



JENA ECONOMIC RESEARCH PAPERS



2012 – 058

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www.jenecon.de

ISSN 1864-7057

The JENA ECONOMIC RESEARCH PAPERS is a joint publication of the Friedrich Schiller University and the Max Planck Institute of Economics, Jena, Germany. For editorial correspondence please contact markus.pasche@uni-jena.de.

Impressum:

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Margin Trading Bans in Experimental Asset Markets

SASCHA FÜLLBRUNN and TIBOR NEUGEBAUER*

ABSTRACT

In financial markets, professional traders leverage their trades because it allows to trade larger positions with less margin. Violating margin requirements, however, triggers a margin call and open positions are automatically covered until requirements are met again. What impact does margin trading have on the price process and on liquidity in financial asset markets? Since empirical evidence is mixed, we consider this question using experimental asset markets. Starting from an empirically relevant situation where margin purchasing and short selling is permitted, we ban margin purchases and/or short sales using a 2x2 factorial design to allow for a comparative static analysis. Our results indicate that a ban on margin purchases fosters efficient pricing by narrowing price deviations from fundamental value accompanied with lower volatility and a smaller bid-ask-spread. A ban on short sales, however, tends to distort efficient pricing by widening price deviations accompanied with higher volatility and a large spread.

JEL Classification: C92, D70, G12

Keywords: Leverage, Asset Market, Price Bubble, Experimental Finance

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NEUGEBAUER: Luxembourg School of Finance, Faculty of Law, Economics and Finance, University of Luxembourg. We greatly acknowledge financial support from the Fonds National de la Recherche Luxembourg (PDR 09 044) und die Université Du Luxembourg (Project IDIAM). We like to thank participants of the ESA World Meeting in Copenhagen 2010, the ESA North American Meeting in Tucson 2010, the ESA Asia Pacific Meeting in Kuala Lumpur 2011 and seminar participants at Karlsruhe and Bochum. We further like to thank Abdolkarim Sadrieh and Andreas Nicklisch for supporting our experiments at the MaxLab and the BonnEconLabs, respectively. Further on we like to thank Daniel Cracau, Marina Schröder and Harald Wypior for lab assistance at the University of Magdeburg.

I. Introduction

The recent financial turmoil has reconfirmed that a major risk in financial markets lies in the bursting of speculative bubbles with tremendous effects on the global financial and economic system.¹ Political regulators attempt to limit bubble growth; but only in the aftermath of the bursting of the bubble, measures are taken to facilitate a soft-landing (e.g. short sale constraints). However, regulators can only have a positive impact on the life-cycle of a bubble, if they know how institutional changes affect prices in financial markets. Note that regulation is a double-edged sword since decision errors may lead from bad to worse.

Given the systemic risk posed by speculative bubbles and their long history, it may be surprising how little attention bubbles have received in the literature and how little understood they are. This ignorance is partly due to the complex psychological nature of speculative bubbles but also due to the fact that the conventional financial economic theory has ignored the existence of bubbles for a long-time. But even if theories on bubble cycles have empirical relevance, it is clear that the issues surrounding the formation and the bursting of bubbles cannot be analyzed with pencil and paper. Conclusions on bubble cycles must be backed with quantitative data analysis. Given the limited number of observed empirical market crashes and their non-recurring nature, an experimental analysis of bubble formation involving controlled and replicable laboratory conditions seems to be a promising way to proceed.

Margin requirement regulations suppose to serve as a control instrument for price bubbles. These requirements may affect the price-level, liquidity, volatility, and trading volume of the security and, thus, may be a good instrument to manage price bubbles. However, these regulations have repeatedly been debated since the stock-market bubble of the nineteen-twenties since free-market supporters suggested that these measures have no effect.² However, the empirical evidence is mixed, and so are the opinions about the effects of intervention by the policy maker.

We address the effects of margin requirement regulations using the standard design for experimental asset-market with salient rewards introduced by Smith, Suchanek, and Williams (1988). We propose the experimental approach to the study of policy regulations because we see considerable limitations to deal with these questions empirically. Since we must assume a high autocorrelation between

¹ In history, we have witnessed the bubble cycle following boom and bust in the real economy over and over again. See Kindelberger (2000) for a history of price bubbles.

² During these times we have witnessed bans of margin purchases (1946-1947 on all US-stocks) or of short-sales (2008-2010 for financial stocks in world markets) depending on the anxiety of the markets.

regulation measures and market phases, we lack the basis for a general conclusion on the impacts of the regulation based on empirical data.³ Independent observations, nevertheless, can be generated in the experimental laboratory. Our experimental design involves a 2x2 factorial design, where we manipulate the ability to margin purchase and to sell short. The experimental results indicate that margin purchasing hinders efficient pricing because a ban on margin purchasing reduces the deviation of market prices from fundamental value accompanied by reduced volatility and increased liquidity. Short selling, however supports efficient pricing because a ban on short selling amplifies the deviation of prices from fundamental value accompanied by increased volatility and reduced liquidity. Finally, we observe that margin trading leads to excessive risk taking, and some traders suffer from margin calls and went bankrupt.

The paper is organized as follows. Section II reviews the related literature, Section 0 presents the details of the experimental design and section IV reports the data analysis. In section V, we summarize our findings and provide concluding remarks.

II. Leverage in asset markets

“I guarantee you that if you want to get rid of the bubble, whatever it is, that [raising margin requirements] will do it. My concern is that I am not sure what else it will do.”

Greenspan, Sept. 24, 1996, Fed Policy Meeting

Do margin requirements have any effects on market prices? Fisher (1933) and also Snyder (1930) mentioned the importance of margin debt in generating price bubbles when analyzing the Great Crash of 1929. The ability to leverage purchases lead to a higher demand, ending up in inflated prices. The subsequently appreciated collateral allowed to leverage purchases even more. This upward price spiral was fueled by an expansion of debt. From the end of 1924, brokers' loans rose four and one-half times (by \$6.5 billion) and in the final phase broker's borrowings rose at more than 100% a year until the bubble crashed. Then, after the peak of the bubble, a debt spiral was initiated. Investors lost trust and started to sell assets. Excess supply deflated prices resulting in a depreciation of collateral. Triggered margin calls lead to forced asset sales pushing supply even further. An increase in defaults on debt, and

³ There have indeed been instances where regulations allow the collection of empirical market-data for the purpose of studying some of the addressed questions. One should, however, not forget that times in which regulations on margin requirements are debated or even changed are not independent of the general market situation.

short sales exacerbated supply and finally assets were being sold at fire sale prices. It only took 6 weeks to extinguish half of the total of brokers' credit. Finally, in 1934, the U.S. Congress established federal margin authority to prevent unjustifiable increases or decreases in stock demand since margin requirements can prevent dramatic price fluctuations by limiting leveraged trades on both sides of the stock market: extremely optimistic margin purchasers and extremely pessimistic short sellers.

A. Margin purchases

Margin purchases allow traders to leverage their portfolio by providing collateral (=margin).⁴ In the U.S., Regulation T gives the Federal Reserve Bank (Fed) the authority to control margin trading in that it may set *margin requirements*. These requirements define how much collateral a trader has to provide relative to debt. Since 1934, the Fed has been in charge of regulating margin requirements; and before 1974 it changed requirements 21 times before fixing it. However, active margin policy as a control for price bubbles has been debated already before the Fed was in charge. The empirical evidence about the impact of margin regulations is mixed, and so are the opinions about the effects of intervention by policy maker.⁵ While some studies claim that margin requirements indeed have an impact on prices, volatility and liquidity (Eckardt and Rogoff 1976, Grube, Joy, and Panton 1979, Lockett 1982, Hardouvelis 1988, Seguin 1990, Hardouvelis and Peristiani 1992, Lee and Yoo 1991, Shiller 2000a, Kofman and Moser 2001), others see no impact (Cohen 1966, Moore 1966, Largay and West 1973, Officer 1973, Kupiec 1989, Sentana and Wadhwani 1992).⁶ Not knowing the reasons for the adjustment of margin requirements during those times, it is debatable whether changing the margin requirements were effective or even necessary.⁷ Thus, the studies highlight the difficulties inherent in formulating a real-world margin regulation since the fear of regulatory intervention is that it may cause harmful unintended consequences. Recently, Geanakoplos (2009) mentioned that the ability to leverage should be regulated and not only

⁴ Some market innovations (e.g., futures and options) may circumvent the regulatory restrictions. However, to purchase assets, margin loan is cheaper and easier to handle than any other type of loan (Hardouvelis and Theodossiou 2002)

⁵ The mixed evidence is also present in future markets (e.g. Fische, Golderg, Gosnell, and Sinha 1990, Day and Lewis 1997, Hardouvelis and Kim 1995, Adrangi and Chatrath 1999, or Chen 2002)

⁶ Some argue that volatility leads margins and not the other way around (Schwert 1989, Hsieh and Miller 1990).

⁷ During his testimony before the Subcommittee on Domestic and International Monetary Policy of the House Committee on Banking and Finance in 2000, Robert Shiller declared those studies not to be convincing and that the Fed margin requirement changes were misaligned in comparison to his price-earnings ratio (Shiller 2000). Find the testimony on <http://archives.financialservices.house.gov/banking/32100shi.shtml>, 03. Dec. 2011.

money supply. Using a heterogeneous agent model, Fostel and Geanakoplos (2008) show that the ability to leverage purchases inflates prices because the ‘natural buyer’ has access to more capital.

Although some experimenters allow for borrowing money with a constant credit line (King, Smith, Williams, and Van Boening 1993, Ackert, Charupat, Church, and Deaves 2006), we seem to be the first to study the relationship between the ability to margin purchase, margin calls and pricing in an experimental asset market setting.

B. Short Sales

Academia and policy makers have no clear result in the discussion whether short selling drives down stock prices or contributes to market efficiency. However, the latter were not reluctant to ban short sales after the crash in 2008 (2008-2010 for financial stocks in world markets). In theory, short sales constraints hinder price discovery and may generate a divergence between prices and fundamental value (Miller 1977, Harrison and Kreps 1978, Duffie, Garleanu, and Pedersen 2002, Hong and Stein 2003, Hong, Scheinkman, and Xiong 2006, Wang 2011). However, in a somewhat different setting this is not true in Diamond and Verrecchia (1987), and other models find short-sales to have a mixed effect on prices (Jarrow 1980, Bai, Chang, and Whang 2006, Cao, Zhang, and Zhou 2007, Gallmeyer and Hollifield 2008, Lim 2011). Finally, Abreu and Brunnermeier (2003) point out that, rational arbitrageurs understand that the market will eventually collapse but meanwhile would like to ride the bubble as it continues to grow and generate high returns.

Empirical evidence indicates that prices tend to inflate when short-selling is restricted (Figlewski 1981, Senchack and Starks 1993, Danielsen and Sorescu 2001, Chen, Hong and Stein 2002, Lamont and Thaler 2003, Ofek and Richardson 2003, Jones and Lamont 2002, Cohen, Diether, and Malloy 2007, Harris, Namvar, and Phillips 2009, Frino, Lecce and Lepone 2011). But other studies find only a weak or no effect on prices (Boehmer, Jones, and Zhang 2008, Beber and Pagano 2010, Diether, Lee, and Werner 2009). Implemented restrictions lead to negative abnormal returns (Chang, Cheng, and Yu 2007, Boulton and Braga-Alves 2010, Boehmer, Huszar, and Jordan 2010, Chen and Rhee 2010, Boehmer and Wu 2010, Tseng 2010, Saffi and Sigurdsson 2011). Empirical studies on the influence of short-sale constraints on the volatility of stock returns are inconclusive. Some find that constraints increase volatility (Ho 1996), others that constraints decrease volatility (Chang et al. 2007) and some that constraints have an insignificant effect (Alexander and Peterson 2008, Diether, Lee, and Werner 2009).

Recent experimental evidence suggests short sale constraints to increase prices. Ackert et al. (2006) and Haruvy and Noussair (2006) find prices to deflate – even below fundamental value in the latter study – while King, Smith, Williams, and Van Boening (1993) find no effect. In a setting with information asymmetries, Fellner and Theissen (2006) find higher prices with short sale constraints but not depending on the divergence of opinion as predicted by Miller (1977). In a setting with smart money traders, Bhojraj, Bloomfield, and Tayler (2009) report short selling to exacerbate overpricing, even though it reduces equilibrium price levels. Hauser and Huber (2012) find short selling constraints with two dependent assets to distort price levels. Our design deviates from the previous studies in several but one important way: We use a more empirically relevant facility in that traders have to provide collateral facing the threat of margin calls.⁸

III. Experimental Design

A. Implementing the Smith, Suchaneck, and Williams (1988) design

We make use of the established asset market design of Smith, Suchaneck, and Williams (1988) (henceforth SSW), that is known to produce speculative price bubbles. This experiment has been replicated and the results have been reproduced in experimental laboratories all over the world.⁹ Table I

⁸ The mentioned studies make restricting assumptions on the ability to sell short. Subjects are not allowed to sell short more than a fixed number of shares, a penalty was imposed if short position were not covered until maturity, dividends were not paid by the short sellers (e.g. King et al. 1993), or subjects trade in two markets simultaneously where liquidity motive may lead to short sales when traders sell short in one market to have money to buy in the other market (Ackert et al. 2006, Hauser and Huber 2012).

⁹ Effects of different treatment variables on the bubble size and cycle length have been investigated including variations in the expected dividend payout (Noussair, Roubin, and Ruffieux 2001, Porter and Smith 2003, Smith, Van Boening, and Wellford 2000, Oechssler, Schmidt, and Schnedler 2007, Noussair and Powell 2008), changes in the subjects' initial endowment of assets and cash (Hussam, Porter, and Smith 2008), the use of tournament compensation for traders (James and Isaac 2000), repetitions with experienced subjects (Dufwenberg, Lindqvist, and Moore 2005, Haruvy, Lahav, and Noussair 2007, Hussam et al. 2008), multiple asset markets (Fisher and Kelly 2000, Oechssler et al. 2007, Ackert et al. 2006), different levels of insider information (Sutter, Huber, and Kirchler 2010) uninformative announcements (Corgnet, Kujal, and Porter 2008) and influences of cash supply (Caginalp, Porter, and Smith 2001). Other studies have investigated the effect of institutional changes, e.g. different trading mechanisms (Van Boening, Williams, and La Master 1993), the existence of a future markets (Porter and Smith 1995, Noussair and Tucker, 2006), derivative markets (Palan 2010) or limit pricing rules and brokerage fees (King et al. 1993). In another study, we also consider initial public offerings within this environment (Füllbrunn, Nicklisch, and Neugebauer 2012). Two facts seem to influence the bubble: Experience within the same cohort (Dufwenberg et al. 2005, Haruvy et al. 2007) and excess cash supply (Caginalp, Porter, and Smith 2001). Reasons for the bubble occurrence are the lack the common knowledge of rationality (Cheung et al. 2010), the active participation

summarizes the parameterization of the experiment. Traders have the ability to buy and sell shares when the market is open in each of 15 trading periods. Traders are endowed with shares and cash randomly assigned to one of three endowment classes. A common, uniformly distributed cash dividend is independently drawn after each period and automatically added to the shareholders' cash balance. Due to the constant expected dividend payment in each period, the share's intrinsic value equals the sum of the remaining dividend payments. We make use of an empirically relevant trading facility in the style of NASDAQ Workstation, where traders are able to submit limit orders and market orders to an order driven continuous electronic market with open order book.¹⁰ After the closing, the dividend payment is revealed and traders receive an information update on their account.

Table I. Parameterization

Notes: The table shows the parameterization of the experimental setting. The experimental currency is *Taler* and 1 Taler = 1 Eurocent.

Number of periods	15			
Duration of trading per period	180 seconds			
Assets	Shares, Cash			
Possible dividends in each period	0	8	28	60
Prob. of dividend to occur in each period	25%	25%	25%	25%
Expected dividend payment/period	24			
Fundamental Value in period t	$24 \times (16 - t)$			
Number of Traders	9			
Endowment class	I	II	III	
# of shares in class	3	2	1	
Cash at hand	225	585	945	
Endowment in expected terms	1305			

B. Implementing Margin Purchasing and Short Selling

We conducted four computerized treatments utilizing a 2x2 factorial design as displayed in Table II. Starting from an empirically relevant situation where margin purchases (in short MP) and short sales (in short SS) are permitted ('MP|SS'), we ban margin purchases in the 'NoMP|SS' treatment, ban short

hypothesis (Lei, Noussiar, and Plott 2001) or irrational subjects due to the misunderstanding of the decreasing fundamental value (Kirchler, Huber and Stöckl in press). However, several key findings of experimental asset markets have been confirmed by recent empirical findings in the Chinese warrant markets (Xiong and Yu 2011).

¹⁰ See for example <http://www.nasdaqtrader.com/TraderP.aspx?id=workstation#>. However, we do not use market maker. Detailed information on the trading rules and instructions can be found in the online supplement (<http://www.ru.nl/economics/@854977/pagina/#top>).

sales in the ‘MP|NoSS’ treatment, and ban both in the ‘NoMP|NoSS’ treatment, which is a replication of the SSW experiment. When margin trading is permitted, margin requirements are violated when debt exceeds collateral. Note that traders hold cash and shares, i.e. margin traders either have a negative cash balance (margin purchases) or negative share holdings (short sales).

Table II. 2x2 Experimental Design

Notes: The table shows the 2x2 treatments design. The treatment variable is i) the ability to have a negative cash balance m , and ii) the ability to have negative share holdings s .

		Margin Purchases	
		Permitted	Banned
Short Sales	Permitted	MP SS	NoMP SS
	Banned	MP NoSS	NoMP NoSS

Traders execute margin purchases when they purchase shares by using loan, collateralized with shareholdings evaluated at the current market value.¹¹ In this case, traders make a *bull market bet*, i.e. they borrow cash to buy shares, wait for the price to rise and sell them with a profit. However, a decline in prices depreciates collateral while keeping loan constant. When prices fall below a certain threshold, such that the loan exceeds the value of the shareholdings (i.e. $\text{debt} > \text{equity}$), a margin call is triggered. Immediately, i) the trader’s buttons are disabled, ii) outstanding orders are cancelled, and iii) the computer starts selling shares at the current market price until margin requirements are met again or until all shares have been sold.¹²

Traders execute short sales when they sell shares without holding them in their inventory, collateralized with sufficient cash at hand.¹³ In this case, traders make a *bear market bet*, i.e. they borrow shares to sell them in the market, wait for the price to decline, buy them back with a profit and return them. Note that the amount of debt equals the total amount the trader has to pay to buy back the outstanding shares. Thus, an increase in prices increases debt and reduces collateral (cash minus value of outstanding shares), simultaneously. When prices exceed a certain threshold, such that the amount to buy back outstanding shares exceeds collateral (i.e. $\text{debt} > \text{equity}$), a margin call is triggered. Immediately, i)

¹¹ We neglect interest rates. Note that currently the Fed sets the interest rate to almost zero percent.

¹² Note that with higher prices, a reevaluation of collateral may stop the forced sale.

¹³ We do not consider lending fees. See Duffie et al. (2002), Geczy et al. (2001), D’Avolio or Ofek and Richardson (2003) for studies on lending fees.

the trader's buttons are disabled, ii) outstanding orders are cancelled, and iii) the computer starts buying shares at the current market price until margin requirements are met again or until all short positions have been covered. Note that short sellers have to pay dividends for their short positions at the end of each period.¹⁴ After period 15, both long and short positions are worthless.¹⁵

In any case, a margin call can lead to bankruptcy. However, the consequences of a margin call hold even during bankruptcy, i.e. outstanding positions continuously being closed although subjects are bankrupt. This is different to any other asset market experiment considering leverage.¹⁶

C. Hypothesis

Although textbook theory neglects defaults on loans, recent models with heterogeneous agents argue that 'natural buyers' (or optimists) inflate prices when having sufficient funds from borrowing money (Fostel and Geanakoplos 2008). Permitting margin purchases endows the natural buyers with sufficient liquidity to express their optimistic beliefs by inflating prices. A ban, however, limits the access to additional funding by reducing the ability to inflate prices too much. Thus, we state our first hypothesis.

Hypothesis 1: A ban on margin purchases attenuates price bubbles.

Analogue argument holds for 'pessimistic' traders (Miller 1977, Harrison and Kreps 1978). Permitting short selling allows pessimistic traders to express their opinion in the market price, ending up in lower price levels. A ban, however, limits the pessimists' ability to incorporate their beliefs into prices and lets optimistic traders determine prices when pessimists ran out of shares. Thus, we state our second hypothesis.

Hypothesis 2: A ban on short sales enhances price bubbles.

D. Implementing the Design in the Lab

Subjects participated in two independent rounds, i.e. subjects interact when inexperienced, and when once-experienced within the same cohort under identical conditions. Before the first round started,

¹⁴ High dividend payments may lead to a margin call in the subsequent period. In this case, the computer automatically starts to cover positions right at the beginning of the next period.

¹⁵ We do not implement a penalty for holding shares until the end as in King et al. (1993).

¹⁶ Note that in the studies mentioned above bankrupt short sellers leave the shares in the market. In our design we buy them back. However, in any case the cash amount in the market is biased in comparison to a market without margin trading.

subjects participated in training periods and answered a computerized questionnaire. Payments equal the final cash balance from both rounds exchanged to Euro (100 Taler = 1 Euro) plus a show-up fee. The experiment was entirely computerized using zTree (Fischbacher 2007). Subjects were recruited using ORSEE (Greiner 2004).¹⁷

The experiments were conducted at the MaXLab of the University of Madgeburg and at the BonnEconLab of the University of Bonn.¹⁸ We recruited 279 students participating in 31 independent experimental market sessions, i.e. 7 sessions in NoMP|NoSS and 8 sessions in all others. We ran either two (18 subjects) or three (27 subjects) sessions in parallel. Due to the comprehension questionnaires, the session lasted between 3 and 3.5 hours. The sessions paid on average 26.60 Euro in MP|SS, 27.20 Euro in MP|NoSS and NoMP|SS, and about 26 Euros in NoMP|NoSS excluding show up fees. Note that the expected payout in each round equals 13.05 Euro.

IV. Experimental Results

In the following, we analyze the experimental data by comparing the market outcomes across and within treatments. For notation: *margin purchasers* are traders who buy on margin, *short sellers* are traders who sell short, and *margin traders* engage in margin purchasing and/or short selling. We consider a hypothesis to be significantly rejected at a significance level of 5% (weakly significant at a level of 10%).

A. Price Deviations from Fundamental Value

Figure 1 depicts the trajectory of average period price deviations from fundamental value for each treatment.¹⁹ The zero line represents the fundamental value, and positive values indicate prices exceeding the fundamental value. The shape of the markers indicate the margin purchase ban (diamonds = MP, circles = NoMP), and the color of the marker indicates the short sale ban (black = SS, white = NoSS). The trajectories form a bubble pattern, i.e. average prices start at or below fundamental value, increase

¹⁷ Since ORSEE tracks the history of student's participation at experiments, we only invited subjects who never participated in asset market experiments before.

¹⁸ We find no location and, thus, pool all data.

¹⁹ The trajectories for each session can be found in the online supplement (<http://www.ru.nl/economics/@854977/pagina/#top>). In 49 out of 930 periods no trades were executed. In the analysis we accordingly handle them as missing.

and reach a peak after intersecting the fundamental value, and finally crash down to fundamental value. The pattern is less pronounced when subjects are once experienced.

Comparing diamonds to circles, the figure suggest a ban on margin purchases to reduce bubble size if short sales are permitted (black) and if short sales are banned (white). Comparing black to white, the figure suggests a ban on short sales to increase bubble size if margin purchases are permitted (diamonds) and if margin purchases are banned (circles). The effect tends to hold even when subjects are once experienced; however, to a lesser degree.

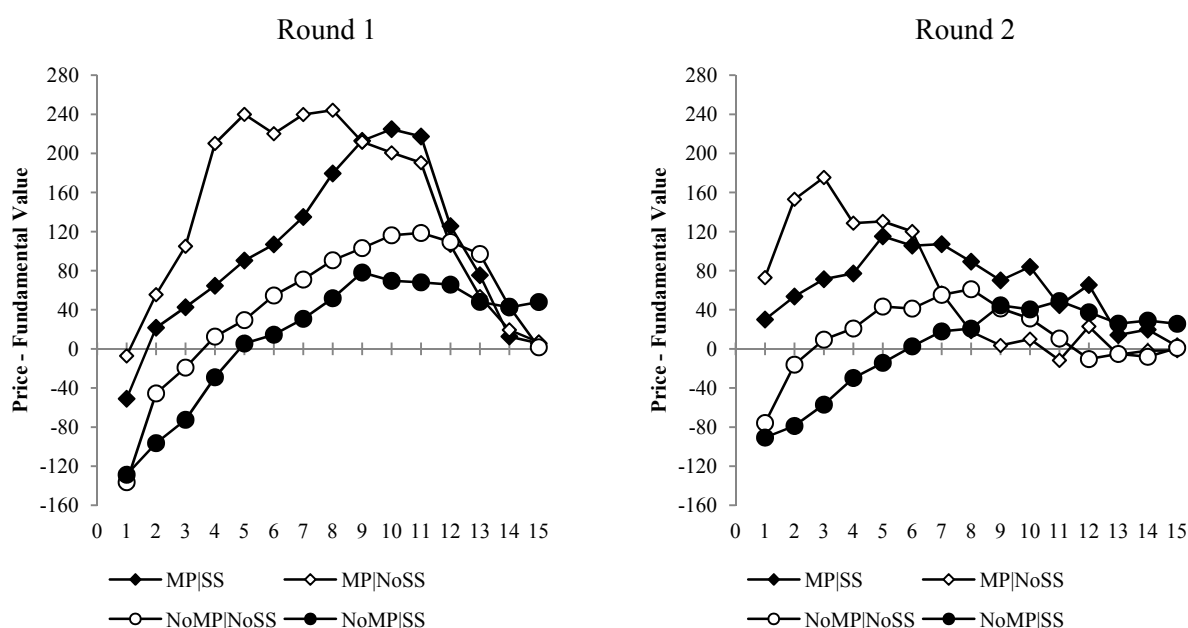


Figure 1. Deviation from fundamental value, by treatment.

Notes: Figures show the trajectory of average period prices minus fundamental value.

To measure the magnitude of speculative bubbles, we follow the recent experimental literature by considering the suggested measures from Stöckl et al. (2010): *Relative Absolute Deviation (RAD)* and

Relative Deviation (RD).²⁰ The first measure equals the average of the absolute per-period deviation of the average price from the fundamental value relative to the average fundamental value as given in (1); with $\bar{P}_t$ as the average price in period t , FV_t as the fundamental value in period t , and $\overline{FV}$ as the average fundamental value.²¹

$$\text{Relative Absolute Deviation} = \frac{1}{15} \times \sum_{t=1}^{15} \frac{|\bar{P}_t - FV_t|}{\overline{FV}} \quad (1)$$

A relative absolute deviation of $RAD = 0.15$ indicates prices on average to deviate about 15% from average fundamental value in either direction (henceforth, we say that the market is *mispriced* by 15%). The second measure equals the average of the per-period deviation of the average price from the fundamental value relative to the average fundamental value as shown in (2).

$$\text{Relative Deviation} = \frac{1}{15} \times \sum_{t=1}^{15} \frac{(\bar{P}_t - FV_t)}{\overline{FV}} \quad (2)$$

A relative deviation of $RD = 0.10$ indicates average period prices to exceed average fundamental value by about 10% (henceforth, we say that the market is *overpriced* by 10%). RD around zero indicates prices to track fundamental value. Both measures together give a clearer picture of the magnitude (RAD) and the direction (RD) of the price bubble. Further on, we consider *Boom Duration* which equals the highest number of consecutive periods where median prices exceed fundamental value (see Haruvy and Noussair 2006). The opposite measure is the *Bust Duration* which equals the highest number of consecutive periods where median prices undercut fundamental value. Table III shows the average of bubble measures for each treatment.²²

We further implement two additional measures that split the *Total Dispersion*, which summarizes the absolute price deviations from fundamental value, in two parts: *Positive Deviation* and *Negative Deviation*. The *Positive (Negative) Deviation* equals the area between prices and fundamental value above (below) fundamental value as indicated in (3) and (4); where $\tilde{P}_t$ equals the median price in period t , and $1_{PD,t}$ ($1_{ND,t}$) equals 1 if $\tilde{P}_t - FV_t > 0$ ($\tilde{P}_t - FV_t < 0$) and 0 otherwise.

²⁰ Stöckl et al. (2010) suggested alternative bubble measures to facilitate comparability across different experimental settings with different parameterizations. Palan (2009) compares several bubble measures used in the literature.

²¹ Thus, $\overline{FV} = \frac{1}{15} \sum_{t=1}^{15} (16 - t) \times 24 = 192$.

²² On (WEBPAGE of authors) we provide supplementary material on bubble measures on session level.

$$Positive\ Deviation = \sum_t |\tilde{P}_t - FV_t| \times 1_{PD,t} \quad (3)$$

$$Negative\ Deviation = \sum_t |\tilde{P}_t - FV_t| \times 1_{ND,t} \quad (4)$$

In the following, we discuss differences within and across treatments using these bubble measures. We make use of regression methods and statistical tests for the analysis.

Observation 1: While MP|SS, MP|NoSS, and NoMP|NoSS are overpriced, prices in NoMP|SS do not deviate significantly from fundamental value.

Support: Average overpricing is positive in all treatments in both rounds as can be seen in Table III; however, quite small for NoMP|SS. A one-sided t-test rejects the Null hypothesis that *RD* is below or at zero in MP|SS and in MP|NoSS, and in NoMP|NoSS only in round 1, but not in NoMP|SS. In sessions without price bubbles, *Boom Duration* and *Bust Duration* only differ by chance while in sessions with price bubbles *Boom Duration* systematically exceeds *Bust Duration*. A one-sided t-test rejects the Null hypothesis that *Boom Duration* is less than or equal to *Bust Duration* in treatments both rounds where margin purchasing is permitted and only in round 1 when margin purchases are banned. A one-sided t-test with similar arguments rejects the Null hypothesis that *Positive Deviation* is less than or equal to *Negative Deviation* in treatments where margin purchasing is permitted and only in round 1 when both is banned. However, we can in neither round reject the hypothesis for NoMP|SS.

Table III. Treatment average of observed bubble measures

Notes: This table reports the treatment average of observed bubble measures defined as in formulas (1), (2), (3), and (4). *Boom (Bust) Duration* equals the greatest number of consecutive periods that median transaction prices are above (below) fundamental values. *** p<0.01, ** p<0.05, * p<0.1 indicate significance levels according to a one-sided t-test evaluating the hypothesis that $X \geq 0$, where X indicates the bubble measure of interest. °°° p<0.01, °° p<0.05, ° p<0.1 indicate significance levels according to a one-sided t-test evaluating the hypothesis that $Bust\ Duration - Boom\ Duration \geq 0$ and that $Negative\ Deviation - Positive\ Deviation \geq 0$.

Round	Treatment	Relative Deviation	Relative Absolute Deviation	Boom Duration	Bust Duration	Positive Deviation	Negative Deviation
1	MP SS	0.508***	0.583	10.75	2.25°°°	1582	113°°°
	MP NoSS	0.723**	0.784	11.00	2.50°°°	2104	82°°°
	NoMP SS	0.068	0.363	7.50	4.88°	623	432
	NoMP NoSS	0.225**	0.395	10.43	2.86°°°	898	236°°
2	MP SS	0.326**	0.403	8.50	4.50°°	964	109°°
	MP NoSS	0.331**	0.403	9.00	3.75°°	907	101°°
	NoMP SS	0.003	0.279	4.63	6.13	410	389
	NoMP NoSS	0.059	0.200	5.86	6.86	357	174

Note that Haruvy and Noussair (2006) find prices to be below fundamental values when short selling is allowed in a likewise setting. Although *RD* is negative in some of our sessions, we cannot confirm their results. However, in Haruvy and Noussair (2006) subjects were required to maintain a minimum cash balance that equals the expected dividend stream of the short position held at the time to be able to pay dividends or the number of short sales were restricted. These strict rules lead to bankruptcies in all sessions without automatically covering the short positions (a short squeeze was not possible). As a consequence, the number of shares in the market in fact was increased and dividend payments for shorted shares have been paid by the experimenter until the end of the market.

Observation 2: Experience tends to reduce the bubble magnitude

Support: The literature reports bubbles to be reduced in magnitude or even to vanish in repetitions within the same cohort leaving parameters unchanged (e.g. Dufwenberg et al. 2005, Haruvy et al. 2007). To evaluate the experience effect, we consider the difference in bubble measures between rounds in any session as the relevant unit of observation. Average differences, shown in Table IV, are negative for *RD*, *RAD*, *Boom Duration*, and *Positive Deviation* and positive for *Bust Duration* and *Negative Deviation*, indicating bubbles to be smaller in round 2 than in round 1. According to a one sided t-test, we find the experience effect to be significant for almost all bubble measures in NoMP|NoSS; the SSW replication. We find no significant experience effect in NoMP|SS. A reason is that deviations from fundamental value are already quite small in round 1. For the remaining treatments, we find significant effects for some but not for all measures.

Table IV. Experience Effect

Notes: This table reports the average of the difference between bubbles measures between round 1 and round 2. Bubble measures are defined as in formulas (1), (2), (3), and (4). *Boom (Bust) Duration* equals the greatest number of consecutive periods with median transaction prices are above (below) fundamental values. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ indicate significance levels according to a one-sided t-test evaluating the hypothesis that $X_2 - X_1 \geq 0$, where X indicates the bubble measure of interest. For *Bust Duration* and *Negative Deviation* the Null hypothesis equals $X_2 - X_1 \leq 0$.

Treatment	Relative Deviation	Relative Absolute Deviation	Boom Duration	Bust Duration	Positive Deviation	Negative Deviation
MP SS	- 0.18	- 0.18	- 2.25**	2.25*	- 619*	- 4
MP NoSS	- 0.39**	- 0.38**	- 2.00	1.25	- 1197**	19
NoMP SS	- 0.06	- 0.08	- 2.88	1.25	- 213	- 43
NoMP NoSS	- 0.17**	- 0.19***	- 4.57***	4.00**	- 541***	- 61
TOTAL	- 0.20***	- 0.21***	- 2.87***	2.13***	- 645***	- 21

To analyze the between treatment effects, we consider random effect regression as given in (5).

$$X_{ir} = \alpha_0 + \alpha_1 BANSS + \alpha_2 BANMP + \alpha_3 R + \alpha_4 R \times BANSS + \alpha_5 R \times BANMP + v_i + \varepsilon_{ir} \quad (5)$$

The dependent variable X_{ir} equals the bubble measure of interest in each session i and round r . The institution dummies capture the effect of banning short sales ($BANSS = 1$) and banning margin purchases ($BANMP = 1$). The repetition dummy R equals 0 when subjects are inexperienced and 1 when subjects are once-experienced. The remaining variables incorporate the interaction effect. Finally, v_i indicates the time constant session specific error and ε_{ir} indicates the idiosyncratic error term that varies over time and over sessions. Table V shows the regression results for any bubble measure of interest.

Observation 3: Banning margin purchases decreases the bubble magnitude.

Support: A ban on margin purchases reduces average overpricing by about 44% (33% in round 2) when short selling is permitted and about 50% (27% in round 2) when short selling is banned. The regressions in Table V show a significant effect of the $BANMP$ coefficient for each bubble measure: the coefficient is significantly negative in RD , RAD , *Boom Duration* and *Positive Deviation*, and significantly positive in *Bust Duration* and *Negative Deviation*. Consistent with Observation 2, the round dummy indicates a lower bubble when once-experienced, with non-significant interaction effects. To consider within round effects of the ban, we use a t-test proposed by Haruvy and Noussair (2006). For the t-test, we consider the price deviation from fundamental value ($\tilde{P}_t - FV_t$) in each period averaged across all sessions in a treatment as the relevant unit of observation, using each period as an observation (yielding 15 observations for each comparison between treatments). In any round, we can reject the Null hypothesis that deviations from fundamental value are less than or equal to cases where margin purchasing is banned when short sales are permitted ($p < 0.010$ comparing $MP|SS$ to $NoMP|SS$) and when short sales are banned ($p < 0.040$ comparing $MP|NoSS$ to $NoMP|NoSS$).

Observation 4: Banning short sales tends to increase the bubble magnitude.

Support: A ban on short selling increases average overpricing by about 22% (0.5% in round 2) when margin purchasing is permitted and about 16% (1% in round 2) when margin purchasing is banned. The regressions in Table V show that the $BANMP$ coefficient is positive in RD , RAD , *Boom Duration* and *Positive Deviation*, and negative in *Bust Duration* and *Negative Deviation*. However, the coefficient is significantly different from zero only in *Boom Duration* and *Negative Deviation*. Applying the same t-test

as for Observation 3, we can reject the Null hypothesis that deviations from fundamental value are greater than or equal to cases where short selling is banned only in round 1; both when short margin purchases are permitted ($p = 0.022$ comparing MP|SS to MP|NoSS) and when margin purchases are banned ($p = 0.001$ comparing NoMP|SS to NoMP|NoSS). The latter result is in line with experimental results from Ackert et al. (2006) and Haruvy and Noussiar (2006) where margin calls are not possible.

Table V. Random Effect Regression on Bubble Measures

Notes: The table shows random effect regressions according to (5). The dependent variable is the bubble measure of interest (see Table III). The independent dummy variables capture the ban on institutions. *BANSS* equals 1 if short selling is banned (i.e. treatments MP|NoSS and NoMP|NoSS), and 0 otherwise. *BANMP* equals 1 if margin purchasing is banned (i.e. treatments NoMP|SS and NoMP|NoSS) and 0 otherwise. *R* equals 0 for round 1 and 1 for round 2. The remaining variables indicate the interaction effect of repetition and ban. Parentheses show robust standard errors, clustered on independent sessions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Relative Deviation</i>	<i>Relative Absolute Deviation</i>	<i>Boom Duration</i>	<i>Bust Duration</i>	<i>Positive Deviation</i>	<i>Negative Deviation</i>
<i>BANSS</i>	0.188 (0.139)	0.119 (0.132)	1.543* (0.795)	-0.845 (0.548)	402.075 (368.289)	-111.159** (53.224)
<i>BANMP</i>	-0.469*** (0.132)	-0.301** (0.126)	-1.957** (0.804)	1.530*** (0.554)	-1,078.425*** (349.792)	239.091*** (54.182)
<i>R</i>	-0.210* (0.122)	-0.200 (0.123)	-1.780 (1.091)	1.345 (1.188)	-679.114** (343.049)	5.636 (49.810)
<i>R x BANSS</i>	-0.158 (0.122)	-0.157 (0.120)	-0.690 (1.435)	0.810 (1.479)	-457.272 (345.195)	3.291 (70.757)
<i>R x BANMP</i>	0.173 (0.119)	0.138 (0.117)	-1.565 (1.407)	0.810 (1.491)	526.541 (335.026)	-58.772 (73.746)
Constant	0.522*** (0.083)	0.623*** (0.078)	10.103*** (0.656)	2.797*** (0.423)	1,642.056*** (224.482)	153.017*** (39.000)
Observations	62	62	62	62	62	62
Number of ind. Sessions	31	31	31	31	31	31
Wald	30.21	42.80	29.92	20.11	42.49	22.01
Prob > F	0.000	0.000	0.000	0.001	0.000	0.001

Observation 5: The margin purchase ban effect outweighs the short sale ban effect

Support: Overpricing is reduced by about 28% (27% in round 2) comparing MP|SS to NoMP|NoSS. Applying the same t-test as for Observation 3 confirms that differences between treatments are significant ($p < 0.001$ in both rounds). Together with Observation 3 and Observation 4, Observation 5 indicates that the price reduction effect of a margin purchase ban is stronger than the price enhancing effect of a short sale ban. Furthermore, Observation 1 supports the hypothesis that only with a margin purchasing ban, short selling allows for efficient pricing along the fundamental value (in line with Ackert

et al. 2006). When margin purchasing is permitted, however, short selling is not sufficiently strong to push prices to fundamental value.

B. Volatility and Liquidity

In the following, we compare the treatments market quality using measures of price volatility and liquidity. We measure volatility using the variance of period prices over all periods (*Variance*) as given in (6), since this is the most common measure of volatility and directly comparable to variance measures from empirical market studies (King et al. 1993, Palan 2009). Volume in period t is indicated by q_t while P_{it} equals the price of executed trade i in period t .

$$Variance = \frac{1}{\sum_{t=1}^{15}(q_t) - 1} \sum_{t=1}^{15} \sum_{i=1}^{q_t} (P_{it} - \bar{P}_t)^2 \quad (6)$$

Our first measure of liquidity is *Turnover*, measuring active trading as given in (7). Since in financial asset markets this turnover ratio is measured by daily volume divided by float, our measure equals the total number of executed trades (q_t) divided by the number of shares in the market, Q .²³

$$Turnover = \frac{1}{Q} * \sum_t q_t \quad (7)$$

Our second measure of liquidity is the (bid-ask-) *Spread*, measuring the average of the end of period bid-ask-spreads as shown in (8). A_t and B_t indicate the lowest ask and the highest bid at the closing of period t , respectively.²⁴

$$Spread = \frac{1}{15} \sum_{t=1}^{15} (A_t - B_t) \quad (8)$$

Treatment averages of these measures are provided in Table VI. To uncover the effect of bans on these measures, we ran random effects regressions according to (5) as can be seen in Table VII.

²³ King (1991) introduced this measure and it has become a standard measure for the SSW design. However, this measure indicates mispricing and was associated with higher bubbles. Our results show that this conjecture is misleading. See also a discussion in Palan (2009).

²⁴ Over all 930 periods we have 27 periods without a bid-ask-spread at the end of the market because in 14 periods no open bid was left at the end of the period and in 13 periods no open ask was left. For the analysis, we omit those periods.

Observation 6: Banning margin purchases tends to decrease *Volatility*, increase *Turnover* and the *Bid Ask Spread*.

Support: The treatment average of *Variance* in Table VI suggest that a margin ban leads to lower volatility, independent of the ability to sell short. The negative *BANMP* coefficient in Table VII – though not significantly different from zero – supports this effect. Comparing each round separately in a t-test using the average standard deviation of prices in each period as the relevant unit of observation, we find a significant effect of banning margin purchases only when short selling is banned independent on the experience level ($p < 0.050$).

Table VI. Observed measures on volatility and liquidity

Notes: This table reports the treatment average of observed bubble measures defined as in formulas (6), (7), and (8). Each posted value equals the treatment average.

Treatment/Round	<i>Variance</i>		<i>Turnover</i>		<i>Spread</i>	
	1	2	1	2	1	2
MP SS	748	245	6.03	4.06	24.31	24.72
MP NoSS	1166	803	4.83	2.36	44.79	38.38
NoMP SS	132	96	7.19	4.26	15.71	14.47
NoMP NoSS	898	102	4.73	2.86	24.76	37.92

Banning margin purchases increases *Turnover* only when short selling is permitted. However, when short selling is banned, the average difference does not seem pronounced. The positive *BANMP* coefficient in Table VII – though not significantly different from zero – supports the positive effect on *Turnover*. Comparing each round separately in a t-test using the average number of executed trades in each period as the relevant unit of observation, we find a significant difference only in round 1 when short selling is permitted ($p = 0.011$).

The treatment averages of *Spread* in Table VI suggest a lower bid-ask-spread when margin purchasing is banned. The negative *BANMP* coefficient in Table VII – though not significantly different from zero – supports the effect. Comparing each round separately in a t-test using the end of period bid-ask-spread averaged as the relevant unit of observation, we find the ban on margin purchases to significantly reduce the spread independent of short selling opportunities and experience level ($p = 0.074$ with NoSS in round 2 and $p < 0.040$ otherwise).

Observation 7: Banning short sales tends to increase *Volatility*, decrease *Turnover*, and the *Bid Ask Spread*.

Support: The treatment averages of *Variance* in Table VI suggest a short sale ban to increase volatility independent of the ability to margin purchase and experience level. The positive *BANSS* coefficient in Table VII – though not significantly different from zero – shows the average effect. Using the analogue t-test from Observation 6, we find a (weakly) significant effect on a short sale ban only when margin purchasing is permitted independent of experience level ($p < 0.060$). However, we find no such effect when margin purchasing is banned.

Table VII. Random Effects Regression of volatility and liquidity measures

Notes: The table shows random effects regressions according to (5). The dependent variable is the liquidity measure of interest as defined in Table VI. Table V provides further explanations regarding the independent variables. Parentheses show robust standard errors, clustered on independent sessions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)
	<i>Variance</i>	<i>Turnover</i>	<i>Spread</i>
<i>BANSS</i>	586.330 (405.155)	-1.810** (0.722)	14.512 (10.198)
<i>BANMP</i>	-447.768 (389.009)	0.549 (0.731)	-14.565 (9.628)
<i>R</i>	-285.195 (287.297)	-2.357*** (0.449)	8.039 (8.041)
<i>R x BANSS</i>	-295.083 (325.683)	0.260 (0.525)	-9.325 (11.140)
<i>R x BANMP</i>	32.058 (320.033)	-0.204 (0.532)	-4.156 (10.636)
Constant	663.606** (294.014)	6.340*** (0.760)	27.516*** (5.483)
Observations	62	62	62
Number of Ind. Sessions	31	31	31
Wald	10.28	91.85	14.12
Prob > F	0.068	0.000	0.015

In Table VI the average *Turnover* is lower when short selling is banned independent of the ability to margin purchase and experience level. The significantly negative *BANSS* coefficient in Table VII confirms this effect, and so does the analogue t-test from Observation 6 ($p < 0.03$).

The treatment averages of *Spread* in Table VI suggest a short sale ban almost to double the bid-ask spread independent of margin purchases and experience level. The positive *BANSS* coefficient in Table

VII – though, not significantly different from zero – supports the average effect. Using the analogue t-test from Observation 6, a ban on short sales significantly reduces the spread with and without margin purchasing opportunities when inexperienced ($p < 0.057$) and only without margin purchases when experienced (0.001).

C. Margin Trading

In the following, we give a brief insight into the occurrence of margin trading. As can be seen from Table VIII, subjects actively engage in margin trading. For example, in MP|SS, almost 30% of all executed trades were margin purchases or short sales. Almost 30% of the shares have been shorted during a round at least in one period, and in some periods the cash circulating in the market is increased by more than 25% when margin purchasing is permitted. To compare margin trading activity across treatments, we make use of a t-test where the number of executed short sales and the number of executed margin purchases in each period averaged across all sessions in a treatment is the relevant unit of observation, yielding 15 observations for each comparison between treatments per round. We find the number of executed short sales to be significantly higher when margin purchasing is banned; however, only in round 1 ($p = 0.008$). This indicates that short selling is perceived to be riskier when “optimists” have sufficient funds to push the price upwards when margin purchasing is allowed. Using the same test for executed margin purchases, we find the number of executed margin purchases to be significantly higher when short sales are permitted; however, only in round 2 ($p = 0.008$). One reason might be the increased supply of shares.

Table VIII. Treatment medians of observed measures on Margin Trading

Notes: Frequency of short sales, margin purchases, and margin trades equals the ratio of executed short sales, margin purchases, and margin trades as a percentage of volume, respectively. Short Interest equals the highest number of executed short sales as a percentage of float (i.e. 18). Ratio of Debt to Cash in Market equals the highest debt in a market divided by the cash available (sum of endowment + sum of dividend payments up to period t) in that period. Frequency of subjects who trade on margin count the number of subjects who executed a short sale or margin purchase at least once. The table depicts median of session values

	<i>Treatment</i>	<i>Frequency of Short Sales</i>	<i>Frequency of Margin Purchases</i>	<i>Frequency of Margin Trades</i>	<i>Short Interest</i>	<i>Ratio of Debt to Cash in Market</i>
Round 1	MP SS	0.11	0.16	0.29	0.305	0.26
	MP NoSS	.	0.16	0.16	.	0.27
	NoMP SS	0.12	.	0.12	0.275	.
Round 2	MP SS	0.19	0.20	0.37	0.305	0.22
	MP NoSS	.	0.24	0.24	.	0.27
	NoMP SS	0.18	.	0.18	0.305	.

Observation 8: The magnitude of margin purchases tends to have a reinforcing effect on the magnitude of the bubble.

Support: Experimental results suggest that providing excessive liquidity in terms of cash leads to higher bubbles (e.g. Caginalp et al. 2001). Margin purchases can be seen as an endogenous cash inflow in the market. In MP|NoSS, we consider the relationship between the highest cumulative period debt and *RD*. The Spearman rank correlation equals 0.762 ($p = 0.028$) in round 1 and 0.927 ($p < 0.001$) in round 2. Considering the number of executed margin purchases the spearman rank correlation equals 0.779 ($p = 0.023$) in round 1 and still 0.518 ($p = 0.188$) in round 2. Although the correlation coefficient is not significant in MP|SS, the results indicate a positive relationship between active margin purchasing and speculative bubbles. No such correlation can be found between active short selling and *RD*.

Margin trading is not without risk and the experimental results show that even in laboratory asset markets some traders bear too much of it. Table IX overviews margin calls and bankruptcies. Margin calls are not triggered in every session.²⁵ The average number of margin calls is lower than 5 across treatments and rounds. Three traders end up bankrupt after executing short sales in NoMP|SS, and seven traders end up bankrupt after executing margin purchases in MP|SS and MP|NoSS.

Table IX. Margin Calls and Bankruptcy

Notes: During a margin call the computer automatically submits an Ask or Bid if prices are such that equity is lower than debt. During a margin call, the computer automatically sells or purchases stocks until margin requirements are met again. If a subject does not have enough funds the margin call will lead to a bankruptcy. A subject is bankrupt, when the number of stock equals zero but debt is positive or when the number of stock is negative and money equals zero. The short sale (margin purchase) columns show the occurrence of margin calls and bankruptcies in treatments where short sales (margin purchases) are permitted.

	Short Sales		Margin Purchases	
	MP SS	NoMP SS	MP SS	MP NoSS
Number of Sessions with Margin Calls	6	6	4	4
Average number of Margin Calls Round 1	5.17	2.33	0.75	5.00
Average number of Margin Calls Round 2	2.17	3.00	2.00	3.50
Number of bankruptcies	0	3	4	3

²⁵ Note that the cash inflow from dividend payments reduce the probability of margin calls in margin purchase treatments, while the requirement to pay dividends increases the probability of margin calls in short sale treatments.

Observation 9: Margin traders tend to make less money than others

Support: By leveraging purchases and sales, traders take more risks to be able to make more money. But do margin traders make more money at all? To evaluate this question, we classify traders into types, i.e. *margin traders*, who trade on margin at least once, and others. Table X shows the average end-of round-earnings within types for each treatment along with the number of subjects. The spearman rank correlation between type and end of round earnings is negative in both rounds and in all three treatments. The coefficient is significantly different from zero only in MP|NoSS and NoMP|SS when subjects are once experienced ($\rho_{MP|NoSS} = -0.276$, $p = 0.019$; $\rho_{NoMP|SS} = -0.269$, $p = 0.022$). Subjects, who executed both margin purchases and short sales in MP|SS earned less than subjects who refrained from trading on margin. This is significant only for inexperienced subjects ($\rho_{MP|SS} = -0.360$, $p = 0.021$).

One final note on the distribution of earnings. Comparing the treatments by evaluating the dispersion of earnings using the coefficient of variation ($CV = \text{session mean of earnings} / \text{deviation of earnings}$), we find that the average CV in the NoMP|NoSS (0.47 in round 1 and 0.28 in round 2) is lower than any other treatment (MP|NoSS 0.54, NoMP|SS 0.51, MP|SS 0.53 in round 1 and MP|NoSS 0.41, NoMP|SS 0.38, MP|SS 0.41 in round 2). Although not statistically significant, the results indicate that it is less risky to participate in markets with margin bans than in the markets where margin trading is permitted.

Table X. Earnings

Notes: Earnings equal average money after final period. Subjects in category *Margin Purchase (Short sales)* purchased (sold) on margin at least once. Subjects in category *Both* purchased on margin at least once and executed a short sale at least once. Nnegative earnings are rescaled as zero earnings.

		Round 1		Round 2	
		# of Subjects	Earnings	# of Subjects	Earnings
MP NoSS	No margin trade	40	1448	46	1388
	Margin Purchases	32	1351	26	1204
NoMP SS	No margin trade	46	1271	49	1563
	Short Sales	26	1312	23	1134
MP SS	No margin trade	26	1423	27	1405
	Margin Purchases	23	1556	19	1172
	Shorts sales	8	1155	15	1365
	Both	15	1043	11	1263

D. Share Allocation

Finally, the question arises, whether bans have an impact on portfolio choice. According to the theoretical considerations of Fostel and Geanakoplos (2008) and Miller (1977), the optimistic traders hold the highest number of shares in their portfolio when they have the opportunity to do so. Since the ability to margin purchase increases the amount of cash necessary to buy more shares and the ability to sell short virtually increases the supply of shares in the market, both bans should decrease the number of shares held by optimists. Thus, a ban on margin purchases and a ban on shorts sales should lead to a more equal distribution of shares. To evaluate this hypothesis, we consider on one hand the *Share Dispersion* as indicated in (9), where Q equals the number of shares in the market and Q_{it} equals the number of shares held by trader $i \in \{1, \dots, n\}$. On the other hand, we consider the *Share Holdings* defined as the average number of shares held by the two traders with the highest share holdings.

$$ShareDispersion = \frac{1}{15} \sum_{t=1}^{15} \sqrt{\sum_{i=1}^n \frac{(Q_{it} - Q/n)^2}{(n-1)}} \quad (9)$$

Table XI. Share allocation

Notes: *Share Dispersion* is given by equation (9). *Share holdings* equals the average number of shares held by the two traders with the highest share holdings in each period. Parentheses show robust standard errors, clustered by independent sessions. *** p<0.01, ** p<0.05, * p<0.1.

Treatment/Round	Share Dispersion		Share Holdings	
	1	2	1	2
MP SS	2.87	2.97	11.61	11.99
MP NoSS	2.25	2.49	10.36	11.08
NoMP SS	2.69	2.62	10.54	10.96
NoMP NoSS	1.97	2.12	9.52	9.88

Observation 10: Both a ban on margin purchasing and a ban on short selling reduces the concentration of shares

Support: Table XI shows the treatment average of *Share Dispersion* and of *Share Holdings*. *Share Holdings* are lower when margin purchasing is banned and/or when short selling is banned. When margin purchasing and short selling is permitted, *Share Holdings* are about 11.5 shares, but only 9.5 when both

are banned. Furthermore, with a ban on margin trading, shares are more equally distributed than when margin trading is not banned since a ban on either institution reduces the *Share Dispersion*.²⁶

A random effects regressions based on (5) and presented in Table XII shows negative *BANSS* and *BANMP* coefficients in both regressions. Although, the *BANMP* coefficient in (1) is not significant, the results indicate an unequal distribution when margin trading is permitted and a more equal distribution when margin trading is banned. In case of short sales, the difference in *Share Dispersion* is quite straightforward since share holdings are negative for some traders. However, this does not explain why the traders with the highest share holdings have fewer shares when short selling is banned.

Table XII. Random Effects Regression on Share Allocation

Notes: The table shows random effects regressions according to (5). The dependent variable is the measure of interest as defined in Table XI. Table V provides further explanation on independent variables. Parentheses show robust standard errors, clustered by independent sessions. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)
	<i>Share Dispersion</i>	<i>Share Holdings</i>
<i>BANSS</i>	-0.669*** (0.241)	-1.138** (0.446)
<i>BANMP</i>	-0.223 (0.253)	-0.955** (0.460)
<i>R</i>	0.085 (0.195)	0.481 (0.617)
<i>R x BANSS</i>	0.174 (0.238)	0.146 (0.593)
<i>R x BANMP</i>	-0.134 (0.245)	-0.163 (0.597)
Constant	2.892*** (0.182)	11.552*** (0.405)
Observations	62	62
Number of Ind. Sessions	31	31
Wald	29.89	26.64
Prob > F	0.000	0.000

V. Conclusion and Discussion

In an attempt to halt the decline in asset values, recent regulatory measures temporarily banned short sales in financial markets. To assess the impact of banning leveraged trading on market mispricing is a complicated task when being reliant on data from real world exchanges only. The effects of margin

²⁶ Note that at the beginning of each round, the initial standard deviation of shares equals 0.87.

bans cannot be clarified; it is unclear if possible price increases following a ban on short sales would come from new long positions or from covered short positions, and the announcement of such measures affects an uncontrolled reaction of the market. Owing to the uncontrolled uncertainties in the real world, asset mispricing can be measured only with weak confidence.

Instead of facing the challenges involved in the real world data analysis, we have provided empirical evidence for the institutional effects of the ban on short sales and margin purchases from a laboratory study by using standard bubble and additional measures of market performance in the well-known experimental design by Smith et al (1988). To evaluate the impact of margin trading on markets, margin purchases or/and short sales are systematically banned in our 2x2 factorial design. Our main results are quite intuitive: a ban on margin purchases reduces price inflation, whereas a ban on short sales, conversely, tends to increase price inflation. Thus, an institutional ban on short sales can indeed affect an alleviation of depressed market valuations. Moreover, our experimental design has enabled us to compare the relative strengths of the effects of margin purchases and short sales. For our experimental setting it turns out that a ban on both short sales and margin purchases produces less inflated prices than when both are permitted. We can conclude that in our setting the effect of permitting short sales undercompensates the effect of permitting margin purchases. We also find that market liquidity is enhanced through a ban on margin purchases and worsened through a ban on short sales. Our findings suggest that short sales have a regulating effect on market liquidity and price inflation when margin purchases are permitted.

In comparison to other experimental studies where limits to margin debt and short sales are rare, our design involves margin requirements comparable to the real world. Highly levered investors face margin calls that lead to forced liquidation of positions, affecting a reinforcement of the swings of the market. We have studied the impact of leverage on individual portfolio decisions to find an increase in risk taking characterized by higher concentrations of risky assets eventually resulting in individual bankruptcies. Thus, our experimental results are in line with theories of margin trading by Irvine Fischer (1933) and by recent heterogeneous agents models (Geanakoplos 2009) which conjecture such effects on asset pricing and portfolio decisions.

As in any laboratory experiment, the results are restricted to the chosen parameters. The baseline Smith et al. (1988) asset market design has been challenged in recent studies (e.g. Kirchler et al. 2011), arguing that some subjects are confused about the declining fundamental value and believe that prices keep a similar level in the course of time. So it would also be interesting to investigate the effects of bans

of margin purchases and short sales, to see if our treatment effects can be repeated in an environment with non-decreasing fundamental values. However, recent experiments by Hauser and Huber (2012) show similar effects using multiple asset markets with a complex system of fundamental values but without margin calls. It would also be interesting to see how margin requirements change performance in multiple asset markets. We leave these open questions to future research.

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