise decreasing function shows the remaining maximum possible dividend return from one share.

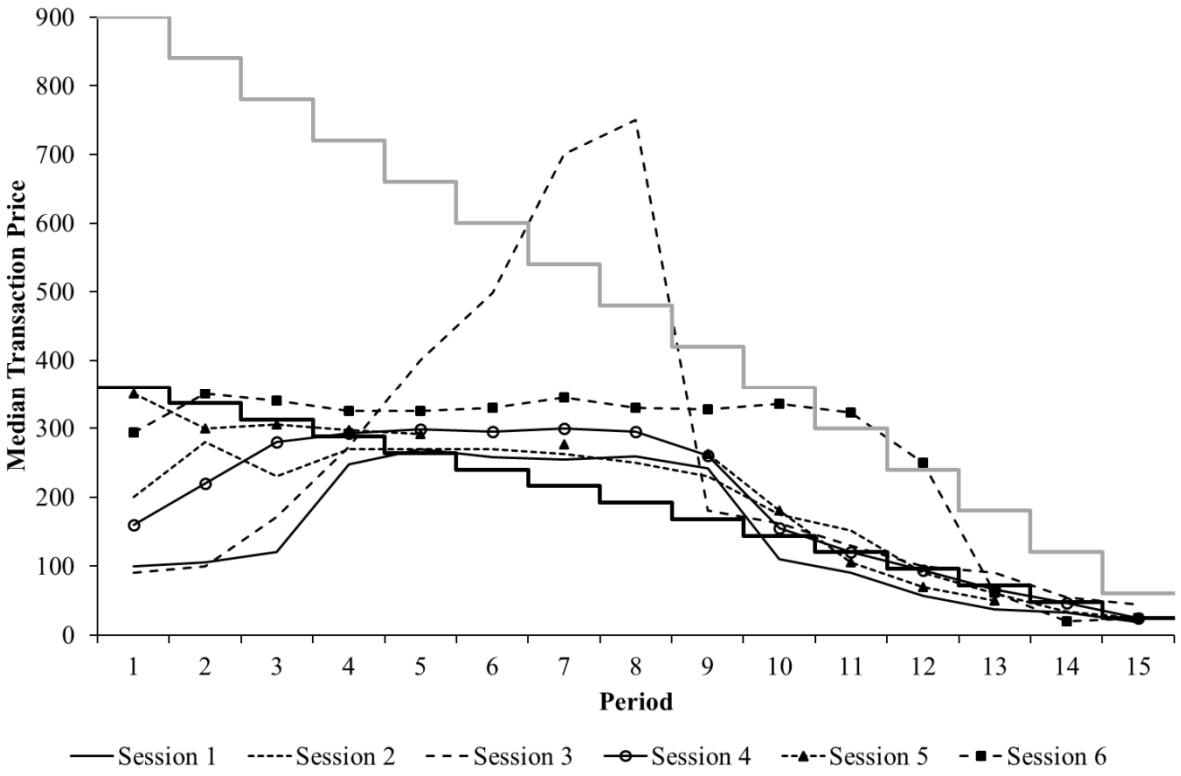

Fig. 2 Median price trajectories in HNP baseline (individual double-auction) markets. The black step-wise decreasing function shows the remaining expected dividend holding value of a share, the grey step-wise decreasing function shows the remaining maximum possible dividend return from one share.

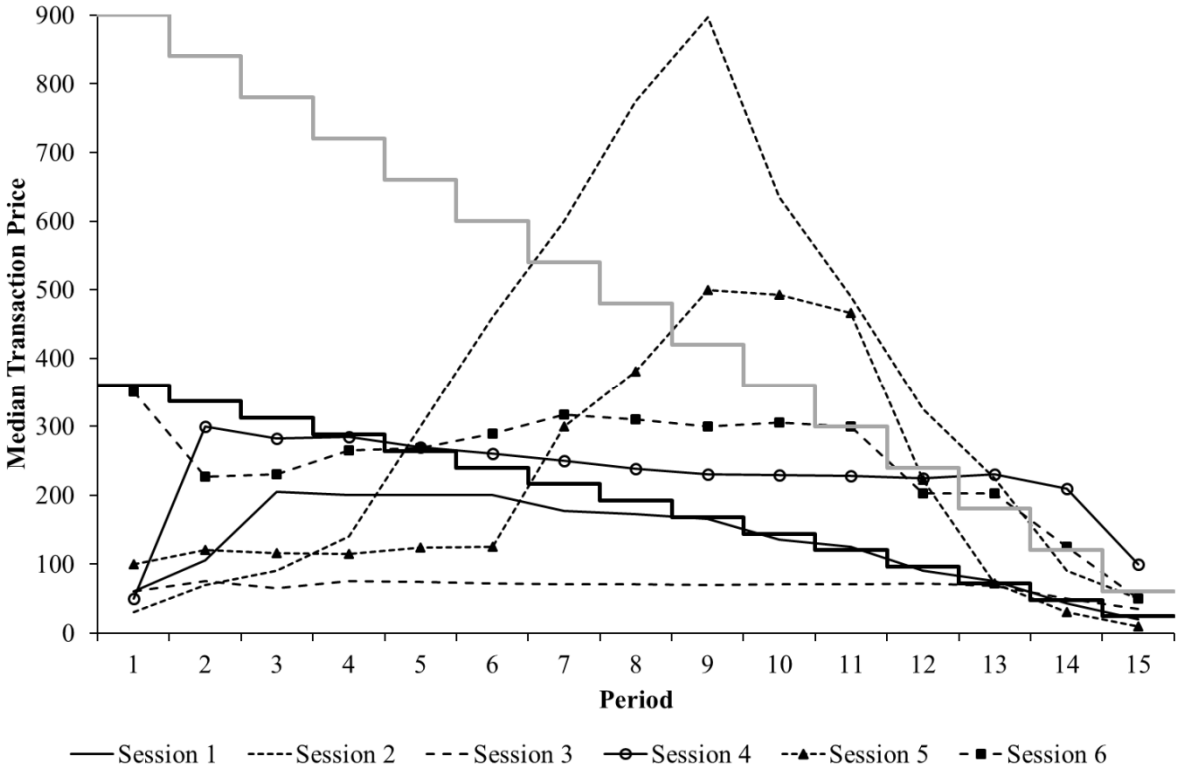

Fig. 3 Turnover of shares by trading period in double-auction treatments, treatment means. The vertical axis measures the average number of times that each share is transacted in each period. The percentage of the total turnover that takes place in each period is noted above (below) the line for the HNP baseline (teams) treatment.

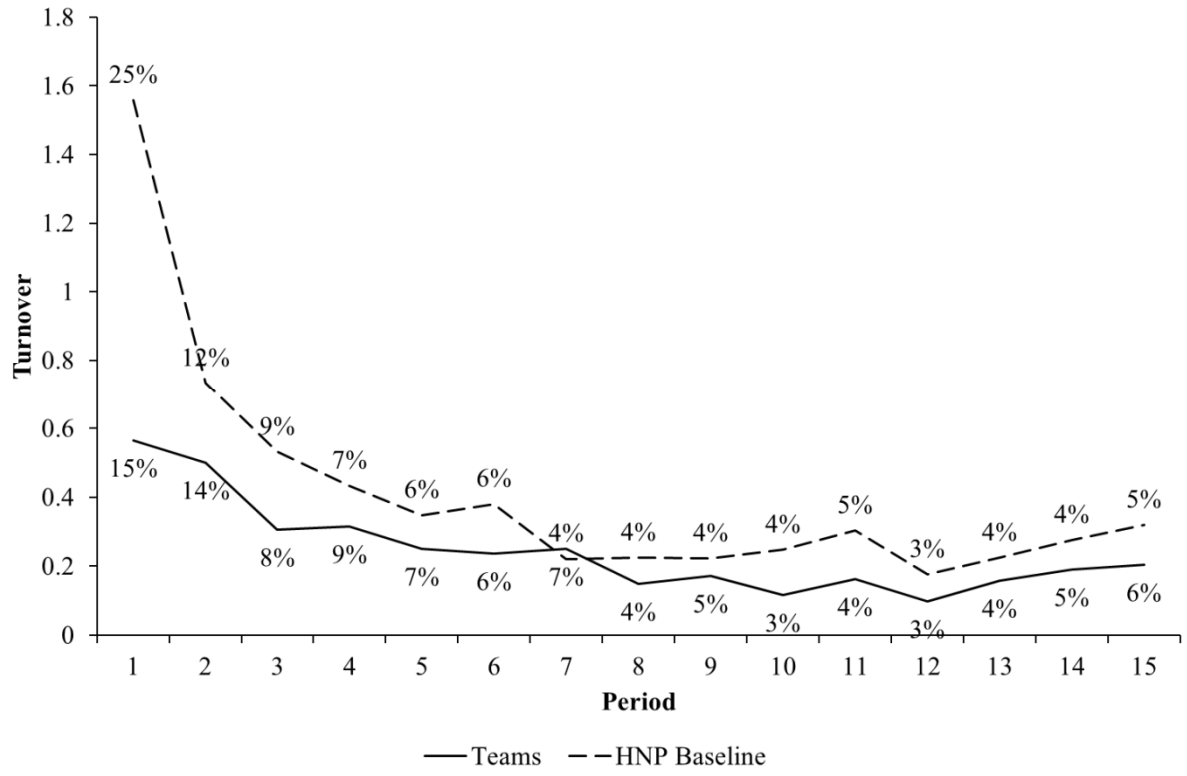

Fig. 4 Standard deviation of period transaction prices in double-auction treatments, treatment means.

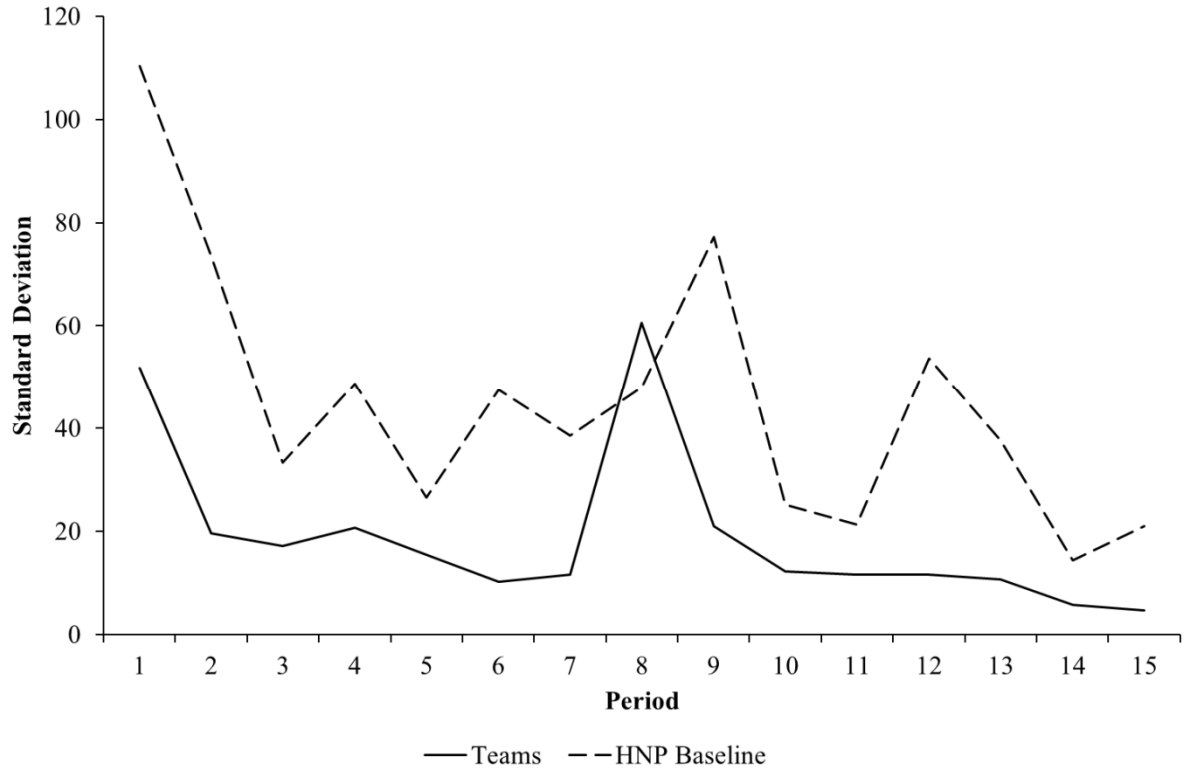

Fig. 5 Market price trajectories in team call markets. The black step-wise decreasing function shows the remaining expected dividend holding value of a share, the grey step-wise decreasing function shows the remaining maximum possible dividend return from one share.

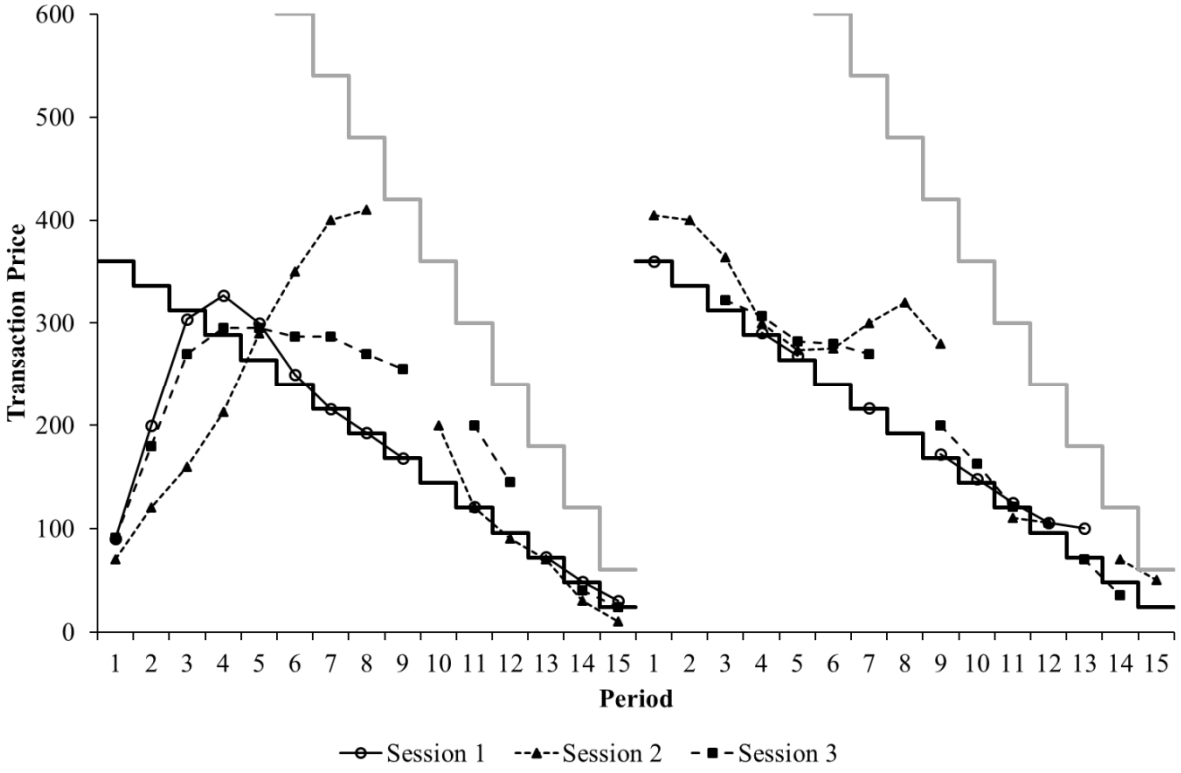

Fig. 6 Market price trajectories in individual call markets. The black step-wise decreasing function shows the remaining expected dividend holding value of a share, the grey step-wise decreasing function shows the remaining maximum possible dividend return from one share.

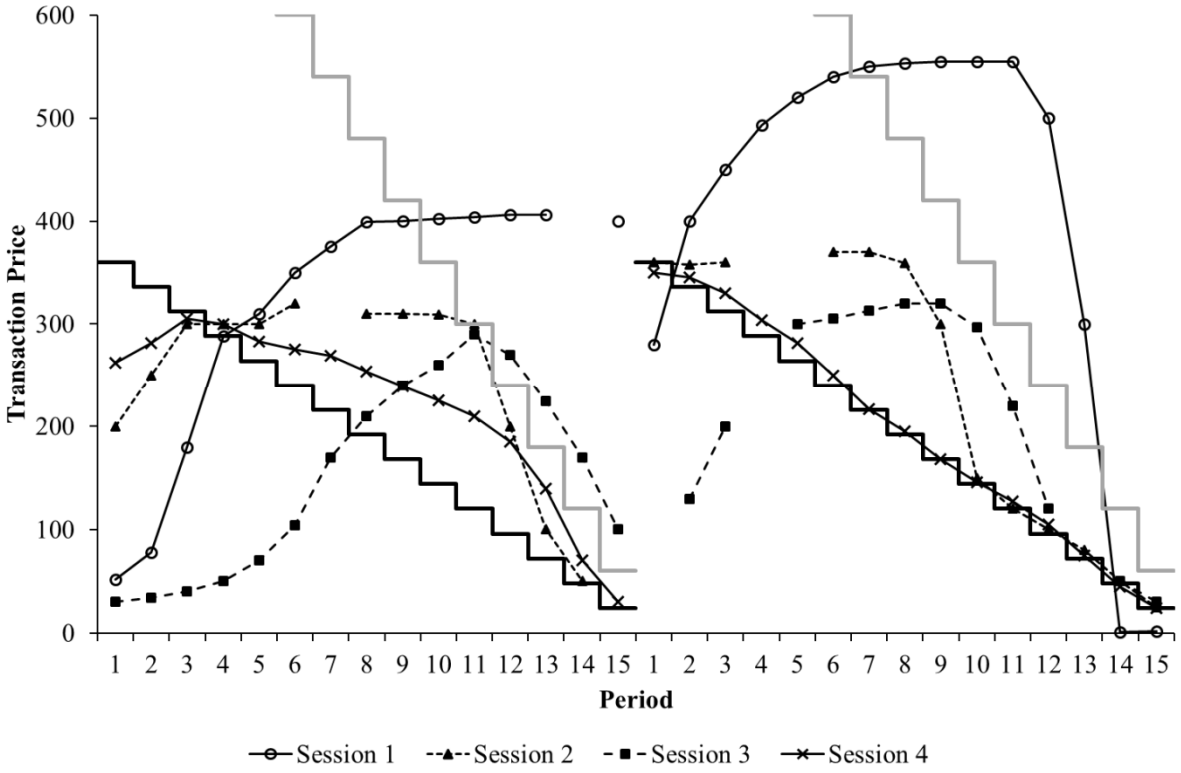

Table 1 Summary demographic and earnings data.

	HNP baseline (*n*=51)	Team double auction (*n*=108)	Individual call markets (*n*=36)	Team call markets (*n*=54)
Average age (years)	n/a [a]	22.7	23.0	22.8
Female (%)	52.9	58.9	44.4	46.3
Economics or Business majors (%)	64.7	85.2	77.8	55.6
Average earnings	EUR 28.45 (USD 36.63)	EUR 29.15 (USD 37.53)	EUR 30.66 (USD 39.47)	EUR 25.24 (USD 32.49)
Range of earnings [b]	EUR 0.1–122.5	EUR 9.3–109.6 [c]	EUR 15.9–63.8	EUR 13.8–37.9
Standard deviation of earnings	EUR 30.57	EUR 16.42	EUR 9.85	EUR 4.92

[a] n/a indicates that data are not available for the HNP baseline condition because the relevant item was not included in their questionnaire.

[b] Earnings for the call market treatments are reported as the total for two market repetitions

[c] These figures exclude an experimenter error that resulted in subjects in one session receiving excess payments (which they only learned of after the experiment had concluded).

Table 2 Bubble measures in double-auction treatments.

	Turnover	*Amplitude*	*Duration*	*Average Bias*	*Average Dispersion*	*Overpriced Transactions*	*Normalized Deviation*	*Dispersion Ratio*
Team double-auction markets								
Session 1	5.17	1.09	7	−45.20	72.27	0.00	7.11	0.17
Session 2	4.17	0.76	7	−5.57	40.83	0.00	2.73	0.25
Session 3	5.31	3.15	6	57.57	145.90	9.95	9.69	0.58
Session 4	3.22	1.12	7	1.80	49.40	0.00	1.79	0.15
Session 5	1.11	0.84	7	10.18	31.27	0.00	0.44	0.14
Session 6	3.03	2.27	7	73.30	87.23	8.26	2.05	0.32
Treatment Average	3.67	1.54	6.83	15.35	71.15	3.03	3.97	0.27
HNP baseline (individual double-auction) markets								
Session 1	6.38	0.91	10	−60.47	61.53	0.00	7.62	0.39
Session 2	6.56	4.30	7	153.13	281.93	12.11	18.13	2.02
Session 3	11.25	1.21	13	−125.23	126.97	0.00	19.03	0.24
Session 4	4.31	3.94	7	33.80	84.33	21.29	5.89	0.83
Session 5	5.50	3.54	9	19.57	170.50	18.69	10.37	0.52
Session 6	3.19	2.22	9	57.50	87.37	11.76	3.18	0.45
Treatment Average	6.20	2.69	9.17	13.05	135.44	10.64	10.70	0.74
t-test, unequal variances (one-sided *p*-values)	0.045**	0.070*	0.025**	0.520	0.063*	0.054*	0.030**	0.071*
Wilcoxon rank-sum test (*p*-value)	0.055*	0.109	0.020**	1.000	0.078*	0.087*	0.037**	0.055*
All inexperienced baseline markets in database (no. of markets)	5.66 (41)	2.85 (5)	8.47 (22)	95.22 (8)	125.18 (8)	n/a (0)	6.60 (18)	n/a (0)

*/** denotes significance at the 0.1/0.05-level respectively. For *t*-tests, we report one-sided *p*-values for the null hypothesis that the mean under the individuals treatment is no further from zero. The entries in the bottom row are derived from a database of bubble measure observations compiled for publication by the second author. The set of observations included in the inexperienced baseline classification are derived from Davies (2006): Decreasing fundamental value treatments, Annex 4, pp. 31–33; Haruvy and Noussair (2006): NSS treatments, Table II, p. 1132; King et al. (1993): Inexperienced baseline treatment, Table 13.1, p. 185; Porter and Smith (1994): Baseline treatment, Table 2, p. 116; Porter and Smith (1995): Baseline treatment, Table 5, p. 521; Smith, Van Boening and Wellford (2000): Markets A2-1 to A2-6, Appendix Table 1, p. 582; and SSW (1988): Experiments 26 and 41, Table 1, p. 1126 and Figure 7, p. 1131.

Table 3 Bubble measures in call market treatments.

	Turnover	*Amplitude*	*Duration*	*Average Bias*	*Average Dispersion*	*Overpriced Transactions*	*Normalized Deviation*
Team call markets, Inexperienced subjects							
Session 1	1.75	1.00	3.00	−24.54	39.15	0.00	1.09
Session 2	2.03	1.94	7.00	−12.79	97.64	0.00	2.15
Session 3	1.69	1.41	8.00	−1.92	71.15	0.00	1.51
Treatment Average	1.82	1.45	6.00	−13.08	69.32	0.00	1.58
Individual call markets, Inexperienced subjects							
Session 1[a]	1.79	16.52	12.00	115.57	215.29	27.69	3.27
Session 2	1.78	1.94	5.00	46.85	86.54	0.00	1.02
Session 3	1.36	4.08	11.00	−41.20	161.20	34.69	2.05
Session 4	2.33	1.22	10.00	29.87	51.20	0.00	1.11
Treatment Average	1.81	5.94	9.50	37.77	128.56	15.60	1.86
Team call markets, Once-experienced subjects							
Session 1	0.72	0.39	3.00	6.56	6.56	0.00	0.05
Session 2	1.78	1.17	3.00	45.38	46.92	0.00	0.65
Session 3	1.19	0.50	2.00	17.90	20.70	0.00	0.22
Treatment Average	1.23	0.69	2.67	23.28	24.73	0.00	0.31
Individual call markets, Once-experienced subjects							
Session 1[a]	1.32	5.19	10.00	224.93	244.80	29.17	2.80
Session 2	1.36	0.87	3.00	51.85	51.85	0.00	0.41
Session 3	1.19	1.68	5.00	37.08	90.08	0.00	1.11
Session 4	3.14	0.16	3.00	5.47	7.20	0.00	0.19
Treatment Average	1.75	1.97	5.25	79.83	98.48	7.29	1.12
All inexperienced call markets in database (no. of markets)	2.48 (27)	3.55 (50)	6.97 (63)	6.88 (50)	99.12 (50)	n/a (0)	2.90 (8)
All once-experienced call markets in database (no. of markets)	1.81 (21)	2.87 (6)	5.84 (13)	43.41 (6)	73.46 (6)	n/a (0)	1.24 (8)

The entries in the bottom two rows are derived from a database of bubble measure observations compiled for publication by the second author. The set of observations included in the inexperienced call market classification are derived from Caginalp, Porter and Smith (1998): Table 1, p. 758 (The fact that a call auction institution was used is taken from Caginalp, Porter and Smith (2001), p. 82, and was confirmed in private communication by Dave Porter.); Caginalp, Porter and Smith (2001): Tables 1a–1c, pp. 84–85, and Table 2, p. 90; Haruvy, Lahav and Noussair (2007): Table 2, p. 1908; Hussam, Porter and Smith (2008): Table 4, p. 934; and Van Boening, Williams and LaMaster (1993): Table 1, p. 181. The set of observations included in the once experienced call market classification are derived from Haruvy, Lahav and Noussair (2007); Hussam, Porter and Smith (2008); and Van Boening, Williams and LaMaster (1993); using the same detailed references as before.

[a] Programming errors led to the creation of one extra share after period 8 of the inexperienced market, and three extra shares after period 14 of the experienced market. The bubble measures were adjusted to reflect these changes in the number of shares.

Appendix A Re-analysis of bubble measures for double auctions, excluding data from the first period.

	Turnover	*Amplitude*	*Duration*	*Average Bias*	*Average Dispersion*	*Overpriced Transactions*	*Normalized Deviation*	*Dispersion Ratio*
Team double-auction markets								
Session 1	4.14	1.05	6	−29.86	58.86	0.00	4.43	0.17
Session 2	3.25	0.62	6	5.46	32.32	0.00	1.38	0.21
Session 3	4.72	3.10	5	80.96	137.04	11.18	8.10	0.58
Session 4	2.83	0.88	6	16.21	38.64	0.00	1.00	0.10
Session 5	0.92	0.84	7	12.20	33.40	0.00	0.38	0.13
Session 6	2.75	2.27	7	83.25	88.75	9.09	1.77	0.28
Treatment Average	3.10	1.46	6.17	28.04	64.83	3.38	2.84	0.24
HNP baseline (individual double-auction) markets								
Session 1	4.62	0.55	9	−43.36	44.50	0.00	2.46	0.37
Session 2	4.03	4.22	6	187.64	278.50	19.71	10.01	2.15
Session 3	8.42	1.21	13	−112.75	114.61	0.00	12.06	0.15
Session 4	3.11	3.59	7	58.36	68.21	28.57	2.68	0.71
Session 5	4.97	3.51	8	39.54	164.11	20.67	9.07	0.51
Session 6	2.69	2.22	9	62.32	92.89	13.95	2.46	0.35
Treatment Average	4.64	2.55	8.67	31.96	127.14	13.82	6.46	0.71
t-test, unequal variances (one-sided *p*-values)	0.079*	0.083*	0.026**	0.467	0.074*	0.043**	0.065*	0.093*
Wilcoxon rank-sum test (*p*-value)	0.262	0.200	0.026**	1.000	0.078*	0.087*	0.055*	0.078*

*/** denotes significance at the 0.1/0.05-level respectively. For *t*-tests, we report one-sided *p*-values for the null hypothesis that the mean under the individuals treatment is no further from zero.

SUPPLEMENTARY MATERIAL

TWO HEADS ARE LESS BUBBLY THAN ONE: TEAM DECISION-MAKING IN AN EXPERIMENTAL ASSET MARKET

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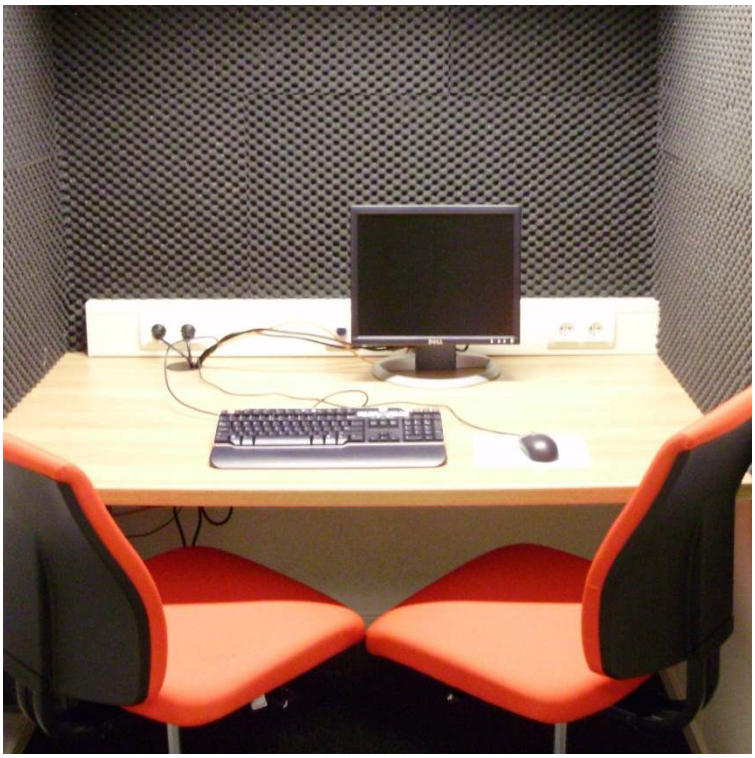
PHOTO OF A CUBICLE IN THE ‘B LAB’



INSTRUCTIONS FOR THE TEAM DOUBLE-AUCTION TREATMENT

1. General Instructions

This is an experiment on decision making in a market. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The experiment consists of a sequence of trading Periods in which you will have the opportunity to buy and sell in a market. The currency used in the market is francs. All trading will be done in terms of francs. The cash payment to you at the end of the experiment will be in euros. The conversion rate is: **100 francs to 1 Euro**.

2. How to use the Computerized Market

In the top right hand corner of the screen you see how much time is left in the current trading Period. The goods that can be bought and sold in the market are called Shares. In the center of your screen you see the number of Shares you currently have and the amount of Money you have available to buy Shares.

If you would like to offer to sell a share, use the text area entitled “Enter offer to sell” in the first column. In that text area you can enter the price at which you are offering to sell a share, and then select “Submit Offer To Sell”. Please do so now. Type in a number in the appropriate space, and then click on the field labeled “Submit Offer To Sell”. You will notice that eighteen numbers, one submitted by each participant, now appear in the second column from the left, entitled “Offers To Sell”. Your offer is listed in blue. Submitting a second offer will replace your previous offer.

The lowest offer-to-sell price will always be on the bottom of that list. You can select an offer by clicking on it. It will then be highlighted. If you select “Buy”, the button at the bottom of this column, you will buy one share for the currently selected sell price. Please purchase a share now by selecting an offer and clicking the “Buy” button. Since each of you had offered to sell a share and attempted to buy a share, if all were successful, you all have the same number of shares you started out with. This is because you bought one share and sold one share. Please note that if you have an offer selected and the offer gets changed, it will become deselected if the offer became worse for you. If the offer gets better, it will remain selected.

When you buy a share, your Money decreases by the price of the purchase. When you sell a share your Money increases by the price of the sale. You may make an offer to buy a unit by selecting “Submit offer to buy.” Please do so now. Type a number in the text area “Enter offer to buy”, then press the red button labeled “Submit Offer To Buy”. You can replace your offer-to-buy by submitting a new offer. You can accept any of the offers-to-buy by selecting the offer and then clicking on the “Sell” button. Please do so now.

In the middle column, labeled “Transaction Prices”, you can see the prices at which Shares have been bought and sold in this period. You will now have about 10 minutes to buy and sell shares. This is a practice period. Your actions in the practice period do not count toward your earnings and do not influence your position later in the experiment. The only goal of the practice period is to master the use of the interface. Please be sure that you have successfully submitted offers to buy and offers to sell. Also be sure that you have accepted buy and sell offers. If you have any questions, please raise your hand and the experimenter will come by and assist you.

3. Specific Instructions for this Experiment

In this experiment you will be randomly paired with a partner, with whom you will be making decisions jointly as a team of two. It is important that both you and your partner agree on each of the decisions you make over the course of the experiment, as they may influence the earnings that you both receive at the conclusion of the experiment. ***At the end of the experiment both you and your partner will each receive the total value of your team's cash balance, converted into Euros at the conversion rate specified at the beginning of these instructions.***

The experiment will consist of 15 trading periods. In each period, there will be a market open for 5 minutes, in which your team may buy and sell shares. Shares are assets with a life of 15 periods, and your team's inventory of shares carries over from one trading period to the next. Your team may receive dividends for each share in its inventory at the end of each of the 15 trading periods.

At the end of each trading period, including period 15, the computer will randomly determine the dividend value for all shares in that period. Each period, each share your team holds at the end of the period:

- earns a dividend of 0 francs for both you and your partner with probability 1/4
- earns a dividend of 8 francs for both you and your partner with probability 1/4
- earns a dividend of 28 francs for both you and your partner with probability 1/4
- earns a dividend of 60 francs for both you and your partner with probability 1/4

Each of the four dividend values is equally likely, thus the average dividend in each period is 24. Dividends are added to your team's cash balance automatically.

After the dividend is paid at the end of period 15, there will be no further earnings possible from shares.

4. Average Holding Value Table

You can use your **AVERAGE HOLDING VALUE TABLE** to help you make decisions. There are 5 columns in the table. The first column, labeled Ending Period, indicates the last trading period of the experiment. The second column, labeled Current Period, indicates the period during which the average holding value is being calculated. The third column gives the number of holding periods from the period in the second column until the end of the experiment. The fourth column, labeled Average Dividend per Period, gives the average amount that the dividend will be in each period for each unit held in your team's inventory. The fifth column, labeled Average Holding Value Per Unit of Inventory, gives the average value for each unit held in your team's inventory from now until the end of the experiment. That is, for each share your team holds for the remainder of the experiment, both you and your partner will each earn on average the amount listed in column 5.

Suppose for example that there are 7 periods remaining. Since the dividend on a Share has a 25% chance of being 0, a 25% chance of being 8, a 25% chance of being 28 and a 25% chance of being 60 in any period, the dividend is on average 24 per period for each Share. If your team holds a Share for the remaining 7 periods, the total dividend for the Share over the 7 periods is on average $7 \times 24 = 168$. Therefore, the total value of holding a Share over the 7 periods is on average 168.

AVERAGE HOLDING VALUE TABLE

Ending Period	Current Period	Number of Holding Periods	×	Average Dividend Per Period	=	Average Holding Value Per Share in Inventory
15	1	15		24		360
15	2	14		24		336
15	3	13		24		312
15	4	12		24		288
15	5	11		24		264
15	6	10		24		240
15	7	9		24		216
15	8	8		24		192
15	9	7		24		168
15	10	6		24		144
15	11	5		24		120
15	12	4		24		96
15	13	3		24		72
15	14	2		24		48
15	15	1		24		24

5. Your Earnings

Your earnings for the entire experiment will equal the amount of cash that your team has at the end of period 15, after the last dividend has been paid. The amount of cash you will have is equal to:

The cash (called “Money” on your screen) your team has at the beginning of the experiment

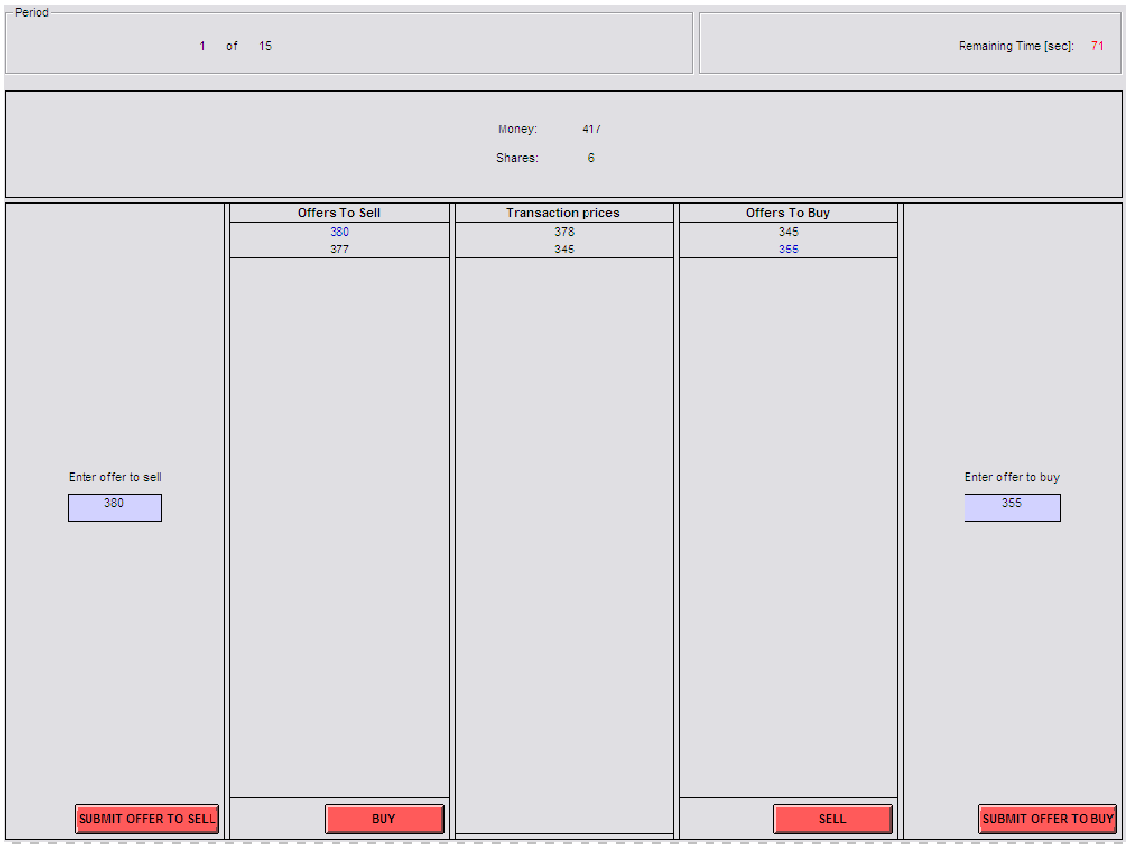
+ dividends your team receives

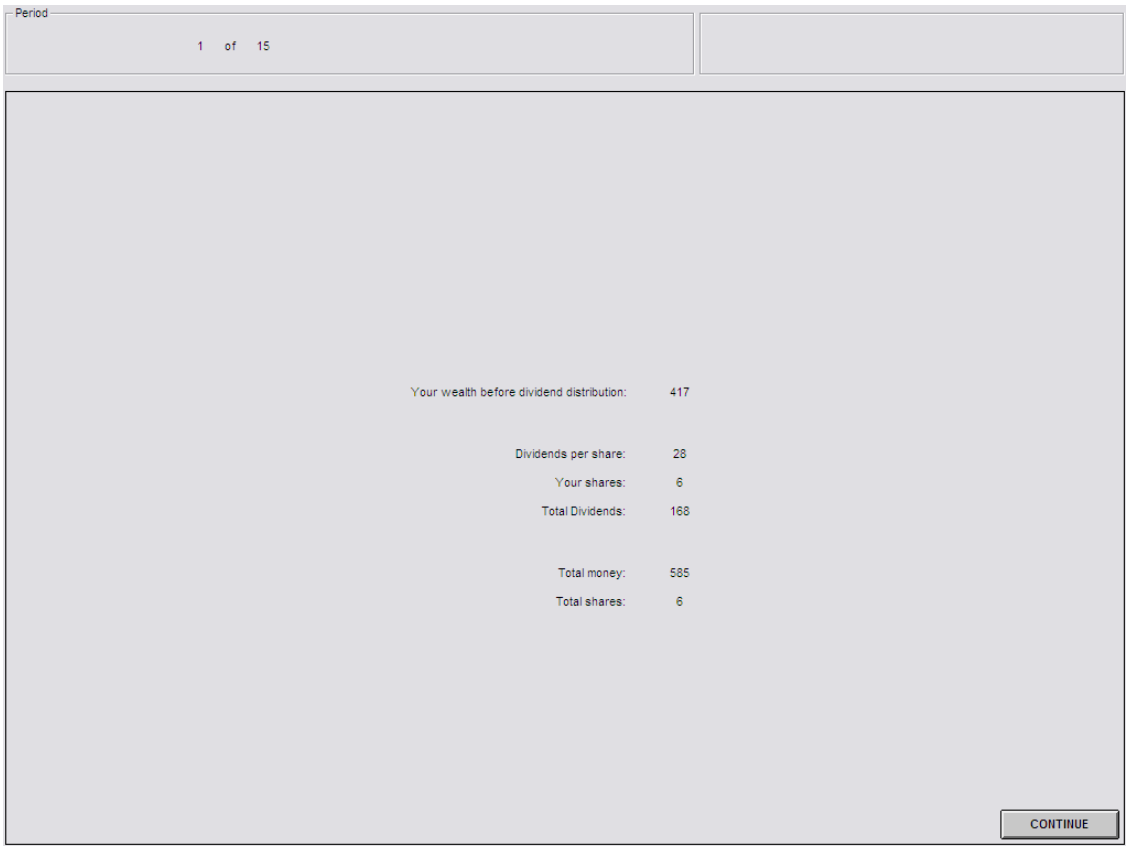
+ money received by your team from sales of shares

– money spent by your team on purchases of shares

Both you and your partner will each receive the total value of this cash balance, converted into Euros at the conversion rate specified at the beginning of these instructions.

SCREEN SHOTS OF THE DOUBLE-AUCTION TRADING PROGRAM





INSTRUCTIONS FOR THE TEAM CALL MARKET TREATMENT

1. General instructions

This is an experiment on decision making in a market. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The experiment consists of two sequences of fifteen periods in which you have the opportunity to buy and sell in a market. The money used in this market is called francs. All buying and selling will be done in francs. The cash payment to you at the end of the experiment will be in Euros.

The conversion rate is: **260 francs to 1 Euro**.

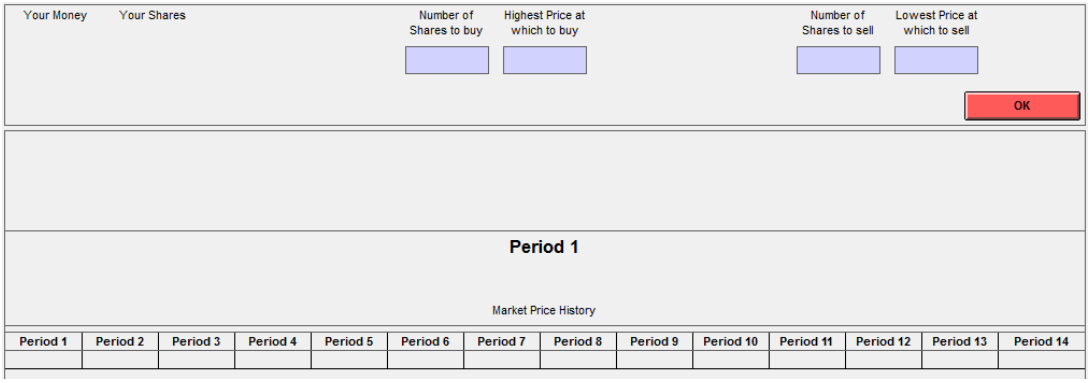
2. How to use the computerized market

In each period, you will see a computer screen like the one shown below. The items that you can buy and sell in the market are called shares. In the top left corner of your screen you will see the number of shares you currently have and the amount of money you have available.

- If you would like to buy shares, you can submit a **buy order**. Your buy order indicates the number of shares you would like to buy and the highest price that you are willing to pay for each share that you buy.

- If you would like to sell shares, you can submit a **sell order**. Your sell order indicates the number of shares you would like to sell and the lowest price that you are willing to accept for each share that you sell.

In each period, you may submit both a buy order and a sell order. The price at which you offer to buy must be less than the price at which you offer to sell. The price that you specify in your order is a per-unit price, at which you are willing to buy or sell *each* share.



Once you click on the OK button, your buy and sell orders for this period are final and can no longer be revised. The period will end after everyone has clicked OK.

The computer will then organize the buy and sell orders and use them to determine the **market price** at which shares will be bought and sold in this period. All transactions in the period will occur at the market price. This will generally be a price such that the number of shares with sell order prices at or below this price is equal to the number of shares with buy order prices at or above this price. Those who submit buy orders at prices above the market price will make purchases, and those who submit sell orders at prices below the market price will make sales.

At the end of each period you will see a results screen. This screen will show the market price, the value of any dividends you earned, and your new balance of money and shares. When you have finished reading this information, please click on the Continue button.

3. Specific instructions for this experiment

In this experiment you will be randomly paired with a partner, with whom you will make decisions jointly as a team of two. It is important that both you and your partner agree on each of the decisions you make, as they will affect the earnings that you both receive from the experiment. ***At the end of the experiment both you and your partner will each receive the total value of your team's money balance, converted into Euros at the rate specified at the beginning of these instructions.***

The experiment will consist of three sequences of fifteen periods. In each period, there will be a market, operating under the rules explained above, in which your team may buy and sell shares. Shares are assets with a life of fifteen periods, and the shares that your team holds will carry over from one period to the next within each fifteen-period sequence.

Your team may receive dividends for each share that it holds at the end of each period. At the end of each period, including period fifteen, the computer will randomly determine the dividend for all shares in that period. In each period, each share that your team holds at the end of that period will pay:

- a dividend of 0 francs for both you and your partner with probability 1/4
- a dividend of 8 francs for both you and your partner with probability 1/4
- a dividend of 28 francs for both you and your partner with probability 1/4
- a dividend of 60 francs for both you and your partner with probability 1/4

Since each of the four dividend values is equally likely, the average dividend for each share in each period is 24 francs. Dividends will be added to your team's money balance automatically after each period. After the dividend has been paid at the end of period fifteen, the sequence ends and there are no further earnings possible from shares.

After the first sequence of fifteen periods has finished, a second sequence will begin. The amount of money and shares that your team has at the beginning of the second sequence will be the same as what it was at the beginning of the first one. The same goes for the third sequence of fifteen periods.

4. Average Holding Value Table

You can use the Average Holding Value Table to help make decisions. It indicates how much, on average, each share will pay in dividends if it is held until the end of the fifteenth period.

The first column shows the ending period of the sequence. The second column shows the current period for which the average holding value is being calculated. The third column shows the number of holding periods from the current period to the ending period. The fourth column shows the average dividend per period for each share that your team holds. The fifth column shows the average holding value per share that your team holds from the current period until the end of the fifteenth period.

That is, for each share that your team holds until the end of period fifteen, both you and your partner will each earn on average the amount shown in column five. The value in column five is calculated by multiplying the values in columns three and four.

5. Your Earnings

Both you and your partner will be paid for your decisions in both sequences of fifteen periods. In each sequence you will each earn the total amount of money that your team has at the end of period fifteen, after the last dividend has been paid. This will be equal to:

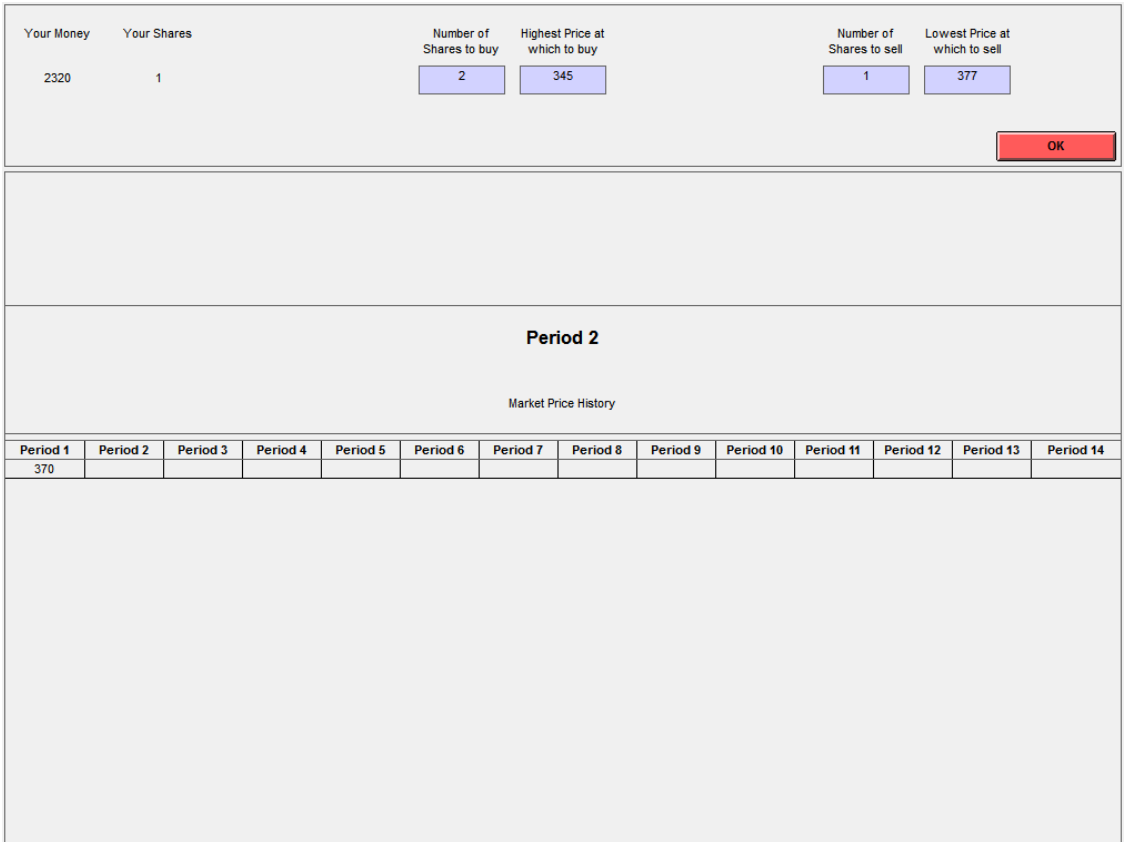
The money your team had at the start of period one
+ Dividends your team received
+ Money your team received from sales of shares
− Money your team spent on purchases of shares

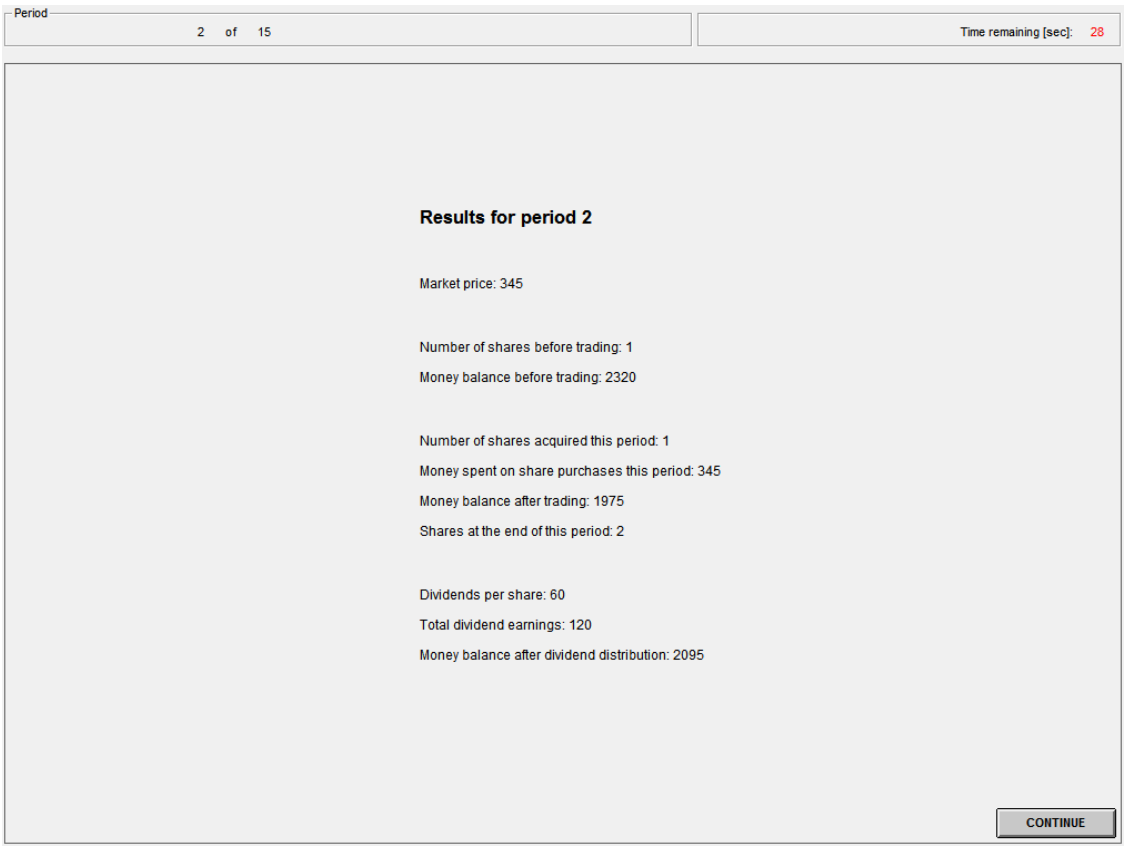
At the conclusion of the experiment, both you and your partner will each receive in cash the total value of this money balance, converted into Euros at the rate specified on page one of the instructions.

AVERAGE HOLDING VALUE TABLE

Ending Period	Current Period	Number of Holding Periods	×	Average Dividend Per Period	=	Average Holding Value Per Share
15	1	15		24		360
15	2	14		24		336
15	3	13		24		312
15	4	12		24		288
15	5	11		24		264
15	6	10		24		240
15	7	9		24		216
15	8	8		24		192
15	9	7		24		168
15	10	6		24		144
15	11	5		24		120
15	12	4		24		96
15	13	3		24		72
15	14	2		24		48
15	15	1		24		24

SCREEN SHOTS OF THE CALL MARKET TRADING PROGRAM





POST-EXPERIMENT QUESTIONNAIRE FOR TEAMS TREATMENTS

Team-ID:

Are you:

[0. female; 1. male]

Your age:

Are you a:

[0. domestic student; 1. international student]

Your native language:

[0. Dutch; 1. other (please specify)]

In what level of degree program are you currently enrolled?

[0. Bachelor's; 1. Master's; 2. M.Phil; 3. PhD; 4. other (please specify)]

What is your current year of enrolment in this degree?

What is your major field of study?

What is your annual income in Euro? (Consider all forms of income, including salaries, tips, interest and dividend payments, scholarship support, student loans, parental support, social security, alimony, child support and others.)

[0. Less than 7,500; 1. 7,501 to 12,500; 2. 12,501 to 17,500; 3. 17,501 to 22,500; 4.More than 22,500]

What is the combined annual income of yourself and all of your family members who live with you at the same residence in Euro? (Consider all forms of income as defined above.)

[0. Less than 20,000; 1. 20,001 to 40,000; 2. 40,001 to 60,000; 3. 60,001 to 80,000; 4. More than 80,000]

What was your strategy during the experiment?

Do you believe that you acted rationally and that you maximized your profit?

[0. Do not agree at all; through to 4. Agree completely]

Did you ever make a mistake in entering a price, or clicked a wrong button? If so, please tell us exactly what went wrong and in what period!

Out of the 9 teams, which rank do you think your team has attained with regard to your earnings ("1" signifying the best, "9" the worst result)?

Do you think your decisions were better or worse than if you had had to reach your decisions alone?

[0. Much worse than alone; through to 4. Much better than alone]

How much did you contribute to the joint decision?

[0. 0%; through to 10. 100%]

Was it easy for you to come to a joint decision?

[0. Not at all easy; through to 4. Very easy]

How did you solve conflicts if you could not agree?

Financial Literacy Questions (All treatments except HNP baseline)

Suppose you had €100 in a savings account and the interest rate is 20% per year and you never withdraw money or interest payments. After 5 years, how much would you have on this account in total?

- ☑ More than €200;
- ☐ Exactly €200;
- ☐ Less than €200;
- ☐ Do not know.

Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?

- ☐ More than today;
- ☐ Exactly the same;
- ☑ Less than today;
- ☐ Do not know.

Suppose that in the year 2010, your income has doubled and prices of all goods have doubled too. In 2010, how much will you be able to buy with your income?

- ☐ More than today;
- ☑ The same;
- ☐ Less than today;
- ☐ Do not know.

Which of the following statements describes the main function of the stock market?

- ☐ The stock market helps to predict stock earnings;
- ☐ The stock market results in an increase in the price of stocks;
- ☑ The stock market brings people who want to buy stocks together with those who want to sell stocks;
- ☐ None of the above;
- ☐ Do not know.

Which of the following statements is correct? If somebody buys the stock of firm B in the stock market:

- ☑ He owns a part of firm B;
- ☐ He has lent money to firm B;
- ☐ He is liable for firm B's debts;
- ☐ None of the above;
- ☐ Do not know.

Which of the following statements is correct?

- ☐ Once one invests in a mutual fund, one cannot withdraw the money in the first year;
- ☑ Mutual funds can invest in several assets, for example invest in both stocks and bonds;
- ☐ Mutual funds pay a guaranteed rate of return which depends on their past performance;
- ☐ None of the above;
- ☐ Do not know.

Which of the following statements is correct? If somebody buys a bond of firm B:

- ☐ He owns a part of firm B;
- ☑ He has lent money to firm B;
- ☐ He is liable for firm B's debts;
- ☐ None of the above;
- ☐ Do not know.

Considering a long time period (for example 10 or 20 years), which asset normally gives the highest return?

- ☐ Savings accounts;
- ☐ Bonds;
- ☑ Stocks;
- ☐ Do not know.

Normally, which asset displays the highest fluctuations over time?

- ☐ Savings accounts;
- ☐ Bonds;
- ☑ Stocks;
- ☐ Do not know.

When an investor spreads his money among different assets, does the risk of losing money:

- ☐ Increase;
- ☑ Decrease;
- ☐ Stay the same;
- ☐ Do not know.

DETAILED SUBJECT POOL ANALYSIS

Table S.1 reports summary statistics of the observable demographic characteristics of the subjects, disaggregated by treatments. For age, financial literacy and income, data are not available for the HNP baseline treatment because these items were not included in their questionnaire. The final two columns of the table report *p*-values for Fisher exact tests of the association between the respective characteristics and the assignment of subjects to, respectively, the HNP baseline vs. team double auction and individual vs. team call market treatments.

In the two double-auction treatments, we find that there are no significant differences between the subject pools with regard to gender and international student status. This is again the case for the two call market treatments. For the call market treatments, we also find no significant differences with respect to age, financial literacy, and personal or family income. (We are unable to report the latter comparisons for the double auctions because the data are not available from the HNP questionnaire.)

We turn next to the specific issue of Business and/or Economics majors vs. all other majors. The relevant results are reported in the bottom three rows of Table S.1. If greater knowledge of Business and/or Economics were responsible for the diminution of price bubbles that we observe, there should be a larger fraction of Business and/or Economics majors in the two treatments in which we observe smaller bubbles, i.e. the team double-auction markets (vs. the HNP baseline) and team call markets (vs. individual call markets). This is not the case. In particular, the fraction of Business majors cannot explain our results, since there is a (not significantly) larger fraction of Business majors in both the HNP baseline and individual call market treatments. This would imply that a larger fraction of Business majors is associated with larger bubbles, which runs counter to intuition. Similarly, the proportion of Economics majors also cannot explain our results, since there are more Economics majors in the team double-auction sessions (which produce smaller bubbles than the HNP baseline) and also more Economics majors in the individual call markets (which exhibit larger bubbles than the team call markets). Finally, when the Business and Economics majors are pooled, the findings mirror those for the Economics majors alone.

On the basis of this analysis, we conclude that there are no significant differences between individual and team subjects with respect to any observable demographic characteristics. We also conclude that there is no consistent association between the proportion of subjects who are Business and Economics majors and the direction of our treatment effects across the two market institutions.

Prompted by a query from a referee, we also searched for subject pool differences within the team double-auction treatment that might account for the comparatively large price bubbles in markets 3 and 6 (relative to the other markets in the same treatment). However, we found no significant differences with regard to age, team gender composition, nationality, financial literacy, personal or family income, or major in markets 3 and 6 compared to markets 1, 2, 4 and 5.

TABLE S.1: SUBJECT POOL COMPARISON

	(1) HNP baseline (*n*=51)	(2) Team double auction (*n*=108)	(3) Individual call markets (*n*=36)	(4) Team call markets (*n*=54)	(1) vs. (2)	(3) vs. (4)
Age (years)	n/a	22.7	23.0	22.8	n/a	0.812
Female (%)	52.9	58.9	44.4	46.3	0.497	1.000
International (%)	80.4	81.5	83.3	79.6	0.917	0.662
Financial Literacy	n/a	7.71	7.22	7.43	n/a	0.694
Personal income (categorical)	n/a	75/37/ 11/2/1	23/10/ 3/0/0	30/18/ 6/0/0	n/a	0.429
Family income (categorical)	n/a	58/22/ 13/9/6	19/6/ 6/3/1	27/12/ 6/5/3	n/a	0.802
Business	45.1%	37.0%	36.1%	35.2%	0.386	1.000
Economics	19.6%	48.1%	41.7%	20.4%	0.001***	0.035**
Economics or Business	64.7%	85.2%	77.8%	55.6%	0.006***	0.043**

Columns 2 to 5 report summary statistics for the subject pools, by treatment. n/a indicates that data are not available for the HNP baseline condition because the relevant item was not included in their questionnaire. Row 1 reports the average age of the subjects in years, row 2 reports the percentage who are female, row 3 reports the percentage who are international students, and row 4 reports the average score on a ten-item test of financial literacy. Row 5 reports the distribution of responses to a measure of personal income elicited on the following ordinal scale: 0 [< € 7500], 1 [€ 7501–€ 12500], 2 [€ 12501–€ 17500], 3 [€ 17501–€ 22500] and 4 [> € 22500]. Row 6 reports the distribution of responses to a measure of family income elicited on the following ordinal scale: 0 [< € 20000], 1 [€ 20001–€ 40000], 2 [€ 40001–€ 60000], 3 [€ 60001–€ 80000] and 4 [> € 80000]. Columns 6 and 7 report two-sided *p*-values from Fisher exact tests of the association between the respective characteristics and the assignment of subjects to the individuals and teams treatments. **/*** denotes significance at the 0.05/0.01-level respectively.