ECONSTOR
Make Your Publications Visible.

A Service of

ZBW Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Michailova, Julija; Schmidt, Ulrich

Working Paper

Overconfidence and bubbles in experimental asset markets

Kiel Working Paper, No. 1729

Provided in Cooperation with:
Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

Suggested Citation: Michailova, Julija; Schmidt, Ulrich (2011) : Overconfidence and bubbles in experimental asset markets, Kiel Working Paper, No. 1729, Kiel Institute for the World Economy (IfW), Kiel

This Version is available at:
https://hdl.handle.net/10419/49375

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

Kiel
Working Papers

Kiel Institute
for the World Economy

Overconfidence and Bubbles in Experimental Asset Markets

by Julija Michailova and Ulrich Schmidt

No. 1729 | September 2011

Web: www.ifw-kiel.de

Kiel Working Paper No. 1729 | September 2011

Overconfidence and Bubbles in Experimental Asset Markets

Julija Michailova and Ulrich Schmidt

Abstract:

This paper investigates the relationship between market overconfidence and occurrence of stock-price bubbles. Sixty participants traded stocks in ten experimental asset markets. Markets were constructed on the basis of subjects' overconfidence, measured in pre-experimental sessions. The most overconfident subjects form "overconfident markets", and the least overconfident subjects "rational markets". Prices in rational markets tend to track the fundamental asset value more accurately than prices in overconfident markets and are significantly lower and less volatile. Additionally we observe significantly higher bubble measures and trading volume on overconfident markets. Altogether, our data provide evidence that overconfidence has strong effects on prices and trading behavior in experimental asset markets.

Keywords: overconfidence, price bubbles, experimental asset market

JEL classification: C92, G12

Julija Michailova
Department of Economics
University of Kiel
Olshausenstr. 40
24098 Kiel, Germany

Ulrich Schmidt
Kiel Institute for the World Economy
24100 Kiel, Germany
Telephone: +49 431 8814-337
E-mail: uschmidt@bwl.uni-kiel.de

The responsibility for the contents of the working papers rests with the author, not the Institute. Since working papers are of a preliminary nature, it may be useful to contact the author of a particular working paper about results or caveats before referring to, or quoting, a paper. Any comments on working papers should be sent directly to the author.

Coverphoto: uni_com on photocase.com

Overconfidence and Bubbles in Experimental Asset Markets*

Julija Michailova[a] and Ulrich Schmidt[a, b, §]

[a] Department of Economics, University of Kiel

[b] Kiel Institute for the World Economy

Abstract

This paper investigates the relationship between market overconfidence and occurrence of stock-price bubbles. Sixty participants traded stocks in ten experimental asset markets. Markets were constructed on the basis of subjects' overconfidence, measured in pre-experimental sessions. The most overconfident subjects form "overconfident markets", and the least overconfident subjects "rational markets". Prices in rational markets tend to track the fundamental asset value more accurately than prices in overconfident markets and are significantly lower and less volatile. Additionally we observe significantly higher bubble measures and trading volume on overconfident markets. Altogether, our data provide evidence that overconfidence has strong effects on prices and trading behavior in experimental asset markets.

Keywords: overconfidence, price bubbles, experimental asset market.

JEL Codes: C92, G12

---

* We are indebted to Briony Pulford and Sabina Kleitman for supporting our measurement of overconfidence as well as to Arlington W. Williams and Brian Kluger for helpful comments on our project. Further we would like to thank Julia Schirrmacher and Dennis Nissen for support in running the experiment. The first author was supported by German Academic Exchange Office (DAAD) scholarship which is gratefully acknowledged.

§ Corresponding author: Ulrich Schmidt, Department of Economics, University of Kiel, Olshausenstr. 40, 24098 Kiel, Germany, email: us@bwl.uni-kiel.de, Phone: +49 431 8801400, Fax: +49 431 8804621.

.

1 Introduction

Although different definitions of the notion of stock price bubbles exist, one thing is common to all of them: bubbles are deviations from the fundamental value of an asset which equals the expected present value of the stream of dividends that owner expects to receive. There exist several problems in determining the fundamental value of an asset, namely estimation of dividends on the asset through the time period, determination of the terminal asset value and discount rates for calculation of the present value. All these components can be controlled in the laboratory asset market.

A question arises, why people pay for an asset a price that differs from its fundamental value? According to Scheinkman and Xiong (2003) overconfidence is the main factor which makes people pay higher prices, than the underlying fundamental value of an asset. Overconfidence is one of the psychological characteristics, stipulating deviations from rational behavior. The concept of overconfidence is based on the large body of evidence from research in cognitive psychology, which suggests that human-beings overestimate their own knowledge, abilities and precision of their personal information. Although the beginning of overconfidence research lies in psychological works, the effect of overconfidence on financial decision making, functioning of financial markets and economic outcomes is a widely researched topic in behavioral economics.

There exist many theoretical papers analyzing the impact of overconfidence on financial markets. In these papers overconfidence is usually modeled as overestimation of the precision of private information and results in underestimation of the variance of asset prices. Well known results in this framework are that overconfidence causes excess trading volume and excess price volatility, as well as the occurrence of the speculative price bubbles (see e.g. Odean, 1998 and Scheinkman and Xiong, 2003). However, there exist only a few experimental studies designed to test how overconfidence affects asset prices and trading behavior. Market experiments which are closely related to the present study have been performed by Kirchler and Maciejovsky (2002), Biais et al. (2005), and Deaves et al. (2009). All these experiments analyzed relation between measures of overconfidence and trading behavior, however did not address the impact of overconfidence on the occurrence of stock-price bubbles directly.

In this paper we report results of an experiment, designed to investigate the role of market overconfidence for the occurrence of stock-price bubbles and the emergence of other stylized facts like excessive trade volume and excessive price volatility. The construction of our asset

markets follows Smith, Suchanek and Williams (1988) and is extended by a new feature, in which markets are composed on the basis of subjects' overconfidence, assessed in pre-experimental studies. In contrast to previous experiments our overconfidence measurement controls for the hard-easy affect and a possible gender bias. From the pre-experimental studies we invited (i) subjects with lowest overconfidence scores and assigned them to one type of markets (referred to as "rational markets" in the sequel) and (ii) subjects with highest overconfidence scores who were assigned to a second type of markets (called "overconfident markets"). Within one market all subjects receive identical information so in principle no trade should occur.

Main findings from our experiment can be summarized as follows. Higher market overconfidence is accompanied by the higher average market prices and larger deviations of prices from fundamental value. Prices in rational markets tend to track the fundamental asset value more accurately than the prices in the overconfident markets, and are significantly lower than the average overconfident prices. Moreover, bubble and burst patterns were observed in overconfident markets, whereas in the rational markets no sudden drop of the aggregated market price to the fundamental value occurred. Volatility of the prices and trade volume proved to be significantly lower in the rational markets, as it was hypothesized.

The paper proceeds as follows. In Section 2 a brief overview of the findings of psychological[1] and financial literature on overconfidence are given; along analysis of the similar work and discussion of the paper's contributions is presented. In Section 3 the research hypotheses are listed. In Section 4 details of the pre-experimental overconfidence measurement are provided. Section 5 provides description of experimental design. In Section 6 data analysis is presented, and, finally Section 7 concludes.

2 Motivation and Related Literature

Following the psychological research in overconfidence, interest in the consequences of economic subjects' overconfidence on financial decision making, functioning of markets and economic outcomes has occurred in behavioral economics. Theoretical models of overconfidence predict that overconfidence causes excess trading volume (De Bondt and Thaler, 1985; Shiller, 2000; Benos, 1998; Caballé and Sákovics, 2003), and excess price volatility (Scheinkman and Xiong, 2003; Benos, 1998, Daniel et al., 1998); it induces

[1] A detailed discussion of the relevant literature is provided in the working paper "Development of the overconfidence measurement instrument for the economic experiment".

occurrence of the speculative price bubbles (Scheinkman and Xiong, 2003) and increases market depth (Odean, 1999; Kyle and Wang, 1997; Benos, 1998); it makes markets underreact to abstract, statistical, and highly relevant information and overreact to salient, but less relevant information (Odean, 1998); it makes returns of financial assets predictable (Daniel et al., 1998, 2001; Scheinkman and Xiong, 2003); overconfidence increases investors' tendency to herd (Hirshleifer, Subrahmanyam and Titman, 1994) and makes them choose riskier and undiversified portfolios (Odean, 1998, 1999; Lakonishok, Shleifer and Vishny, 1992), overconfident investors trade more aggressively, i.e. their trading activity is too high (Odean, 1999; Gervais and Odean, 2001) and their expected utility is reduced (De Long et al., 1991; Odean, 1998). Most of these papers are based on the initial assumption of traders' overconfidence, which is modelled as overestimation of the precision of private information that manifests itself via underestimation of the variance of the private signal that subjects get, or, in other words, too tight confidence intervals for the value of the risky asset (Glaser and Weber, 2007).

There are relatively few empirical and experimental studies designed to test the impact of overconfidence on financial decisions, market outcomes and subjects' performance. Some of them present only an indirect evidence of such impact, as they measure overconfidence via different proxies. For example Statman et al. (2006) test the hypothesis of interdependence between overconfidence and high trading volume for the USA stock market. As a proxy for the degree of overconfidence they suggest using high past returns, i.e. they argue that after high past returns posterior volume of trade will be higher, as successful investment increases the degree of overconfidence. These conclusions are supported by Kim and Nofsinger (2003) for the Japanese stock market. Barber and Odean (2001) take as proxy for overconfidence the gender of traders, i.e. their proposition is that, based on the psychological literature, women are less overconfident than me and thus are going to trade less.

Experiments enable a more direct test of the hypothesis that a certain degree of overconfidence leads to specific trading behavior on financial markets. Market experiments which explicitly focus on overconfidence were conducted by Kirchler and Maciejovsky (2002), Biais et al. (2005), and Deaves et al. (2009).

Kirchler and Maciejovsky (2002) run a multi-period experimental market and analyze development of overconfidence of the participants in the course of the experiment. Miscalibration of subjects was measured before each trading period, via two price prediction tasks: point prediction and interval prediction. Their results indicate that participants of the experiment were well-calibrated in certain periods, and under- or overconfident in other

periods. They also find that higher degree of overconfidence is negatively correlated with the earnings of the participants of the experiment.

Biais et al. (2005) use a questionnaire to measure, among other psychological traits, the degree of overconfidence via interval estimation tasks in a group of 245 students. Several weeks after the overconfidence measurement subjects participated in an experimental asset market. The main results show that although miscalibration does not lead to an increase in trading activity it reduces trading performance of the subjects, and miscalibrated traders show "excessive confidence in their assessment of the value of the asset".

Deaves et al. (2009), conduct their experiment in order to test premises that overconfidence leads to an increase in trading activity and that gender influences trading activity through differences in overconfidence. To some of their sessions subjects were assigned based on their gender, to others based on a pre-experimental measured overconfidence score. The main finding reported in their paper is that greater overconfidence leads to higher trading volume and leads to reduced earnings, but there is no evidence that overconfidence and trading activity are gendered.

The present experimental design extends and complements previous studies with respect to the following aspects:

First of all, most of the previous experiments concentrate on the connection between overconfidence and high trading volume, but none of them was aimed at discovering the impact of overconfidence on the occurrence of stock-price bubbles. Second, there were no papers that previously used suggested procedure of markets formation, based on the participants' inborn level of overconfidence, and have managed directly connect changes in traders' psychological characteristics to the occurrence of bubbles. Although Deaves et al. (2009), as mentioned above, run several sessions to which subjects were assigned by the degree of overconfidence, the issue of association of overconfidence with bubble was not in their focus, and therefore not explored. They also utilized a different overconfidence measurement methodology which, as argued below, may be prone to several distortions, and opted for different market structure (a battery of one-period markets per session vs. one multi-period market).

Third, previous experiments provided participants by private information with differences in signal quality, which already creates a potential for trade. For instance in the experiment of Kirchler and Maciejovsky (2002) half of the participants had no information about the dividend distribution, and the other half had complete information. The experimental design of Biais et al. (2005) relies on an asymmetric information trading game, where traders observe

different private signals: bullish, bearish, and neutral. Deaves et al. (2009), also supply their subjects with different signals (in terms of quality) that depend on the results of the pre-experimental test. Moreover they try to manipulate the subjects' beliefs so that they think that their signals are more accurate. In our approach, all subjects are given the same information and, therefore all differences between both type of markets can be attributed to overconfidence.

Fourth, overconfidence may not have been accurately measured in previous studies. Findings from the psychological research show that overconfidence is the most pronounced for the hard questions (few people know the right answer) and the least for the easy ones (most of the people give a correct answer). However, none of the abovementioned papers uses a measurement device balanced with respect to this hard-easy effect. This could have artificially created high levels of under- or overconfidence. For example in the experiment of Deaves et al. (2009) none of the subjects gets even close to the perfect calibration measure, and even the best calibrated participants exhibit rather high degree of overconfidence. For our study, we created the specially tailored test, weighted for the inclusion of easy, hard and medium difficulty questions and also accounting for a possible gender bias.

Finally, we use two constructs to measure subjects' overconfidence: a (pre-experimental) general knowledge test and a stock-price prediction task during the main experiment. Biais et al. (2005) and Deaves et al. (2009) use only (pre-experimental) general knowledge tests, where overconfidence is estimated via the interval estimation tasks. In the experiment of Kirchler and Maciejovsky (2002) a pre-experimental overconfidence measurement did not take place; overconfidence was measured during the experiment with a price prediction task. Our design enables not only the evaluation of the students' pre-experimental degree of overconfidence, and based on that, the construction of rational and overconfident markets but also to infer how overconfidence evolves in the course of the experiment and how this is related to bubble and burst patterns.

3 Experimental Design

3.1 Pre-Experimental Overconfidence Measurement

There are several reasons why overconfidence might have been measured inadequately in previous studies. Most of these studies followed the prominent work of Russo and Schoemaker (1992) and used interval elicitation tasks to assess overconfidence. However, these tasks are prone to produce extreme overconfidence (see Klayman et al., 1999).

Additionally, previous measures were neither balanced to the hard-easy effect nor country, or gender balanced. As mentioned above, hard-easy effect manifests itself through the increase in the degree of overconfidence with the increase in the difficulty of the questions. As result from the hard-easy effect country and gender biases may occur.[2] Country bias rests on the fact, that some questions might be easy in one country, but in another one they might be hard. Gender bias is produced by the choice of questions that could be easier for men than women (e.g. sports, masculine hobbies) and vice versa. Unbalanced tests can artificially create high levels of under- or overconfidence either in the whole group, or in parts of it. Finally, overconfidence was often assessed based on the insufficient number of assignments or test items; psychological studies of overconfidence usually employ a substantially higher number of items, and the minimum number of items for a reliable test is ten (Kline, 1993).

Our overconfidence measurement differs from that used in previous economic experiments in several respects. First, another test format was chosen, namely multiple choice tasks which are clearer to subjects and not inherently prone to production of extreme overconfidence levels (see Klayman et al., 1999). Second, our measurement is balanced with respect to the hard-easy effect, by the inclusion of an equal number of questions of the three difficulty levels (hard, medium-difficulty and easy). Third, we control for possible gender and country biases and include more items than previous studies.

The instrument was obtained in a two-stage procedure. First, a pilot study was performed in order to assess difficulty of the 50 initial items. For this pilot study 50 general knowledge questions, unrelated to economics, financial markets or experiments, were selected from the German quiz web-page *http://wissen.de*. Questions on this web page have four short (one or two-word) multiple exclusive answers. Questions are not connected to economics, as otherwise they could cause biased results if the same test is used with a heterogeneous pool of subjects (see Daeves et al., 2009). In choosing test questions we have tried to avoid gender bias, which, as mentioned above, could result in inappropriate levels of under- or overconfidence for one gender. In our test, we gave for each question only three alternative answers, only one of which was right. Students were given 30 minutes to answer each of the 50 questions, and state their level of confidence in the correctness of their answer. For this purpose they could use any number in the range from 33% (complete uncertainty) to 100% (complete certainty). Three monetary prizes were offered for those participants who got the most questions right. A reward on the basis of competition in test accuracy was chosen in

[2] See Hemert et al. (2001) for a general discussion of these effects.

order to decrease the desire of subjects to share answers, and thus increase reliability of the obtained individual bias scores.

The under- or overconfidence of each participant was measured as her bias score. The bias score of each individual was calculated as the difference between the mean confidence level across all questions and the proportion of correct answers (see Equation 1). A positive bias score represents overconfidence and a negative bias score represents underconfidence. A bias score of zero indicated accurately calibrated person (neutral person).

$$\textit{bias score (BS)} = \textit{average \% confidence} - \textit{average \% correct} \quad (1)$$

Based on the analysis of the pilot-test outcomes, a final test (*test-18*) was constructed from 18 questions (referred to as *test-18* in the sequel) of the three difficulty levels: six hard, six medium difficulty, and six easy questions. Items were differentiated according to their difficulty on the basis of the number of correct answers in the pilot study. This methodology follows Pulford and Colman (1997).

Pre-experimental overconfidence measurement was performed during several economics lectures at the University of Kiel. In each of the chosen classes, students were notified that they had an opportunity to take part in the short experiment on the voluntarily basis, for which a general knowledge quiz (*test-18*) had to be filled out. For this activity 15 minutes were given. Participants of each pre-experimental session competed for the three prizes of 30, 20 and 10 EUR, which were awarded to those who answered the most questions right. Before students started with the tests, a planned market experiment was advertised, and those subjects who were eager to take part in the economic experiment were encouraged to mark their interest on the tests by ticking the "I'm interested in participation in further experiments" option and leaving their e-mail address. This pre-experimental procedure allowed us to obtain a large pool of students with their estimated bias scores and to ensure that the two stages of the experiment were perceived by students as two rather non-associated sessions.

More than 200 students showed interest in the forthcoming economic experiment. A database of the interested persons included information on 222 students' name, age, nationality, subject of studies, semester and overconfidence score. Consistent with previous research, subjects in the database on average were overconfident (*BS*: M = 11.78, SD = 10.58). As explained above, we focused in the experiment on the least and the most overconfident subjects, whom are further on called rational and overconfident subjects, respectively. These students were approached via e-mail and invited to register for the main experiment.

Appendix A presents data on the bias scores of the various (pre-)experimental subgroups: all participants who were in the database and all students who participated in the experimental sessions (a subsample of those in the database). All groups seemed to be extremely overconfident, except for the participants of the rational market. A hypothesis of the equality of the average overconfidence of different subgroups was tested against the alternative that different subgroups varied by their overconfidence levels. The mean equality hypothesis is failed to be rejected for the difference between overconfidence of male versus female subjects both in the whole sample of pre-experimental test participants, as well as among all participants of the main experiment. The bias score of the participants of overconfident markets is significantly higher than the bias score of the participants of rational markets.

3.2 The Main Experiment

For each of our ten sessions six participants were recruited from the set of subjects who participated in the pre-experimental overconfidence measurement. None of our subjects participated before in a similar asset market experiment. The 60 subjects were comprised of 35 males and 25 females, aged 19 to 28 (M = 22.73, SD = 2.06), and to 87% of German nationality. Approximate time required to conduct the experiment was one hour. Subjects earned on average 390.36 ECU (10.54 EUR, SD = 197.89) on the asset market (without the reward for the forecasting activity). Men earned on average more ECUs than women, 447 ECU compared to 335 ECU. This difference is significant (Mann-Whitney $Z = -2.646$, $p < 0.01$, one-sided). Instructions familiarized participants with the rules of the experimental market. English translation of instructions can be found in Appendix B.

All experimental sessions were conducted in the computer lab. Six players participated in each of the experimental asset markets. Subjects could take part in only one experimental session and only in that type of the market (rational/overconfident) to which they were appointed based on the results of the pre-experimental overconfidence measurement. The experiment was programmed and conducted with z-Tree (Fischbacher, 2007).

At the beginning of sessions students were given time to read the detailed instructions and ask questions. At the end of the time devoted for reading the instructions, the experimenter read out loudly the most important information. Two trial periods followed, during which students could familiarize themselves with the experimental software, and again were allowed to ask questions if something was unclear to them. Both prior to the trial periods and after them subjects were informed that these periods had no impact on their results and payoff.

The design of trading rounds followed Smith, Suchanek, and Williams (1988) with slight changes in the price forecasting task, and was performed as a continuous anonymous double auction. Prior to the start of the experiment each trader was endowed with an equal amount of experimental assets and cash: 300 units of experimental currency (ECU) and 3 units of the experimental asset. Every experimental market consisted of the sequence of 15 trading periods lasting at most 180 seconds during which each trader could post her bid and ask prices for asset units. Each participant could purchase asset units by spending an amount of their working capital, or sell units of the inventory and thereby increase their working capital. At the end of each trading period, each asset in the inventory of the participants paid a dividend with possible values of 0.0, 0.8, 2.8, or 6.0 ECU. Probability of each dividend value was 0.25, so the expected dividend of each asset amounted to 2.4 ECU in each trading period. As the terminal asset value is zero, the fundamental value of an asset, thus, equals $n \times 2.4$ ECUs, where n is the number of trading periods remaining until the end of the experiment.

At the end of trading periods, participants were shown market summary information from the past period, and were asked to predict the average market price for the next period as well as to state how confident they were that their price forecast was correct. To express their confidence subjects could use any value between 0% and 100%. Participants were paid for their predictions based on their accuracy. Each period subjects were given feedback on their accuracy and their reward for the price forecasting task. Point estimation for the price prediction task, as used by e.g. SSW (1988), was chosen over interval estimation due to several reasons. First, overconfidence measures obtained through interval estimation by Kirchler and Maciejovsky (2002) did not vary in time and remained in the area of overconfidence; however, their point-estimate measure varied in time and took values from overconfident, to well-calibrated, and underconfident. Second, this form of price prediction task enabled comparison between pre-experimental and post experimental overconfidence measures.

At the end of the experiment, subjects were paid in cash the amount of money corresponding to their final working capital converted at the predefined exchange rate to Euros. Final working capital (FWC) equaled:

$$FWC = (300\ ECU\ starting\ capital) + (dividend\ earnings) + (stock\ sales\ revenue) - (stock\ purchase\ cost) \quad (2)$$

Reward for the accuracy of predictions was constructed to be an additional income source in order to encourage conscious engagement in the experiment. The closer the prediction was to

the actual average market price, the higher was the reward. The reward scheme used in the experiment was similar to the suggested by Haruvy, Lahav, and Noussair (2007)[3]:

Level of Accuracy	Reward
Within 90% -110% of actual price	3 ECU
Within 75%-125% of actual price	1 ECU
Within 50%-150% of actual price	0.5 ECU

Both monetary reward and the feedback about their predictions' accuracy were used for improving the subjects' calibration in the price prediction task.

4 Results

Average Prices

In this section various summary statistics of the two types of the market are compared. Each session counts as one (independent) observation. Totally ten sessions were conducted, five overconfident markets and rational markets. If not stated otherwise, all data for each type of the market are ranked from the lowest to the highest.

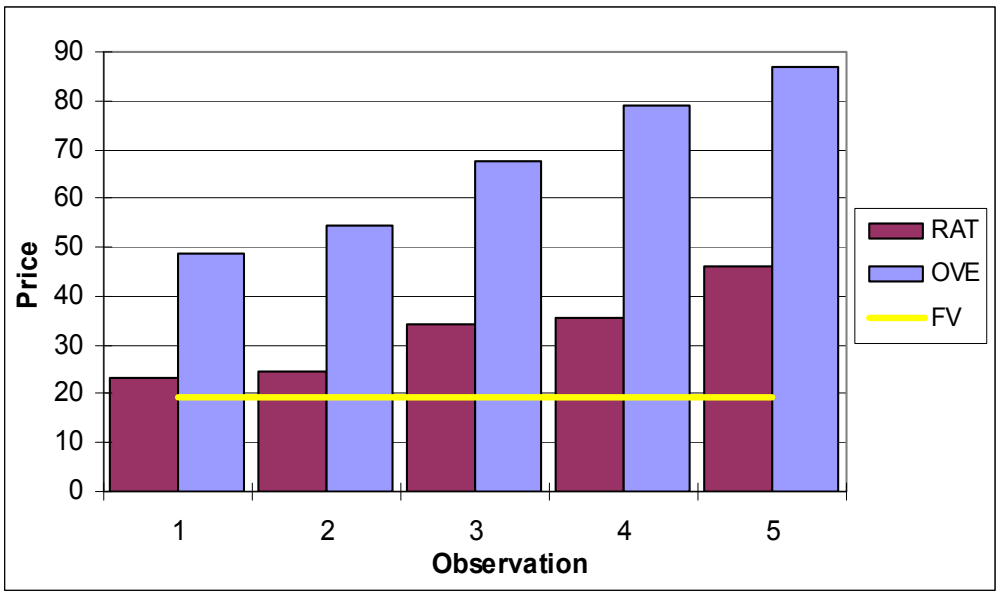


Figure 1: Average asset prices

Figure 1 shows that on average prices in the overconfident markets are substantially higher than in the rational markets. The average market price for the rational markets was 33 ECUs

[3] This incentive scheme instead of a quadratic scoring rule was chosen for the sake of keeping the instructions simple (Haruvy et al., 2007).

(SD = 9.41) and 67 ECUs (SD = 16.02) for the overconfident markets. This difference is significant (Mann-Whitney U = 0.0, $p < 0.01$, one-sided). The average fundamental value (FV) equals 19.20 ECU, depicted by the yellow line in Figure 1. Wilcoxon Signed Rank test supports that prices both in the rational and in the overconfident markets are higher than the FV (Wilcoxon T = 1.89, $p < 0.05$, one-sided).

Evolution of Average Prices

Figure 2 presents the development of average prices for rational and overconfident markets in the course of the experiment. The straight blue line indicates that FV diminishes by 2.4 in each of the 15 trading periods.

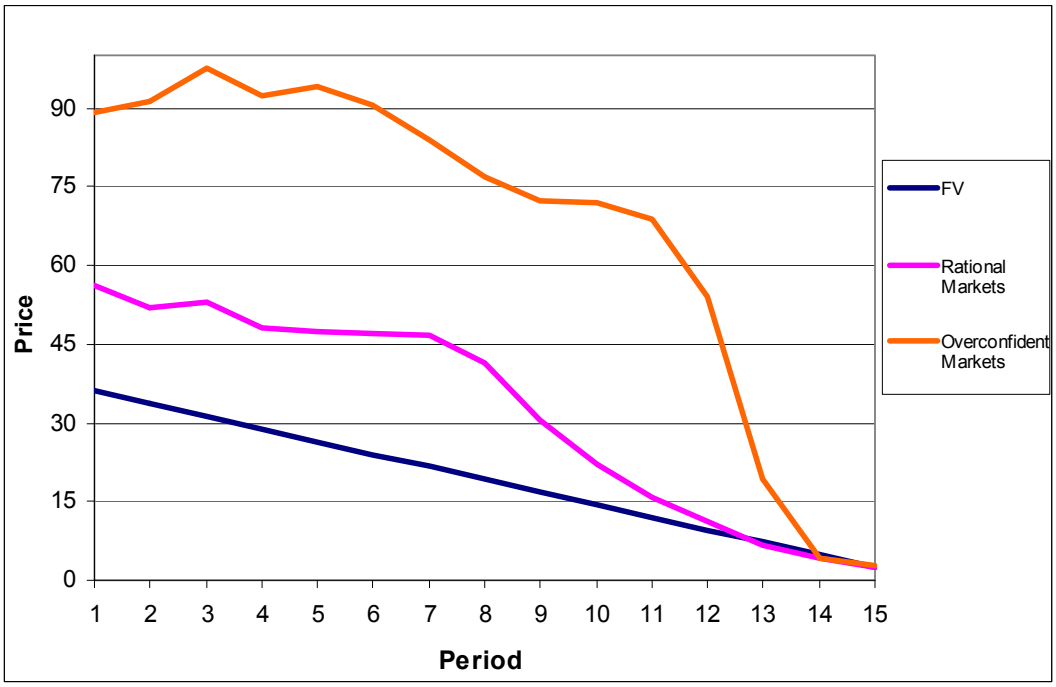


Figure 2: Development of the average market price

Visual data analysis suggests that prices deviate from FV in both types of the markets. However prices in the rational markets deviate from FV to a smaller extent than in the overconfident markets and tend to track FV more accurately. It can also be seen that in the overconfident markets the bubble and burst pattern is more pronounced than in the aggregated rational markets, where no sudden drop of the aggregated market price to FV is observed.

Volatility

Figure 3 presents volatility in both types of markets, measured in terms standard deviation of prices. A Mann Whitney U test confirms that volatility in the overconfident markets is

significantly higher than in the rational markets (Mann-Whitney U = 4, $p < 0.05$, one-sided). For both types of the market, Wilcoxon Signed Rank test enabled rejection of the null hypothesis that the volatility of prices was equal to the volatility of FV (SD = 10.73) in favor of the alternative hypothesis that volatility was higher (Wilcoxon T = 1.89, $p < 0.05$, one-sided).

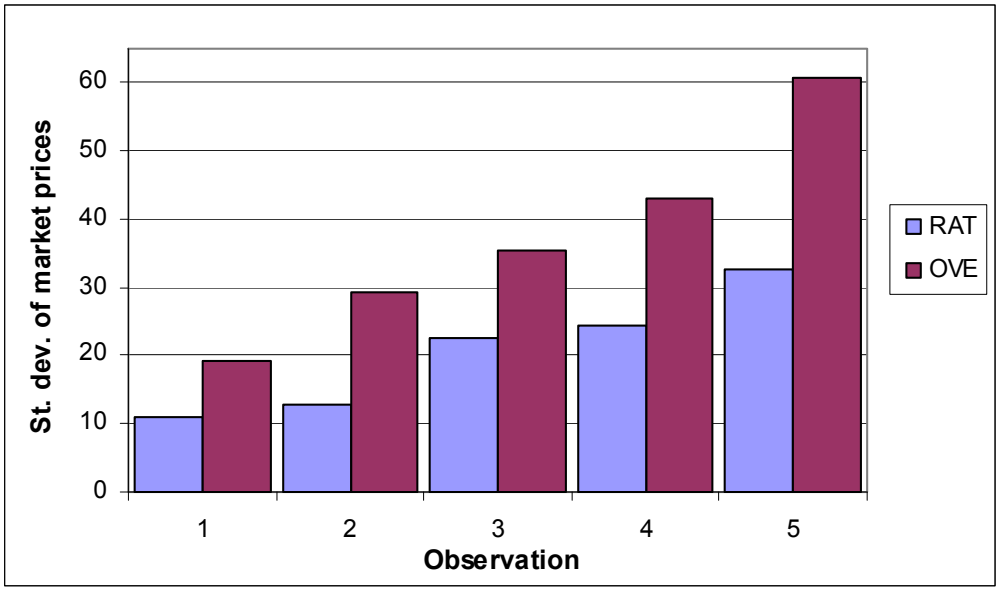


Figure 3: Volatility of asset prices in both types of markets

Trading Activity

According to the No-Trade Theorem by Milgrom and Stokey (1982) rational agents who differ from each other only in terms of information and who have no reason to trade in the absence of information will not trade. Figure 4 shows that this result does not hold for our experimental markets, even though there was no private information at all in our design. Wilcoxon Signed Rank test of the hypothesis that turnover (calculated as number of assets traded in one period divided by the total number of assets, i.e. 18) equals zero is rejected for both markets in favor of the alternative hypothesis that turnover is significantly higher than zero (Wilcoxon T = 1.896, $p < 0.05$, one-sided).

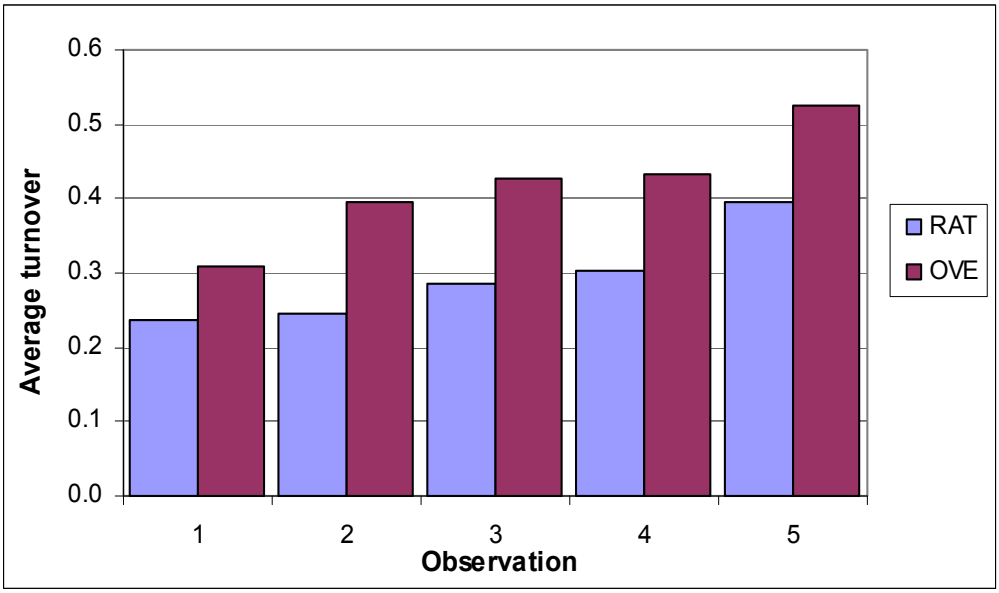


Figure 4: Average trading activity (turnover) in both types of markets

Trading activity in the rational markets is lower than in the overconfident ones: average market turnover in rational market sessions is 28% (5 units of the asset) and 44% (8 units of the asset) in overconfident sessions. This difference turns out to be significant (Mann-Whitney $U = 1.5$, $p < 0.05$, one-sided).

Evolution of the joint average market turnover for five experimental sessions of rational market and five overconfident markets is shown in Appendix C. It can be observed that the joint average market turnover decreased over the trade periods in both types of markets. Increase in trading activity in the last period can be attributed to an end-game effect.

Price-Forecasting

Bias score (BS) from the price forecasting task was calculated for each session separately, as an average from all participants' forecasts about the next period's average price and their confidence in the answer. The score was calculated based on the "binary" methodology: if the average price was equal to the forecast it got a weight of one, otherwise a weight of zero. Overconfidence measure from the pre-experimental test is strongly correlated with the overconfidence measure from the forecasting task (Spearman's rho (8) = 0.65, $p < 0.05$, one-sided). According to Cohen (1988) this correlation coefficient is considered to be large, thus we can assume that both constructs measure the same phenomenon. This result also suggests that overconfidence is a robust phenomenon in our sample.

Figure 5 indicates that on average the bias score from the price forecasting task was higher in the overconfident markets than in the rational ones. On average overconfidence in price prediction task differed between the two types of market by 10 units (BS in rational markets M = 50.08, SD = 8.96; in overconfident markets M = 60.31, SD = 5.02). BS value for the overconfident market is significantly higher than BS for the rational market (Mann-Whitney $U = 4.0$, $p < 0.05$, one-sided).

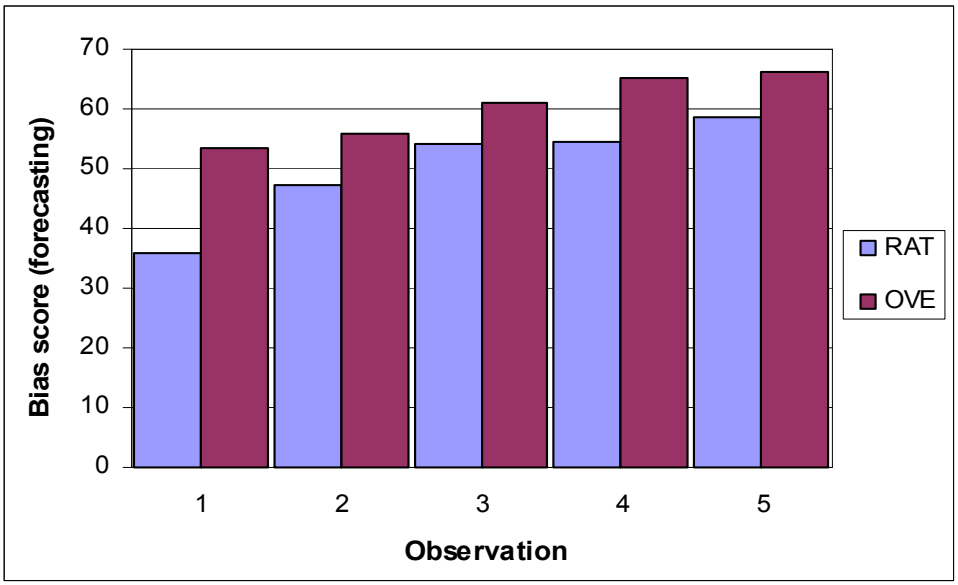
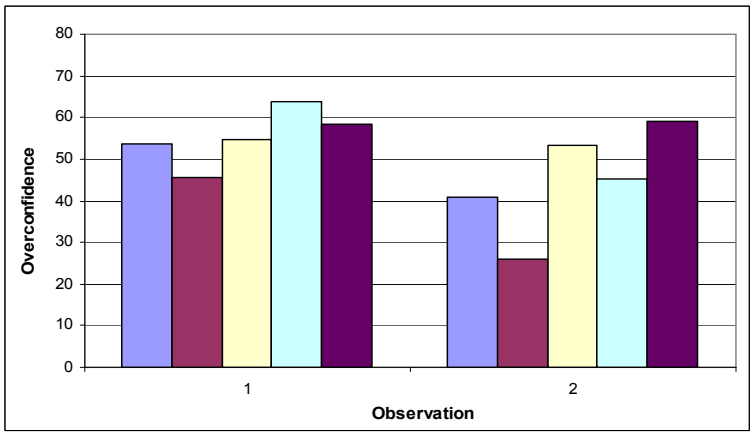


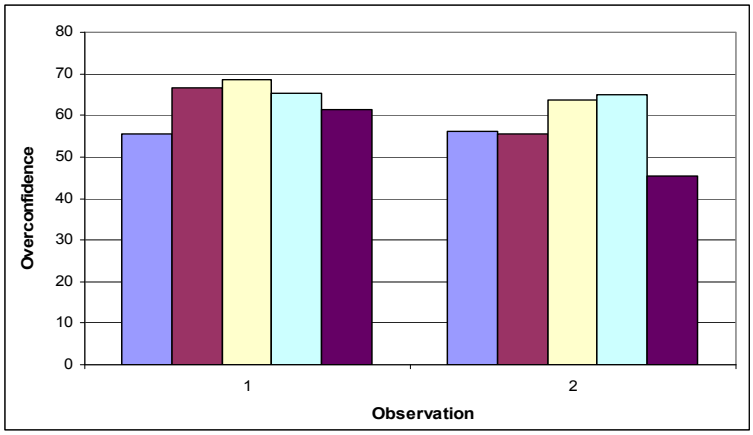
Figure 5: Average overconfidence in both types of markets

Evolution of the Bias Score

To investigate whether overconfidence reduces to the end of the game, data of the price prediction task were divided into two time intervals of seven periods each, and two overconfidence measures for each market were calculated: one score for the first seven periods BS(2-8), and the second for the last seven periods BS(9-15). Figure 6 demonstrates that for most of the markets overconfidence measures calculated from the data on the price prediction for the first seven periods are higher than those calculated from the last seven last periods. Wilcoxon Signed Ranks test confirms that BS(2-8) is significantly higher than BS(9-15) ($Z = -2.429$, $p < 0.01$, one-sided). This finding could serve as an explanation why bubbles mostly burst close to the end of the experiment.



a.



b.

Figure 6: Comparisons of BS(2-8) and BS(9-15): a. rational market; b. overconfident market

Bubble Measures

From the previous analysis we obtained evidence, that although prices, volatility and turnover in rational markets are significantly lower than in overconfident markets, they are still much higher than initially hypothesized. In other words, rational markets might also be prone to bubbles, but of a smaller magnitude. To analyze this issue, we calculate several measures of the magnitude of bubbles that were developed by previous authors (e.g. King et al., 1993; Van Boening et al., 1993; Porter and Smith, 1995; Noussair and Tucker, 2006; Dufwenberg et al., 2005). These measures are: Haessel-R2, Price Amplitude, Normalized Absolute Deviation, Normalized Average Deviation, and Velocity. Table 1 reports the values of the measures by session and treatment. Appendix D presents graphs of average market prices and turnover values per period in each of the ten markets.

The Hassel-R^2 (Haessel, 1978) measures goodness-of-fit between average market price per period and the intrinsic asset value. It determines how well the variation in actual market prices (around their mean) is accounted for by the variation in the fundamental value (around

its mean), or, in other words, the proportion of the variation in market price which can be explained by variation in fundamental value. Hassel-R^2 converges to 1 if trading prices converge to fundamental values[4]. It is estimated by the R^2 associated to the regression of market prices on the fundamentals, where fundamental value is seen as an estimator for the average market price obtained from some linear model. A comparison of average contract prices obtained from the rational market with those obtained from the overconfident one, reveals that variation in the average prices in the rational market fit variation in the intrinsic value better in most of the sessions. Thus goodness of fit measure is significantly higher in rational markets (Mann-Whitney $U = 3$, $p < 0.05$, one-sided).

Table 1: Bubble measures in each session

Session	Treatment	Hassel-R2	NPD	NAD	Amplitude	Velocity
1	OVE	0.581	9.144	9.308	1.69	4.61
2	OVE	0.535	24.908	24.939	2.25	5.94
3	OVE	0.414	38.257	38.380	2.87	7.89
4	OVE	0.288	13.008	13.196	1.32	6.50
5	OVE	0.877	25.874	25.961	3.33	6.39
6	RAT	0.906	5.745	6.133	1.09	4.56
7	RAT	0.571	1.769	3.412	0.67	5.94
8	RAT	0.944	9.593	9.924	1.67	4.28
9	RAT	0.805	3.781	4.099	1.15	3.56
10	RAT	0.942	0.983	1.017	0.30	3.67

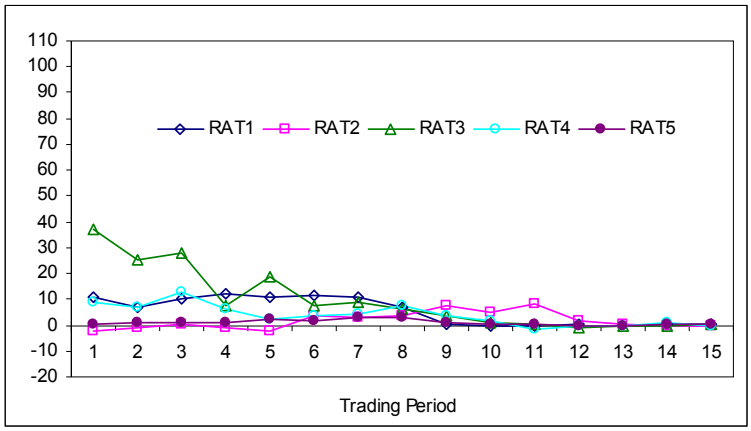
The Normalized (Average) Price Deviation is calculated by summing up all deviations of market contract prices from fundamental value and dividing this sum by the total number of stocks in the market:

$$NPD = \frac{\sum_{i=1}^{q} [P_{ti} - FV_t]}{TSN} \tag{3}$$

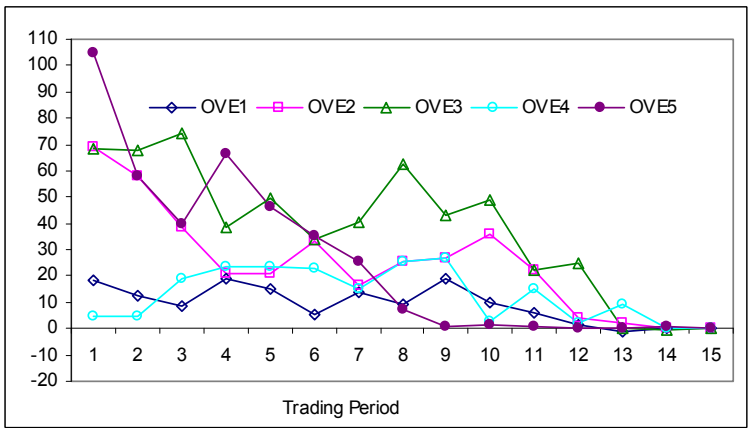
Here, P_{it} is the price of the ith share in period t, FV_t is the fundamental value in period t, q is the number of contracts in period t, and TSN is the total number of shares in the market (18). This measure is calculated for each period. Table 1 presents average value for each of the markets.

[4] See Dufwenberg et al. (2005) for an explanation why this measure is appropriate to experimental settings with no uncertainty about the last period.

From the analysis of the NPD it can be determined whether stocks in that period were overpriced or underpriced relative to the fundamental value (a value of under- or overvaluation per-share). Average market value of the NDP can be treated as an indicator of the aggregated average under- or overvaluation per-stock in that market. Figure 8 depicts, for each of the two types of asset market, normalized price deviations from fundamental value per period. Results from rational markets are presented in the upper part of the panel, and from overconfident markets - in the lower part. From Table 1 one can see that prices are on average much more overvalued in the overconfident market than in the rational market and this difference is significant (Mann Whitney U = 1, $p < 0.01$, one-sided).



a.



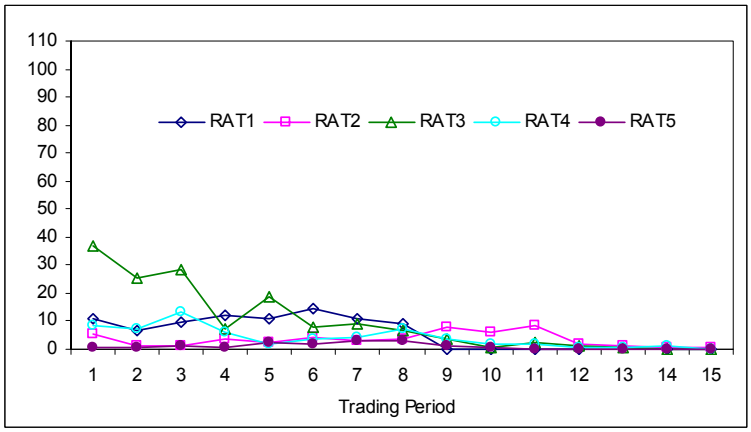
b.

Figure 8: Normalized price deviations from FV by trading period and overconfidence level: a. rational market, b. overconfident market

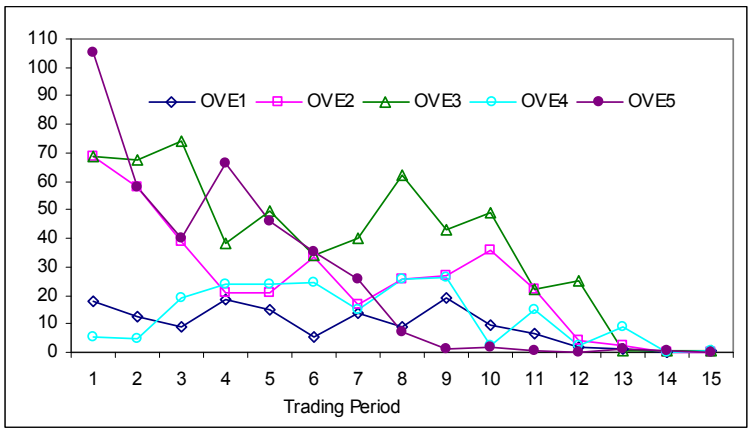
The Normalized Absolute Deviation is similar to the NPD, and is found as the sum, over all transactions of that period, of the absolute deviations of the market prices from fundamental value, divided by the total number of stocks in the market:

$$NAD = \frac{\sum_{i=1}^{q} \left| P_{it} - FV_t \right|}{TSN} \qquad (4)$$

NAD measures the dispersion of the contract prices around the fundamental value, and high values of NAD point out that large number of transactions are being conducted at prices above the fundamental value. Figure 9 depicts absolute price deviations from fundamental value per period for each of the two types of asset market. Results from rational markets are presented in the upper part of the panel, and from overconfident - in the lower part. From Table 1 one can see that on average contract prices in the overconfident market differ by more experimental units from the fundamental value (22.36 ECU) than in the rational market (4.92 ECU), and this difference is significant (Mann Whitney U = 1, $p < 0.01$, one-sided). Since there are not many cases of undervaluation relative to fundamental value, there are no considerable differences in the values of NAD and NPD.



a.



b.

Figure 9: Normalized absolute price deviations from FV by trading period: a. rational market, b. overconfident market

The Price Amplitude (APL) is the maximum value of the shift of average contract price from the fundamental value for an experimental session. It is found as the difference between the maximum positive and the maximum negative deviation of the average period price from the fundamental value of that period, normalized by the initial fundamental value:

$$APL = \max\left\{\frac{(P_t - FV_t)}{FV_1}\right\} - \min\left\{\frac{(P_t - FV_t)}{FV_1}\right\} \quad (5)$$

Here, P_t is the average contract price and FV_t is the fundamental value in period t. Initial fundamental value is given by $FV_1 = 36$ ECU.

Higher price amplitudes imply greater bubbles, and larger swings in the market price of the asset relative to fundamental value. From the Table 1 one sees that the price amplitudes in the overconfident market are on average more than twice as high as in the rational markets, and this difference is statistically significant (Mann-Whitney U = 1.00, $p < 0.01$, one-sided).

Velocity of the Asset is found by dividing the total number of transactions over the experimental session by the total number of stocks in the market. This measure is connected to the volume of trade: the higher is the velocity, the higher is the volume of trade, suggesting, according to Noussair and Tucker (2006), either heterogeneous expectations or biases in decision making prompting trade. From the Table 1 one can see that the velocity of stocks in the overconfident market is significantly higher than in the rational market: on average each stock is "turned over" 6.27 times in the overconfident market, and only 4.38 times in the rational market. This difference is significant (Mann Whitney U = 1.50, $p < 0.05$, one-sided).

Correlation coefficients between bubble measures and measures of overconfidence (pre-experimental and forecasting bias scores) are large and significant (see Appendix E). This provides additional evidence that overconfidence has a significant effect on pricing and trade behavior in experimental asset markets.

Altogether, the results presented in this section demonstrate that although bubbles in the rational markets are not completely eliminated, they are less severe in comparison to the bubbles in overconfident markets[5]: bubble measures calculated for the rational sessions are statistically significantly smaller than the ones obtained from the overconfident sessions. Moreover size of the bubble measures increases with the increase in market overconfidence.

Comparison to other experiments

Table 2 presents data from several experiments which had similar structure to our, i.e the asset market had duration of 15 periods and the fundamental value was declining each period. In the experiments of Smith, Suchanek, and Williams (1988), Porter and Smith (1995), Van Boening, Williams, and Le Master (1993) bubble and crash pattern in prices is widely

[5] This is in line with Ackert et al. (2009) who found irrationality (i.e. probability judgement errors) to be correlated with magnitude and frequency of price bubbles.

observed. On the contrary, experimental sessions of Noussair and Tucker (2006) yield practically no bubbles. On average values of Normalized Absolute Deviation[6] and the Amplitude from the rational treatment are higher than the values from the "no-bubbles" experiment of Noussar and Tucker (2006) but are lower than those obtained from the other three experiments; thus there is evidence of the smaller deviations from the fundamental value in the rational market treatment. Measures obtained from the overconfident market treatment are consistent with those observed in previous studies of markets of this type.

Table 2: Average values of some of the bubble measures from previous studies

Average values from our experiment	NAD	Velocity	Amplitude
Overconfident markets	2.24	6.27	2.29
Rational markets	0.49	4.40	0.98
Average values from previous research			
Noussair and Tucker (2006)	0.24	0.99	0.33
Smith, Suchanek, and Williams (1988)	5.68	4.55	1.24
Porter and Smith (1995)	--	5.49	1.53
Van Boening, Williams, and Le Master (1993)	5.12	5.05	4.19

5 Conclusions

In this paper results of an experiment, designed to investigate the role of market overconfidence for the occurrence of stock-prices bubbles have been reported. The design of the experiment follows Smith, Suchanek and Williams (1988) and is extended by a new feature, in which markets are constructed on the basis of subjects' overconfidence, measured in pre-experimental studies. In the experiment two types of markets are constructed, rational and overconfident ones. Our results refine differences between market outcomes in the experimental treatments and suggest the existence of the connection between market overconfidence and market outcomes.

Although all traders in our study have identical information we observe that trading activity in rational markets is significantly higher than zero; however it is significantly lower than in the overconfident markets. Our results show very clearly that higher market overconfidence is

[6] For the comparison of NAD measure from our experiment to those of the other experiments, it has to be divided by ten. The reason is that, previous studies used an expected dividend equal to 0.24 ECU is each period; in our experiment it is 2.40 ECU.

accompanied by the higher average market prices and larger deviations of the prices from fundamental value. Although average prices in both types of markets significantly exceed the fundamental value, prices in rational markets tend to track the fundamental asset value more accurately than the prices in the overconfident markets, and are significantly lower than the average overconfident prices. Moreover, bubble and burst patterns were observed in the aggregated overconfident market, whereas in the rational market no sudden drop of the aggregated market price to the fundamental value occurred. Volatility of the prices and trade volume proved to be significantly lower in the rational market, as it was hypothesized.

Results show that both constructs that were used in the experiment to measure overconfidence (pre-experimental and price-forecasting task bias scores) are highly correlated, thus both constructs measure the same phenomenon. We find evidence that overconfidence is decreasing in the course of the experiment, supporting the view that overconfidence is decreasing with experience (see Menkhoff et al., 2006; opposite results have been reported by Kirchler and Maciejovsky, 2002).

Analysis of five bubble measures (NPD, NAD, Amplitude, Hassel-R2, and Velocity) revealed that in the markets formed of overconfident subjects bubbles are more likely to occur and that they are significantly larger in magnitude than in rational markets. Large and significant correlation between bubble measures and measures of overconfidence provide additional evidence that overconfidence has significant effect on price and trading behavior in experimental asset markets. Comparison of the selected bubble measures to measures obtained in related experiments suggests that there is evidence of smaller deviations from the fundamental value in our rational markets than in previous studies. Therefore, we may conclude that overconfidence is a dominant factor for the occurrence of stock-price bubbles.

References

Ackert, L. F., Charupat, N., Deaves, R., Kluger, B. D., (2009), Probability Judgment Error and Speculation in Laboratory Asset Market Bubbles. Journal of Financial and Quantitative Analysis, Vol. 44(03), p. 719-744.

Barber, B., Odean, T., (2001), Boys Will Be Boys: Gender, Overconfidence and Common Stocks Investments. Quarterly Journal of Economics, Vol. 116(1), p. 261-292.

Benos, A., (1998), Aggressiveness and Survival of Overconfident Traders. Journal of Financial Markets, Vol. 1, p. 353-383.

Biais, B., Hilton, D., Mazurier, K., Pouget, S., (2005), Judgmental overconfidence, self-monitoring and trading performance in an experimental financial market. Review of Economic Studies, Vol. 72(2), p. 287-312.

Caballé, J. and Sákovics J., (2003), Speculating Against an Overconfident Market. Journal of Financial Markets Vol. 6, p. 199-225.

Cohen, J., (1988), Statistical Power Analysis for the Behavioural Sciences (2nd ed.). New Jersey: Lawrence Erlbaum, 567 p.

Daniel, K., Hirshleifer D., Subrahmanyam A., (1998), Investor Psychology and Security Market Under-And Overreactions. Journal of Finance, Vol. 53(6), p 1839-1885.

Daniel, K. D, Hirshleifer, D., Subrahmanyam, A., (2001), Overconfidence, arbitrage, and equilibrium asset pricing. Journal of Finance, Vol. 56 (3), p. 921–965.

Deaves, R., Lüders, E., Luo, G. Y., (2009), An Experimental Test of the Impact of Overconfidence and Gender on Trading activity. Review of Finance, Vol. 13(3), p. 555–575.

De Bondt, W. F. M., Thaler R., (1985), Does the Stock Market Overreact? The Journal of Finance, Vol. 40(3), p. 793-805.

De Long, J. B., Shleifer, A., Summers, L. H., Waldmann, R. J., (1991), The Survival of Noise Traders in Financial Markets. The Journal of Business, Vol. 64(1), p. 1-19.

Dufwenberg, M., Lindqvist, T., Moore, E., (2005), Bubbles and Experience: An Experiment, The American Economic Review, Vol. 95(5), p. 1731-1737.

Fischbacher, U., (2007), z-Tree: Zurich Toolbox for Ready-made Economic Experiments. Experimental Economics, Vol. 10(2), p. 171-178.

Gervais, S., Odean, T., (2001), Learning to be Overconfident. Review of Financial Studies, Oxford University Press for Society for Financial Studies, Vol. 14(1), p. 1-27.

Glaser, M., Weber, M., (2007), Overconfidence and trading volume. The Geneva Risk and Insurance Review, Vol. 32(1), p. 1-36.

Haruvy, E., Lahav, Y., Noussair, Ch., (2007), Traders' Expectations in Asset Market: Experimental Evidence. Working Paper.

Hemert, D. A. v., Baerveldt, C., & Vermande, M.,(2001), Assessing Cross-Cultural Item Bias in Questionnaires. Acculturation and the Measurement of Social Support and Family Cohesion for Adolescents. Journal of Cross-Cultural Psychology, Vol. 32(4), p. 381-396.

Hirshleifer D., Subrahmanyam, A., Titman S., (1994), Security Analysis and Trading Patterns When Some Investors Receive Information Before Others. Journal of Finance, Vol. 49(5), p. 1665-1698.

Kim, A. K., Nofsinger, J. R., (2003), The Behavior and Performance of Individual Investors In Japan. Working paper.

Kirchler, E., Maciejovsky, B., (2002), Simultaneous Over- and Underconfidence: Evidence from Experimental Asset Markets. Journal of Risk and Uncertainty, Springer, Vol. 25(1), p. 65-85.

Klayman, J., Soll., J. B., Gonzáles-Vallejo, C., Barlas, S., (1999), Overconfidence: it depends on how, what, and whom you ask. Organizational Behavior and Human Decision Processes, Vol. 79(3), p. 216-247.

Kline, P., (1993), The Handbook of Psychological Testing. London; New York: Routledge, 627 p.

Lakonishok, J., Shleifer, A., Vishny, R. W., (1992), The Impact of Institutional Trading on Stock Prices. Journal of Financial Economics, Elsevier, Vol. 32(1), p. 23-43.

Milgrom, R., Stokey N., (1982), Information, Trade and Common Knowledge. Journal of Economic Theory, Vol. 26(1), p. 17-27.

Menkhoff, L., Schmidt, U., Brozynski, T., (2006), The Impact of Experience on Risk Taking, Overconfidence, and Herding of Fund Managers: Complementary Survey Evidence. European Economic Review, Vol. 50(7), p. 1753-1766.

Noussair, Ch., Tucker, S., (2006), Futures Markets and Bubble Formation in Experimental Asset Markets. Pacific Economic Review, Vol. 11(2), p. 167–184.

Odean, T., (1998), Volume, Volatility, Price and Profit When All Traders are Above Average. Journal of Finance, Vol. 53(6), p. 1887 -1934.

Odean, T., (1999), Do Investors Trade Too Much? American Economic Review, Vol. 89(5), p. 1278-1298.

Porter, D., Smith, V., (1995), Futures Contracting and Dividend Uncertainty in Experimental Asset Markets. Journal of Business, Vol. 68, p. 509–541.

Pulford, B. D., Colman, A. M., (1997), Overconfidence: Feedback and Item Difficulty Effects. Personality and Individual Differences, Vol. 23(1), p. 125-133.

Russo, J. E., Schoemaker, P. J. H., (1992), Managing Overconfidence. Sloan Management Review, Vol. 33, p.7-17.

Scheinkman, J. A., Xiong, W., (2003), Overconfidence and Speculative Bubbles. Journal of Political Economy, Vol. 111, p. 1183-1219.

Shiller, R. J., (2000), Irrational Exuberance. Princeton, N.J.: Princeton Univ. Press, 344 p.

Smith, V. L., Suchanek G. L., Williams A. W., (1988), Bubbles, Crashes, and Endogenous Expectations in Experimental Spot Asset Markets. Econometrica, Vol. 56(5), p. 1119-1151.

Statman, M., Thorley, S., Vorkink, K., (2006), Investor Overconfidence and Trading Volume. Review of Financial Studies, Vol. 19, p. 1531–1565.

Van Boening, M., Williams A., LaMaster, S., (1993), Price Bubbles and Crashes in Experimental Call Markets. Economics Letters, Vol. 41, p. 179–185.

APPENDIX A: BIAS SCORE OF THE VARIOUS (EXPERIMENTAL) SUBGROUPS

Pre-experimental Test					
OBS	Group	Mean	SD	Min	Max
201	All	11.78	10.57	-11.33	43.50
93	Female	9.62	10.68	-11.33	38.89
108	Male	13.37	10.28	-10.28	43.50
	Male vs. female diff.	3.75 (0.57)	--	--	--
Experiments					
OBS	Group	Mean	SD	Min	Max
60	All	11.20	12.08	-5.89	43.50
25	Female	9.96	12.45	-5.89	38.89
35	Male	12.08	11.91	-4.72	43.50
30	Overconfident	21.33	8.26	10.17	43.50
30	Rational	1.06	4.03	-5.89	6.78
	Male vs. female diff.	2.13 (0.81)	--	--	--
	Overconfident vs. rational diff.	20.27 (0.00)	--	--	--
OVE market	Male vs. female diff.	-0.65 (0.64)	--	--	--
RAT market	Male vs. female diff.	0.68 (0.76)	--	--	--

APPENDIX B: TRANSLATION OF INSTRUCTIONS

INSTRUCTIONS

In this experiment we are going to create a market in which you will trade units of a fictitious asset (i.e. "shares" of a "stock") that earn a dividend over a series of trading periods. The instructions are simple, and if you follow them carefully and make appropriate decisions YOU MAY EARN A CONSIDERABLE AMOUNT OF MONEY which will be PAID TO YOU IN CASH at the end of the experiment.

The currency used in the market is called Gulden. All trading and earnings will be in terms of Guldens. At the end of experiment, the Guldens that you have accumulated will be converted to euros at the exchange rate of 0.27 EUR for each 10 Guldens and you will be paid in euros. Note that the more Guldens you earn, the more euros you get!

Duration of the experiment

The market will take place over a sequence of 15 trading periods. You may think of each trading period as a "business or trading day". Each trading period has a maximum length of 180 seconds at which time the market will close for that period. The remaining time left in each period will be shown by a clock on your computer screen.

The market period can be ended before the trading time expires by a UNANIMOUS vote of all participants in the market to end trading for that period. This alternative stopping rule allows the group as a whole to bypass the usual 180 second stopping rule. Each participant can vote by pressing the key labeled VOTE. Pressing VOTE and thus voting to end that market period does not eliminate you from participating further in trading for that period; it simply says that you are ready to end trading in the current period and move on to the next period.

Initial Endowments of Participants

Each trader at the beginning of the trading game is endowed by STARTING CAPITAL equal to 300 Guldens and 3 units of assets. During the experiment you may purchase or sell assets. At the END of each trading period you will receive a DIVIDEND on EACH UNIT asset unit in your inventory.

Dividend Process

You will not know the exact value of your dividend per unit prior to the end of each trading period. At the end of each trading period you will be told the value of your dividend per unit

and your dividend earnings (dividend earnings = assets × dividend per unit). They will be added to your working capital.

Your dividends are drawn randomly each period. The possible values of your dividend per unit and the associated probability of occurrence are given below:

dividend	0.0 Gulden	0.8 Gulden	2.8 Gulden	6 Gulden
probability	1/4	1/4	1/4	1/4

Thus, the average dividend over many draws is 2.4 Gulden (=0.0*1/4+0.8*1/4+2.8*1/4+6*1/4)

Before each trading period information on potential income from holding your assets till the end of the experiment (15th period) is provided to assist you in formulation of your market decisions. The following information is given to you: maximum, average and minimum possible dividends (the same in each period), and maximum, average and minimum earnings per inventory unit over the remaining experiment periods.

Reward scheme

Your decisions regarding the purchase and sale of asset units and your end-of-period inventory level (dividend earnings = dividend per unit × end-of-period inventory) should rest on the fact that at the end of the experiment your cash earnings are based on your final working capital which equals:

(300 Gulden starting capital) + (dividend earnings) + (asset sales revenue) - (asset purchase cost).

At the end of the game your assets have no value!

The rules of the Experimental Market

Suppose we open the market for Trading Period 1 and that you wish to enter your bid or offer. To enter bid (price at which you wish to buy an asset): type in the price for which you wish to buy an asset. Then click the box labeled “ENTER BID”. To enter offer (price at which you wish to sell an asset): type in the price at which you wish to sell your asset and then click on the box “ENTER OFFER”.

Notice that bids are going to be ranked in the decreasing order on the right side of the screen, and sale offers in the increasing order on the left-hand side of the screen.

Suppose now, that you wish to accept Seller’s offer and purchase one unit of the asset. To do this first click the appealing price, standing in the column named “SALES OFFERS”, and

then click the button labeled “ACCEPT OFFER”. If you wish to accept Buyer’s bid click on the appealing price, standing in the column “BIDS” and then click the button labeled “ACCEPT BID”. Note that after a contract has been made, all bids and offers are erased and a new auction begins.

Upon buying/selling one unit of the commodity the transaction price (sales or purchase) will be added to (if you have sold), or subtracted from (if you have bought) your working capital immediately, same is valid for the assets’ inventory.

Your inventory at the end of a trading period is carried over to the beginning of the next trading period. At the end of each trading period your working capital will be increased by the amount of your dividend earnings (dividend earnings = number of units in your inventory × dividend per unit).

You can buy asset units as long as your working capital is greater than or equal to the purchase price. If you attempt to enter a bid or accept a seller’s offer that is greater than your working capital, the action will be ignored and you will receive an error message on your display screen. You can sell assets as long as your inventory is greater than zero. If you attempt to enter an offer or accept a buyer’s bid, when you have no assets in your inventory, the action will be ignored and you will receive an error message on your display screen.

Market Information

At the end of each trading period you will have the opportunity to see the market price summary information from the past trading periods, which will include such information as average market contract price, the highest, and the lowest market price, volume traded and dividend for that period.

Additional Means to Earn

At the end of each trading period you will be asked to enter a forecast of the average contract price in the next trading period. Information on the current period's mean price will be available for your inspection prior to entering a forecast. Information on your forecasting accuracy, consisting of the actual price, and your price forecast from the past periods will be available to your inspection after entering a forecast.

You will be paid for your predictions, based on their accuracy. The closer the prediction is to the actual average market price, the higher is the reward. Reward scheme for predictions' accuracy:

Level of Accuracy	Earnings
+/- 5% from the actual price	3 Gulden
+/- 12.5% from the of actual price	1 Gulden
+/- 25% from the actual price	0,5 Gulden

Your income from "forecasting part" will be converted to euros at the same rate as mentioned above and paid to you at the conclusion of the experiment.

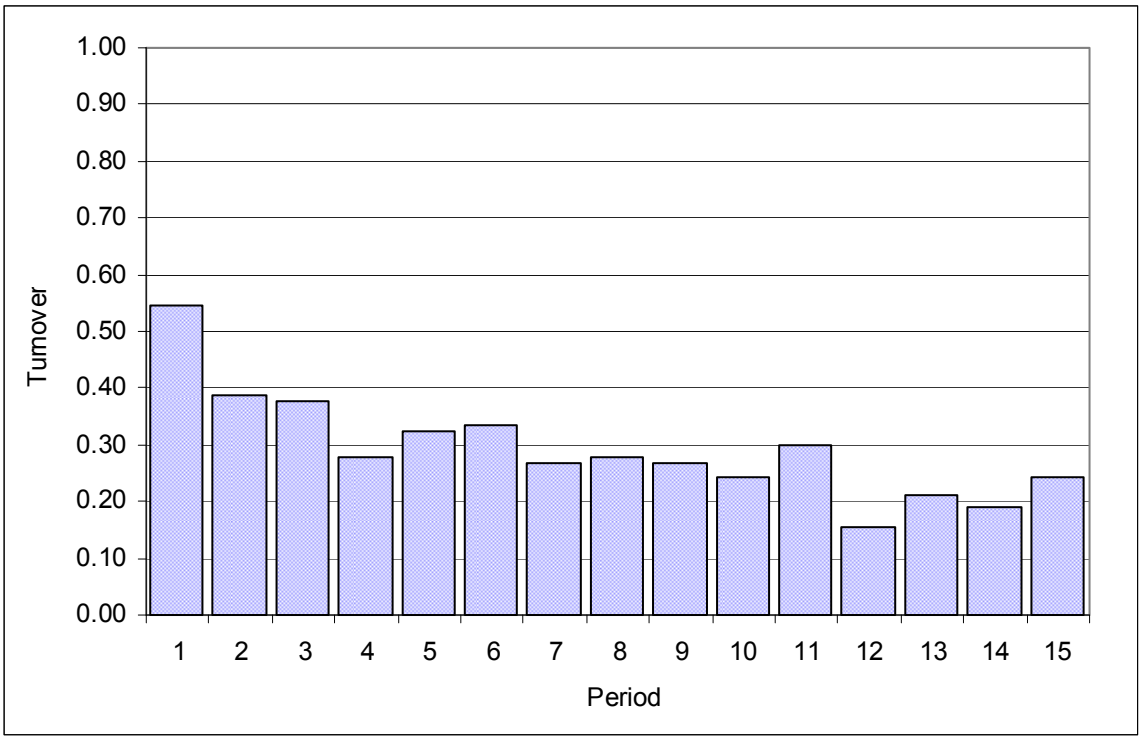
In the gap marked "Confidence level" you have to write how confident you are that your price forecast is correct! You can use any number between 0% and 100% to express your confidence, that your forecast is correct. Thus 0% means that you completely do not believe that your forecast can be true, and 100% means that you are completely sure that your Forecast will be correct.

This is the end of the instructions!

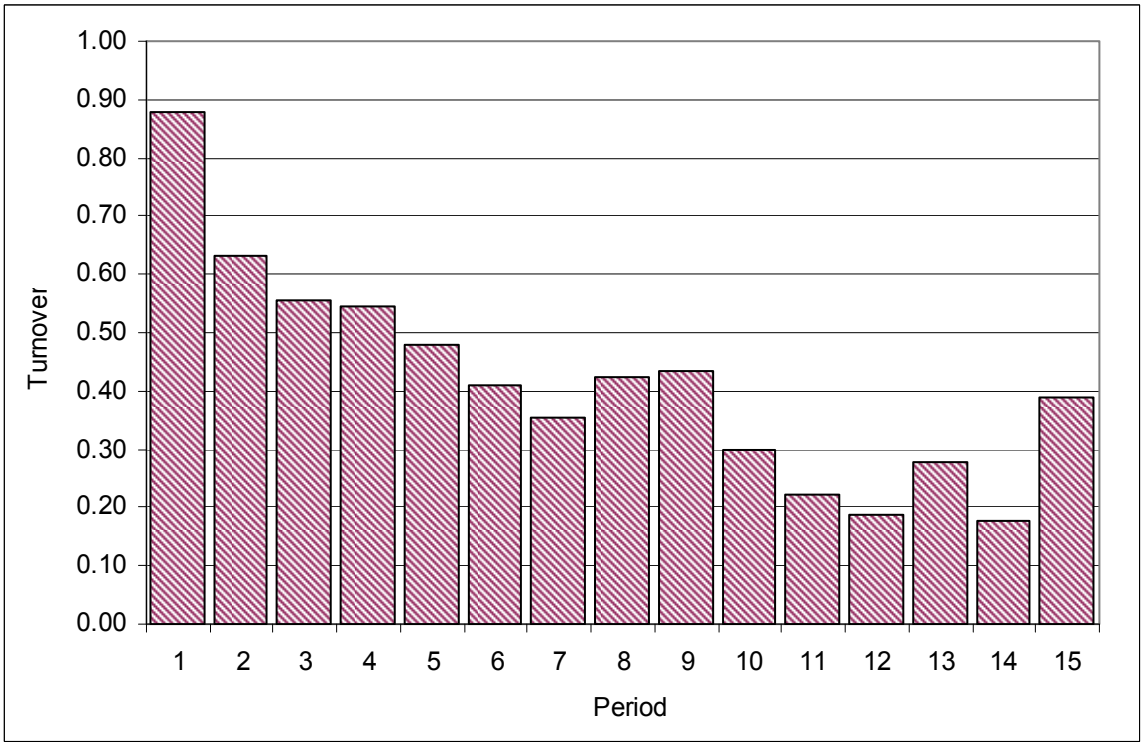
If you have a question that was not fully answered by the instructions please raise your hand and ask the experiment monitor before proceeding.

BEWARE! YOUR EARNINGS MAY SUFFER IF YOU PROCEED INTO THE MARKETPLACE WITHOUT UNDERSTANDING THE INSTRUCTIONS!

APPENDIX C: JOINT AVERAGE TURNOVER DEVELOPMENT (a. Rational market, b. Overconfident market)



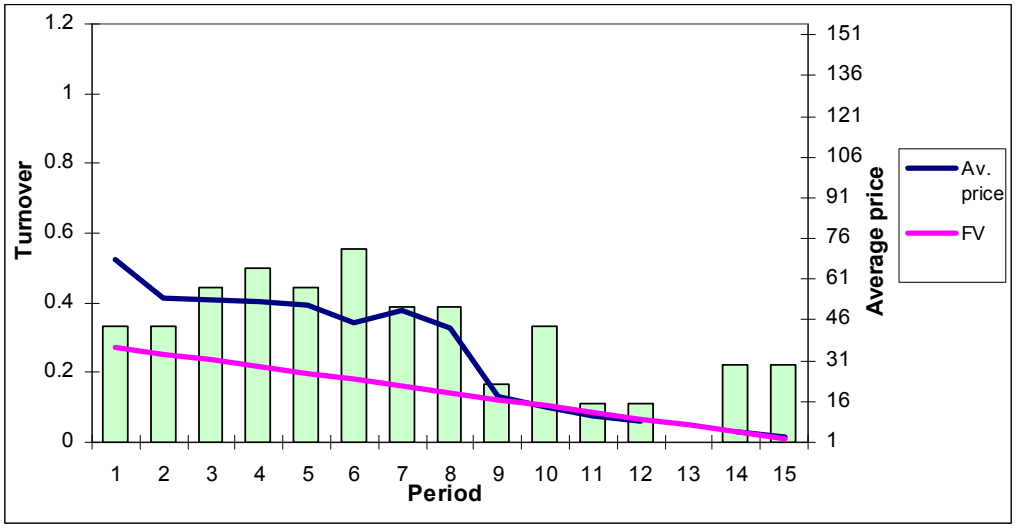
a.

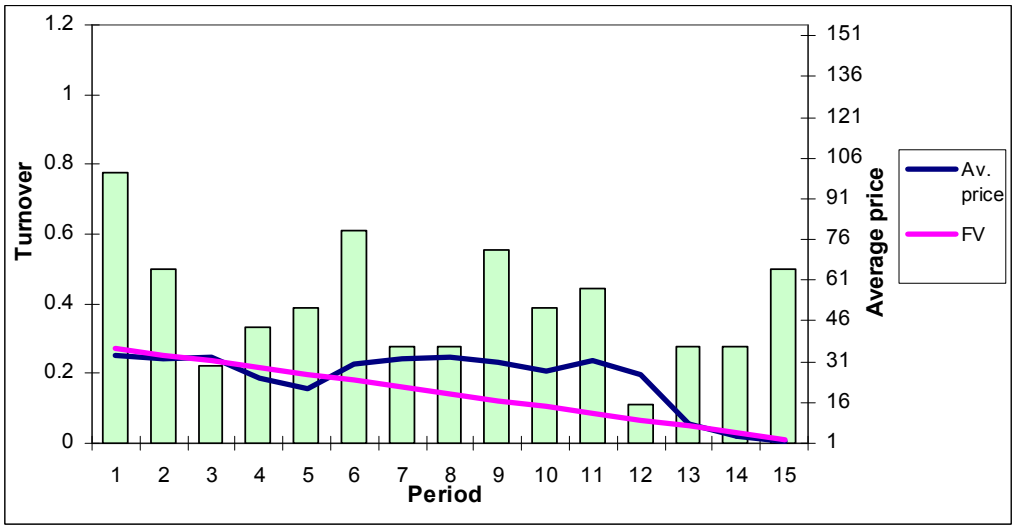


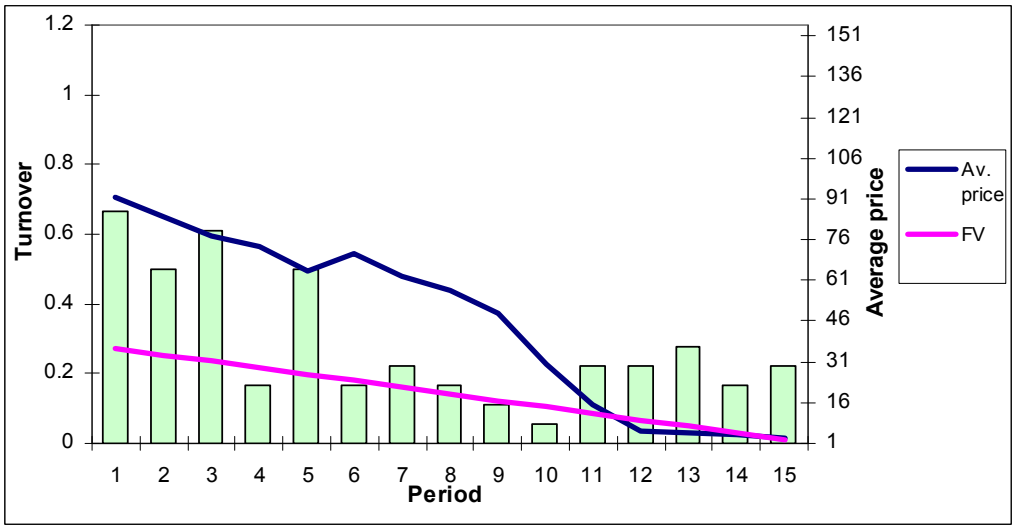
b.

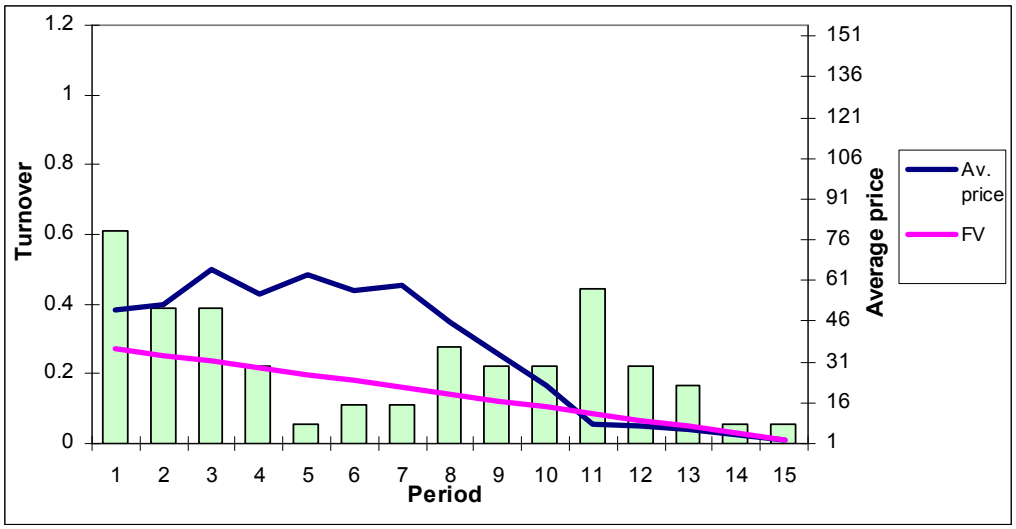
APPENDIX D: DEVELOPMENT OF AVERAGE PRICE AND TRADE VOLUME IN EACH MARKET

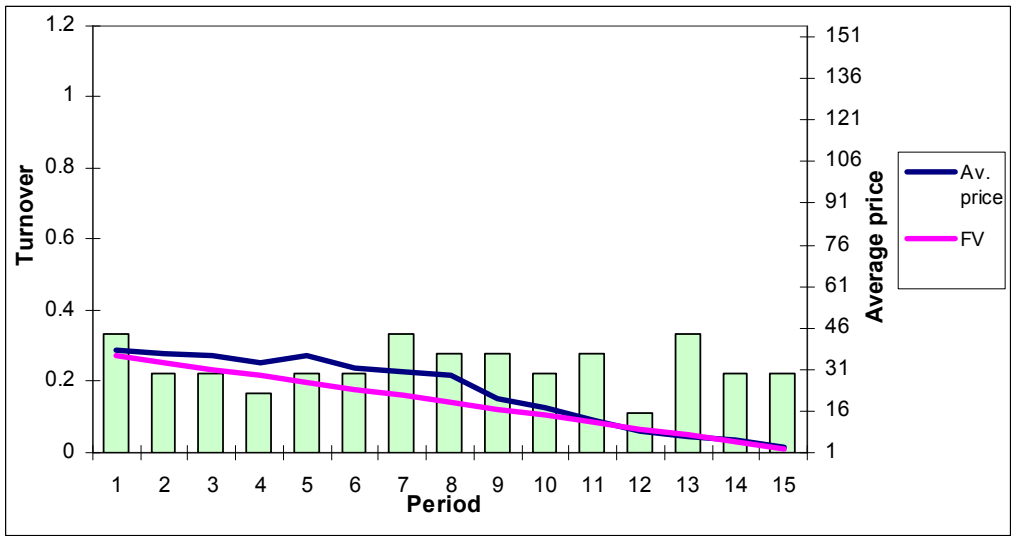
Rational Markets

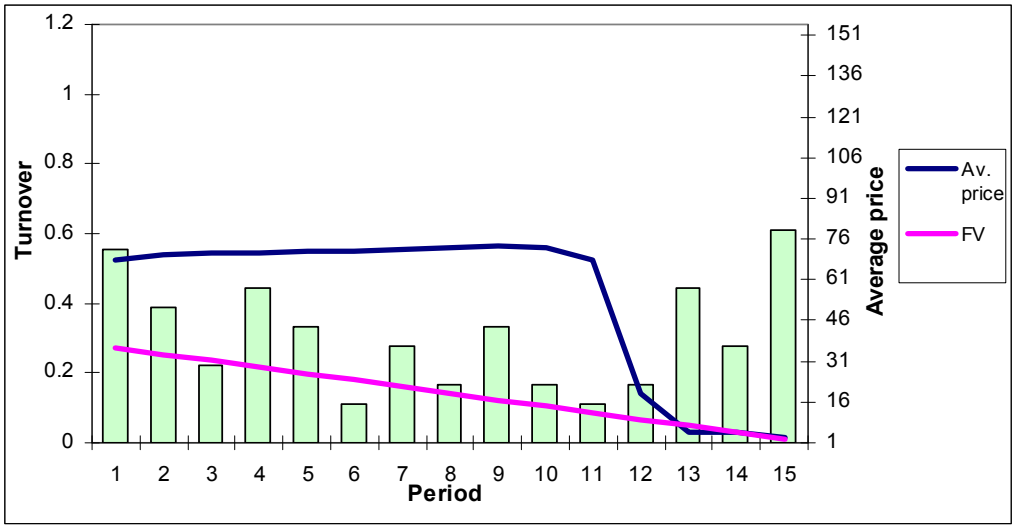


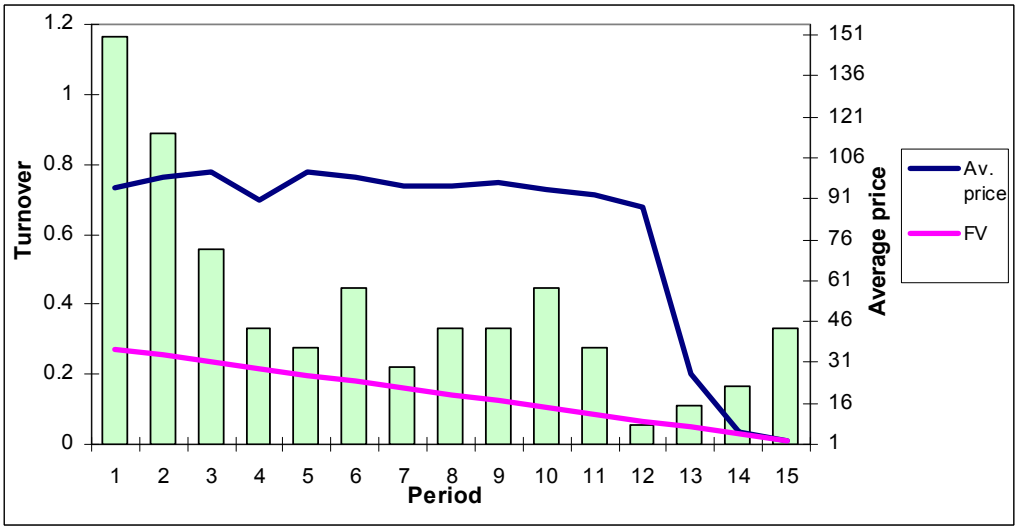


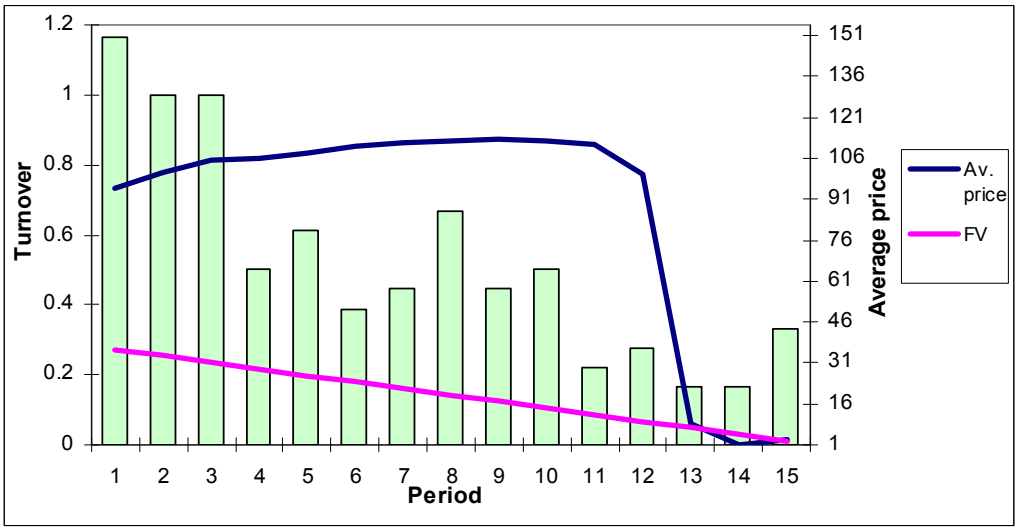


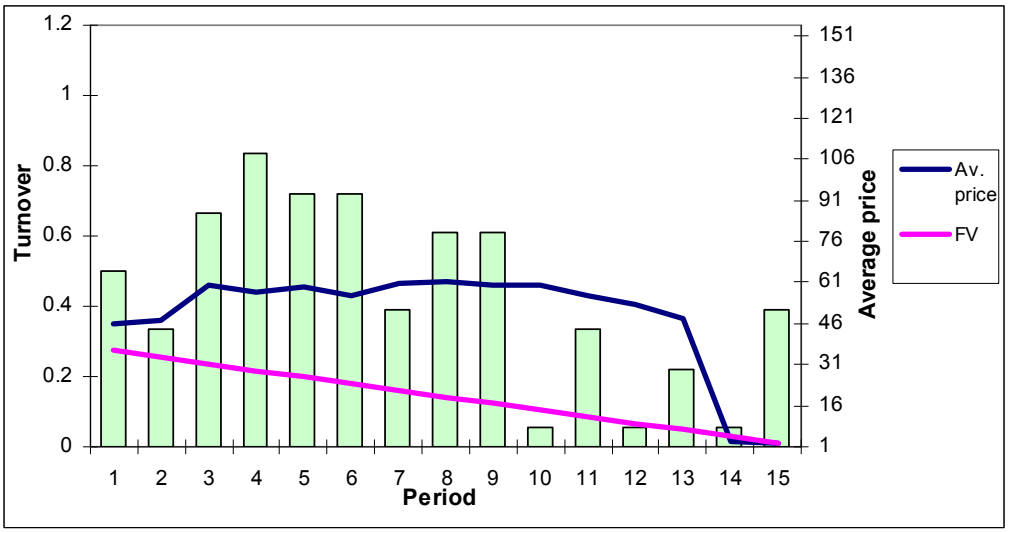

1.2
1
0.8
0.6
0.4
0.2
0
Turnover
151
136
121
106
91
76
61
46
31
16
1
Average price
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Period
Av. price
FV

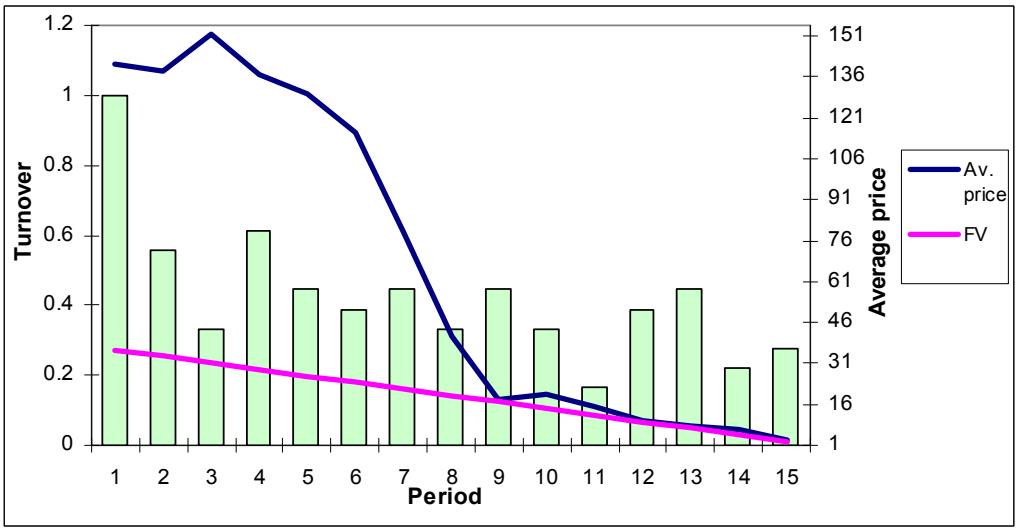

1.2
1
0.8
0.6
0.4
0.2
0
Turnover
151
136
121
106
91
76
61
46
31
16
1
Average price
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Period
Av. price
FV


Turnover
Average price
Period
Av. price
FV


Turnover
Average price
Period
Av. price
FV


Turnover
Average price
Period
Av. price
FV


1.2
1
0.8
0.6
0.4
0.2
0
Turnover
151
136
121
106
91
76
61
46
31
16
1
Average price
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Period
Av. price
FV


1.2
1
0.8
0.6
0.4
0.2
0
Turnover
151
136
121
106
91
76
61
46
31
16
1
Average price
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Period
Av. price
FV

APPENDIX E: SPEARMAN'S RHO CORRELATION COEFFICIENT BETWEEN BIAS SCORES AND BUBBLE MEASURES

	BS (pre-experimental)	BS (forecasting)
Hassel R2	-0.770 ($p<0.05$, one-sided)	-0. 673 ($p<0.05$, one-sided)
NPD	0. 745 ($p<0.01$, one-sided)	0.636 ($p<0.05$, one-sided)
NAD	0. 745 ($p<0.01$, one-sided)	0.636 ($p<0.05$, one-sided)
Velocity	0. 717 ($p<0.01$, one-sided)	0.550 ($p < 0.1$, one-sided)
Amplitude	0. 661 ($p<0.05$, one-sided)	0.515 ($p<0.1$, one-sided)