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Can Concentration Control Policies Eliminate Bubbles?

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Abstract

We report the results of an experiment designed to study the effect of asset-holdings caps on the formation of bubbles and crashes in laboratory asset markets. Bubbles and crashes are a quite robust phenomenon in experimental settings. Motivated by concentration control policies employed in the Chinese real-estate market, we explore the effects of permanent and short-term caps on individual asset holdings. We find that permanent caps greatly reduce positive bubbles, but tend to generate negative bubbles in later periods. Under short-term caps, on the other hand, we observe no negative bubble in later periods. Furthermore, we also observe no positive bubbles. Our results indicate that concentration control policies can be effective in eliminating bubbles if properly designed.

JEL Classification

C90, D03, G02, G12, G18

Keywords

experimental asset markets
bubbles
concentration-control policies

1 Introduction

A bubble is defined as "trade in high volumes at prices that are considerably at variance with intrinsic values" (see King et al. (1993)). Commodity and financial asset market bubbles have a long history: the Dutch tulip mania (1634-1637), the South Sea Company Bubble (1720), the Roaring Twenties stock-market bubble (1922-1929), the Dot-com bubble (1995-2000) and more recently, real-estate bubbles in the US as well as Europe and China.

Bubbles generate price distortions that are potentially associated with allocative inefficiencies and have often led to financial crises. Thus, economists are naturally drawn towards studying bubbles via theoretical models and empirical methods. Laboratory experiments provide a useful tool to study bubbles empirically since they allow economists to control a variety of factors that are difficult or impossible to control in field environments (e.g., market microstructure and the fundamental values of the assets).

Smith et al. (1988) were the first to observe price bubbles in long-lived finite-horizon experimental asset markets. Many subsequent studies have found that bubbles and crashes are a robust phenomenon in experimental settings. To the best of our knowledge, the only treatment variables that appear to dampen significantly price bubbles are experience of all or some of the traders in the same market environment (Smith et al., 1988; Van Boening et al. 1993; Dufwenberg et al. 2005; Haruvy et al. 2007), the timing of dividend payments (each period versus a lump-sum payment at the end of the trading horizon, e.g., Smith et al. (2000)), constant fundamental value or decreasing cash-to-asset ratio (Kirchler et al. (2012)), and the payment of interest on cash *with* increasing fundamental value (Giusti et al. (2012)).[1]

In this paper we use experimental methods to study the impact of asset-holdings concentration policies on asset-market price dynamics, and whether concentration-control policies can eliminate or dampen the magnitude of bubbles. Policies of this type are currently being employed in China in response to the real-estate bubble. For instance, a new policy was introduced in Beijing in 2010 dictating that a native Beijing family could own at most two houses, and non-native Beijing families were allowed to own only one house.[2] Recent news dispatched by Bloomberg indicates

[1]Hussam et al. (2008) show that if the environment is subject to changes in liquidity and uncertainty, then even experience is not sufficient to eliminate bubbles. Noussair and Tucker (2006) eliminate the spot market bubble via a stylized experimental design of a futures market for every spot market period. Crockett and Duffy (2009) show that intertemporal consumption smoothing inhibits the formation of bubbles. Lei and Vesely (2009) show that it is possible to mitigate bubbles without subjects actually participating in market trading activity. In their study, subjects simply observe and receive earnings from a series of random dividend draws prior to participating in a trading market of equal length.

[2]Similar policies were also applied in Shanghai and other Chinese major cities.

that these policies are successful in cooling off the real-estate market.[3] It is important to note that these policies were implemented in conjunction with other policies such as increases in downpayments. In laboratory economies, on the other hand, concentration-control policies can be explored in isolation.

Regulations of individual asset-holdings are also in place in the stock exchange markets. For example, the US Security and Exchange Commission requires filing and public disclosures from anyone who acquires more than 5 percent of the outstanding shares of any class of a corporation (Williams Act).[4] In UK, concentration related policies are in place in order to ensure equal treatment of all shareholders. In particular, the City Code on Takeovers and Mergers requires from a person or a group which accumulated 30% of the voting rights of a company, to make a cash offer to all other shareholders at the highest price paid in the 12 months before the offer was announced.[5]

Our first empirical finding is that in environments à la Smith et al. (1988) asset-holdings concentration is significantly and positively correlated with the magnitude of bubbles, which suggests that policies limiting concentration can indeed dampen bubble formation. Given this finding, and motivated by some of the policies adopted in China in response to the real estate bubble, we implemented policies that place caps on individual asset holdings in the lab. Our treatment variables are associated with the duration of the cap: permanent versus short-term cap. The permanent cap was in place for the entire time horizon of the market, while the short-term cap was imposed only in the first half.

Our main findings are that permanent caps reduce positive bubbles by imposing a constraint on the most aggressive (net) buyers, but these caps introduce negative bubbles in the latter half of the trading horizon by limiting demand at prices below the fundamental value. However, with short-term caps, neither positive nor negative bubbles are observed. Intuitively, caps constrain momentum trading, i.e., trading based on price trends, see Caginalp and Ilieva (2008), Caginalp et al. (1998) or Caginalp et al. (2000). Also, demand is no longer constrained in the second half of the trading horizon, preventing prices to fall sharply below the fundamental value.

Our study complements the literature by showing that asset-holdings caps limit the impact of momentum traders. While the experience, the fundamental value process and liquidity levels of traders are generally beyond the control of the regulators,

[3]See http://www.bloomberg.com/news/2012-09-18/china-august-home-prices-rise-in-fewer-cities-easing-policy-woes.html.

[4]The Williams Act denotes the 1968 amendments to the Securities Exchange Act of 1934. For more detailed information please see the US Securities and Exchange Commission guidance on mini-tender offers and limited partnership tender offers at http://www.sec.gov/rules/interp/34-43069.htm

[5]For more details please visit the official Code website, http://www.thetakeoverpanel.org.uk/the-code/download-code. The threshold is set at 30% since this is the level considered to be sufficient to gain an effective control over a company.

asset holdings caps may be simpler to implement.[6]

Our results indicate that the implication for field environments, where the relevant time horizons are unknown and presumably very long, is that caps should be appropriately introduced and lifted endogenously in response to sudden increases and decreases in prices. Indeed, there is evidence that at the beginning of 2012 purchase restrictions were eased in Shanghai and then tightened again in the second half of 2012.[7]

2 Hypotheses

In this section we formulate four hypotheses that will guide our experimental design and data analysis.

We start by conjecturing that asset-holdings concentration in initial periods is an important factor contributing to bubble formation. Specifically, the concentration of asset holdings among a small number of traders in initial periods may have important effects on price dynamics and bubble formation as it indicates the strength of demand for asset units. Concentration in initial periods may also reveal a strong propensity for momentum trading (i.e., trade based on price trends) among a subset of traders.[8]

Hypothesis 1. *The asset-holdings concentration ratio in initial periods is positively correlated with the magnitude of bubbles.*

Some economists argue that China is experiencing bubbles in the real-estate markets of large cities. In order to restrict the demand for housing, the Chinese government has implemented a variety of policies, including a cap on the number of owned houses. Motivated by the latter policy and by Hypothesis 1, we conjecture that imposing appropriate caps on individual asset holdings may help constrain demand based on momentum trading and thus reduce the magnitude of bubbles.

Hypothesis 2. *The permanent asset-holdings cap reduces the magnitude of positive bubbles.*

[6]Our findings are consistent with the work of Caginalp and Ilieva (2008) who show that bubbles are fueled by the cash of momentum traders and bubbles tend to burst when momentum traders become cash constrained. In our study, asset holdings caps become binding for momentum traders before the cash constraint. Caginalp et al. (1998) show that the initial cash/asset ratio affects price dynamics. These studies also shed light on factors affecting bubble formation.

[7] See Shanghai Eases Home Purchase Restrictions, Bloomberg, February 21, 2012 and Shanghai Tightens Home-Buying Rules for Singles, BloombergBusinessweek, August 23, 2012. Further evidence of endogenous responses can be found in the article China Expands Home-Purchase Limits, Wall Street Journal, July 14, 2011.

[8]Momentum traders are defined by Caginalp and Ilieva (2008) as those who "buy stocks with the expectation of a continued rise in prices and sell stocks with the expectation of a continued fall in prices."

If asset-holdings caps become binding and thus effectively limit demand after some initial trading periods, they may generate downward price dynamics that are reinforced by momentum trading. The price may fall and stay below fundamental value, since the permanent cap also restricts the demand by fundamental-value traders (see Appendix B for evidence of this phenomenon).[9] As a result, negative bubbles may appear in later periods.

Hypothesis 3. *The permanent asset-holdings cap generates negative bubbles in later periods.*

Negative bubbles imply price distortions and thus are not desirable. We conjecture that in order to reduce negative bubbles, the cap should be lifted in later periods. That is, the cap should not be permanent but short-term. A short-term cap may not have the same negative bubble-creation tendencies as conjectured for a permanent-cap mechanism since demand by fundamental-value traders and other traders is not constrained if the price falls below the fundamental value in the latter periods (see Appendix B).

Hypothesis 4. *The short-term asset-holdings cap reduces the magnitude of positive bubbles and does not generate negative bubbles.*

3 Experimental Design

3.1 Market Structure

Our experimental design builds on the seminal study of Smith et al. (1988). We created a laboratory market in which agents have the opportunity to trade an asset with a stochastic dividend process. The market had a finite time horizon of 15 periods. At the end of each period, each unit of the asset in a trader's inventory paid an uncertain dividend of 0, 8, 28, or 60 francs (the experimental currency) with equal probability (e.g., Smith et al., 1988; King et al., 1993; Caginalp et al., 2000; Lei et al., 2001; Haruvy and Noussair, 2006; Hussam et al., 2008). Therefore, the expected value of the dividend payment in each period was 24 francs. It was publicly known that the dividend was independently drawn each period and the actual dividend paid in each period was the same for all traders. Since there was no terminal buy-out for asset holdings upon completion of the market, asset units were worthless at the end of period 15. Given common knowledge of the dividend process, the fundamental value of the asset can be calculated at any time within the experiment. More specifically,

[9] Fundamental-value traders were defined by Caginalp and Ilieva (2008) as traders who buy assets when the price is below the fundamental and sell when the price is above the fundamental.

Treatment	Year and Location of Data Collection	Number of		Individual Asset –Holdings Cap (of 18 shares)...	
		Sessions	Subjects	Introduced	Removed
Unconstrained	2011-2012 U Canterbury & Indiana U	4 5 1 1	12 9 8 7	-	-
Permanent Cap	2012 Indiana U	4 1	9 8	in period 1	-
Short-term Cap	2012 Indiana U	4 1 1	9 8 7	in period 1	in period 9

Table 1: Summary of Treatments.

assuming risk neutrality, the fundamental value is calculated as the expected value of the dividend in each period (24 francs) times the number of periods remaining (including the current period). The fundamental value of the asset is, therefore, declining from 360 francs in period 1 to 24 francs in period 15.

At the beginning of the experiment, each trader was endowed with ten units of the asset and a cash balance of 10,000 francs. Traders had the opportunity to buy and sell asset units in each period via a continuous double auction with an open order book. Each trading period lasted either 120 or 180 seconds. Subjects could not purchase more units than they could afford nor sell more units than they had in their inventories, i.e., negative cash balances and short selling was not allowed. Inventories of asset units and cash balances were carried over from period to period. No interest was paid on cash holdings and there were no trading fees.

3.2 Experimental Treatments

This study consists of three treatments that differ by the number of asset units that a trader is allowed to own. Table 1 summarizes the treatment characteristics reported in this study.

The baseline (Unconstrained) treatment has no asset ownership constraints imposed. More specifically, a traders purchases are only constrained by their cash holdings, i.e., depending upon trading prices it is conceivable for a single trader to own the total market stock of the asset. The Permanent Asset-Holdings Cap (Permanent Cap) treatment restricts the asset ownership of each trader to 18 units across the entire time horizon, which is 1.8 times the individual trader initial endowment. The Short-Term Asset Holdings Cap (Short-Term Cap) treatment is identical to the Permanent Cap treatment except that the constraint is removed at the start of period 9.

Forecast Accuracy	Forecast Earnings
Within 10% of actual price	50 francs
Within 25% of actual price	20 francs
Within 50% of actual price	10 francs

Table 2: Forecast Earnings.

At the beginning of each period across all treatments, traders made forecasts of the average transaction price for that period.[10] They were paid for the accuracy of their forecasts as indicated in Table 2. All earnings from forecasting accumulated in a separate account from the traders' cash on hand, and thus these payments did not affect the market capital-asset ratio.

The US sessions had a conversion rate of 600 francs to 1 US dollar. The New Zealand sessions had a conversion rate of 800 francs to 1 NZ dollar and included a version of the Holt and Laury (2002) risk- elicitation mechanism. The parameters in both locations were set to generate average hourly earnings of $18.

3.3 Experimental Procedures

The experiment consisted of 22 markets conducted at the University of Canterbury in Christchurch, New Zealand and Indiana University in Bloomington, Indiana, USA. The number of participants in each market varied from seven to twelve subjects. The subjects were recruited from undergraduate courses across both universities via their respective recruitment/subject management program.[11] Many of the subjects had taken part in previous experiments in economics and other disciplines, but no subjects had participated in markets of comparable designs and each subject participated in only one market of this study. The markets were computerized using the z-Tree software package.[12] At the end of a session, the subjects' final holdings of francs were converted to NZ (US) dollars at the predetermined and publicly known conversion rate. Each session lasted approximately 90 minutes including instructional period and payment of subjects. Subjects earned on average $26.

At the beginning of each session, subjects were provided the instructions of the first task of the experiment.[13] The instructions for all tasks were projected on an overhead. The first stage in all sessions consisted of a cognitive reflection test (Frederick, 2005) to measure the cognitive ability of all subjects. This stage was hand-run with the

[10]The five baseline sessions conducted in New Zealand did not have price forecasting.

[11]ORSEE (see Greiner, 2004) was used at the University of Canterbury and the IELab recruiting system was used at Indiana University.

[12]See Fischbacher (2007) for a discussion of the z-Tree software package.

[13]The instructions for all stages of the experiment are provided in the appendix.

subjects providing their answers to the three questions on a decision sheet. Subjects were given as much time as they needed to complete the three questions. Subjects received two dollars for each correct answer at the end of the session. Once everyone finished, the decisions sheets were collected and the instructions for the second stage were handed out. For some sessions, the second stage was a version of the Holt and Laury (2002) risk-elicitation mechanism, which was also hand-run. Once again, subjects were given as much time as required to complete the series of lotteries. No earnings information was provided for either the cognitive reflection test or risk-elicitation mechanism until the end of the session. Once everyone had finished, the decision sheets were collected and the instructions for the market were handed out. The subjects were given 15 minutes to read the instructions on their own after which the experimenter summarized the market via a series of bullet points placed on the overhead.[14] After the summary, the subjects were given five minutes to complete a short quiz. The experimenter went over the answers on an overhead and then started the market. When the market finished, earnings from the risk-elicitation mechanism were calculated by draws from two bingo cages that determined the specific lottery to be used and the outcome of that lottery. The subjects were privately paid their earnings for all stages of the experiment.

4 Bubble Measures

A wide array of bubble measures is used in the experimental asset markets literature. In this section, we introduce bubble measures that are relevant to our analysis.

We start by providing a quantitative criterion to identify the existence of positive and negative bubbles. One of the bubble definitions is provided by Noussair et al. (2001) in an environment with constant fundamental value: "the median transaction price in five consecutive periods is at least 50 units of experimental currency (about 13.9%) greater than the fundamental value." We modify their definition and extend it to account for both positive and negative bubbles.

In particular, we say that a session exhibits a *positive bubble* if the average price exceeds the fundamental value by 30% or more for at least five consecutive periods. Similarly, a *negative bubble* is observed if the average price falls below the fundamental value by 30% or more for at least five consecutive periods.[15]

Given that the fundamental value is declining in our environment, we chose to increase the bubble threshold from 13.9% to 30%. Otherwise, the definition of a

[14]The five Baseline sessions conducted in New Zealand had the market instructions read aloud instead of subjects reading them on their own.

[15]The qualitative results of our paper are robust to extending the definition of a bubble to four consecutive periods.

bubble would be too restrictive, especially in later periods. For example, in period 15, the fundamental value is 24 units of experimental currency, and a deviation of 3.36 units would exceed the 13.9% threshold.

Formally, we define binary indicator functions for positive and negative bubbles.

Positive Bubble Indicator

$$I_{+} = \begin{cases} 1 & \text{if} \quad \exists t: \quad \overline{P}_{t+s} \geq 1.3 * f_{t+s} \quad \text{for} \quad s = 0,1,2,3,4 \\ 0 & \text{otherwise} \end{cases} .$$

Negative Bubble Indicator

$$I_{-} = \begin{cases} 1 & \text{if} \quad \exists t: \quad \overline{P}_{t+s} \leq 0.7 * f_{t+s} \quad \text{for} \quad s = 0,1,2,3,4 \\ 0 & \text{otherwise} \end{cases} .$$

Next we describe other bubble measures commonly used in the literature.

Relative Absolute Deviation

$$RAD = \frac{1}{T} \sum_{t=1}^{T} \frac{|\overline{P_t} - f_t|}{\overline{f}}$$

The RAD measures the average level of mispricing (see Stöckl et al. (2010)). It is calculated by taking the average of the absolute value of the differences between the average price and the fundamental value across all periods t, and it is normalized by the average fundamental value. For example, a value of 0.10 indicates that on average mean prices per period differ 10% from the average fundamental.

Relative Deviation

$$RD = \frac{1}{T} \sum_{t=1}^{T} \frac{\overline{P_t} - f_t}{\overline{f}}$$

The RD is similar to the RAD, but it uses price deviations rather than absolute price deviations (see Stöckl et al. (2010)). The value of this measure indicates whether there is overvaluation or undervaluation. For example, a positive (negative) value of RD indicates that on average the asset is overvalued (undervalued).

Normalized Absolute Deviation

$$NAD = \sum_t \sum_i \frac{|P_{it} - f_t|}{f_1 * T * TSU}$$

The NAD is the sum, over all transactions, of the absolute deviations of prices from the fundamental value, divided by the total number of units outstanding and normalized by the total number of periods and the initial fundamental value. A high NAD indicates a large amount of trading activity at prices deviating from fundamental value.

Normalized Turnover

$$TR = \frac{\sum_t n_t}{T * TSU}$$

The TR provides the total number of transactions over the life of the asset divided by total stock of units, normalized by the total number of periods. A value of 0.10 indicates that on average 10% of all units are traded in each period. Thus, a high TR value indicates a high volume of trade.

Normalized Price Amplitude

$$A = \frac{1}{f_1} \left[\max_t \left(\overline{P_t} - f_t \right) - \min_t \left(\overline{P_t} - f_t \right) \right]$$

The A is defined as the difference between peak and trough of mean period prices relative to the fundamental value, normalized by the initial fundamental value. A high A indicates large price swings relative to the fundamental value.

Positive Duration

PD = the maximum number of consecutive periods in which the average price exceeds the fundamental value by at least 30%.

Negative Duration

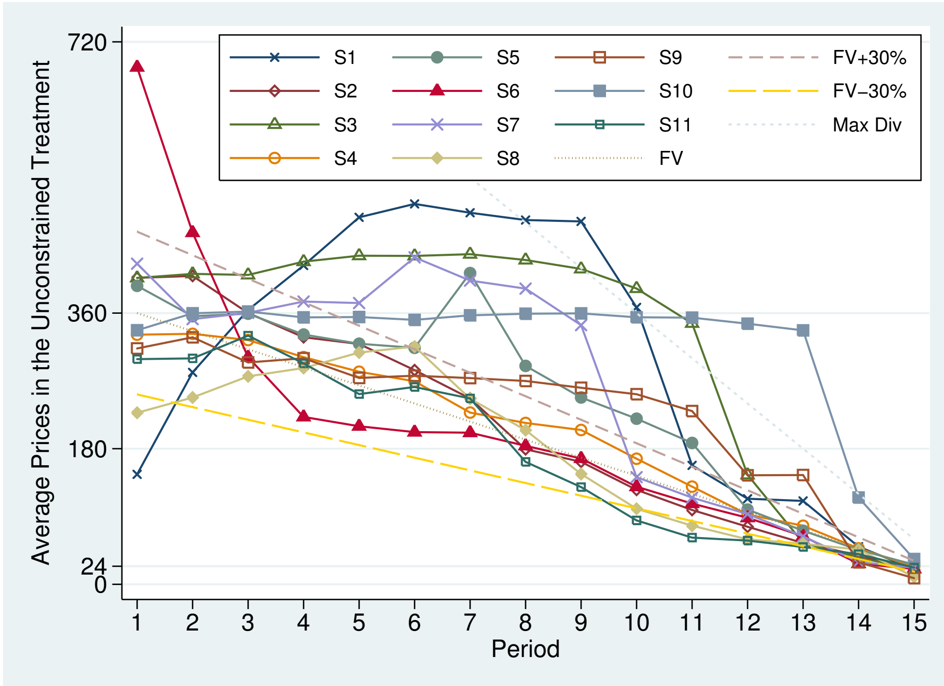

Figure 1: Average price in the Unconstrained treatment.

ND = the maximum number of consecutive periods in which the average price is below the fundamental value by at least 30%.

A high PD (ND) indicates the presence of a positive (negative) bubble.

Haessel-R^2

$$\text{Haessel-R}^2 = (\text{coef. correlation})^2$$

The Haessel-R^2 measures the goodness-of-fit between observed (mean prices) and fundamental values. It is appropriate, since the fundamental values are exogenously given. The Haessel-R^2 tends to 1 as trading prices tend to fundamental values.

5 Results

Figures 1, 2, and 3 depict the time series of average transaction prices and fundamentals in our treatments, namely Unconstrained, Permanent Cap, and Short-Term Cap. Periods are shown on the horizontal axis and average transaction prices are indicated on the vertical axis. The dashed line denoted FV indicates the fundamental value, FV+30% (FV-30%) indicates the fundamental value plus +30% (-30%) of the fundamental value, and the line denoted Max Div denotes the maximum possible total dividend (i.e., the fundamental value if the maximum dividend is realized in ev-

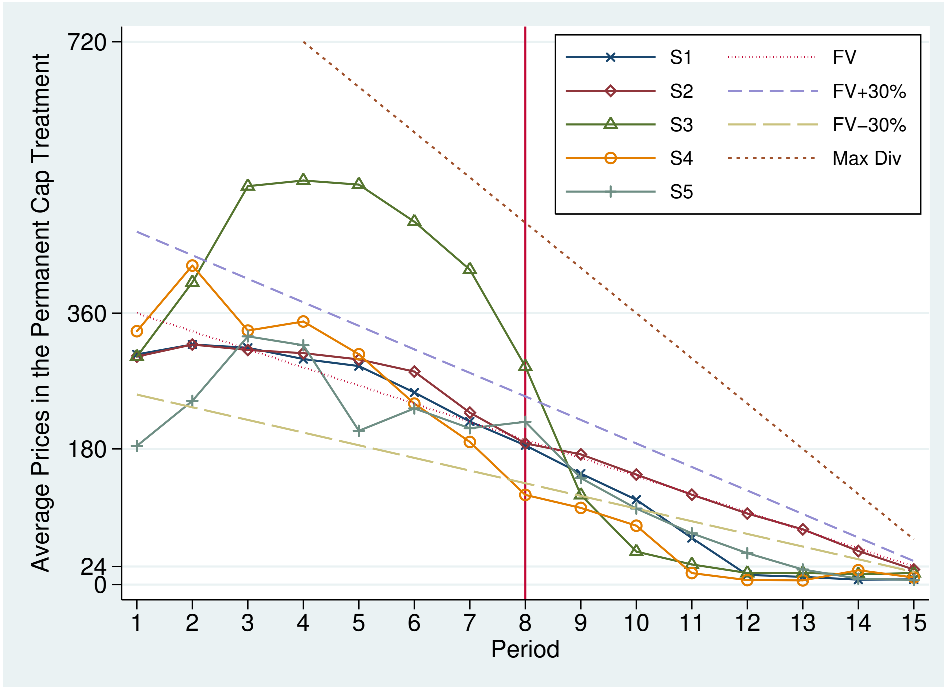

Figure 2: Average price in the Permanent Cap treatment.

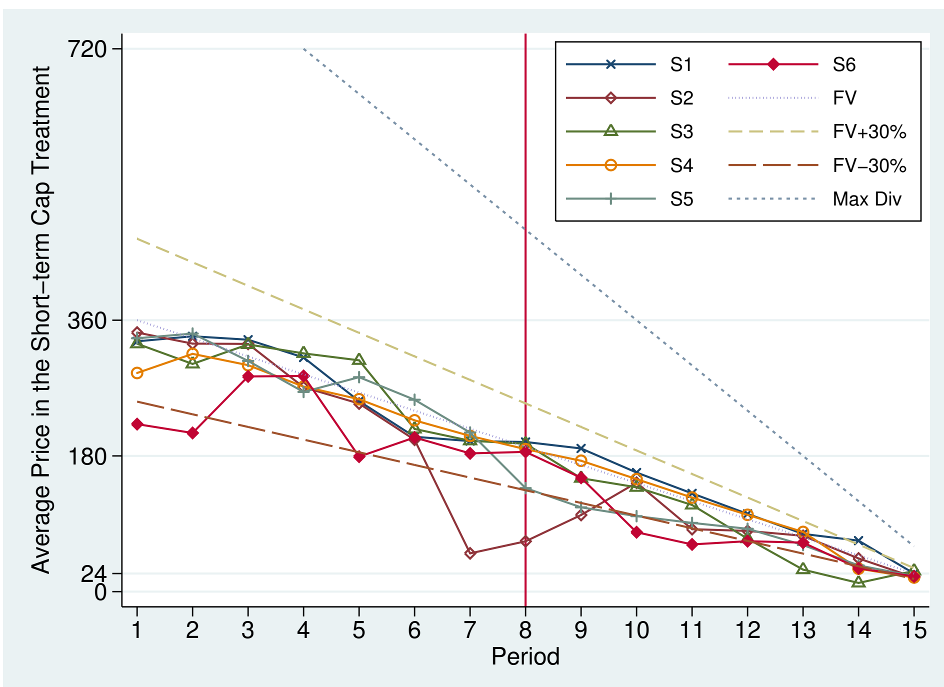

Figure 3: Average price in the Short-Term Cap treatment.

ery period). According to Figure 1, average transaction prices in the Unconstrained treatment display large departures from the fundamental value in six out of eleven sessions, while the average transaction prices remain close to the fundamental value in the remaining sessions.

In the Permanent Cap treatment, on the other hand, only one session out of five exhibits a positive bubble pattern. Thus, a permanent cap helps to dampen positive bubbles. However, as the cap becomes a binding constraint on some traders' holdings and thus constrains the demand for asset units (roughly around period 8), average transactions prices follow downward dynamics, which eventually lead to negative bubbles. Finally, Figure 3 indicates that in the Short-Term Cap treatment there are neither positive nor negative bubbles in six out of six sessions.

In what follows, we perform a more rigorous data analysis to confirm the informal observation that asset holdings caps have a dampening effect on asset price bubbles.

5.1 Concentration, Bubbles, and Asset Holdings Caps

We start by showing that asset holdings concentration is an important factor in bubble formation in experimental asset markets. In particular, we focus on the most aggressive (net) buyers since we conjecture that their behavior in initial periods has an important effect on price dynamics and bubble formation. Namely, the higher demand generated by these traders increases the trading price in initial periods. This fuels momentum trading (i.e., trade based on price trends, see Caginalp and Ilieva (2008)) thus generating significant upward deviations from the fundamental value.

To illustrate the impact of the most aggressive buyers on bubble formation, we adopt the Concentration Ratios (CR_n) as concentration measures. The Concentration Ratio CR_n is the sum of the market units of the top n traders with the largest asset holdings.[16] We analyze data from 24 market sessions with unconstrained environments à la Smith et al. (1988). More information on the parameters of each session is provided in the Table 3. [17]

Result 1. *The asset-holdings concentration ratio in initial periods is positively correlated with the magnitude of bubbles.*

Support for Result 1: Figure 4 shows that in initial periods, concentration measures CR_1, CR_2, CR_3, CR_4 are positively and significantly correlated with Relative

[16] Another commonly used measure of concentration is the Herfindahl Index which is the sum of squares of asset units of all traders, not just the top ones. However, CR_n measures are a better fit for our purposes given that we are interested in measuring the behavior of the most aggressive buyers.

[17] The notation in the Experience column may require some explanation. The notation n stands for inexperienced, x stands for once experienced, xx for twice experienced, and n&x for a mixture of inexperienced and once experienced subjects.

Session Type	Data Collection		Experience	Other Design Features				
				Number of		Initial (average)		Expected Dividend
	Year	Location		Sessions	Subjects	Cash Endowment per Trader	Asset Endowment per Trader	
Unconstrained Older	1984	U of Arizona & Indiana U	n	1	9	5.85	3	0.24
			n	2	12	6.80	2.33	0.16
			x	4	9	5.85	2	0.24
			x	1	9	13.24	1.77	0.24
			xx	3	9	5.85	2	0.24
			n&x	2	9	5.85	2	0.24
Unconstrained Newer	2011 & 2012	U of Canterbury & Indiana U	n	4	12	10,000	10	24
				5	9			
				1	8			
				1	7			

Table 3: Older and Newer Unconstrained Sessions.

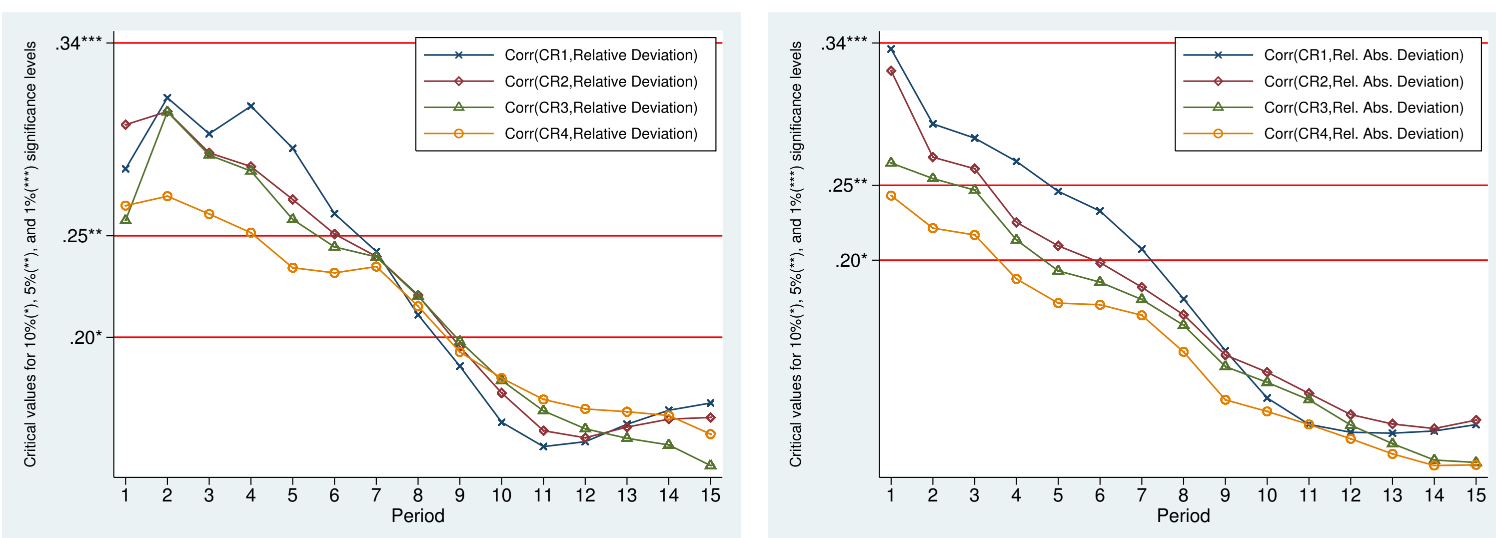

Figure 4: Kendall correlations of concentration ratios with relative deviation (left) and relative absolute deviation (right).

Deviation and Relative Absolute Deviation bubble measures.[18] The graphs show Kendall correlation coefficients between concentration measures in each period and bubble measures. The critical values at the 1%, 5%, and 10% significance levels are reported on the vertical axis of each graph. Correlations are the highest and most significant in initial periods, they decline over time and become statistically insignificant in later periods.Note that critical values coincide with the magnitudes of Kendal correlation coefficients.

Furthermore, for a given period, the smaller is n[19], the higher is the correlation coefficient, indicating that the behavior of the top one or top two net buyers has the strongest effect on the size of the bubble. We obtain very similar results with other commonly used bubble measures, such as Amplitude and Haessel-R^2 (see Figure 6 in the Appendix). The results are robust (at lower significance levels) to splitting the sample into two subsamples of the newer and older data, 11 and 13 sessions respectively.[20] □

Given this empirical relationship between concentration and bubble measures, we propose a policy that imposes a cap of 18 units on the asset holdings of each trader. This policy could potentially constrain the demand of the most aggressive buyers and thus limit their impact on price formation. This type of quantity control policy has been recently implemented to limit bubble formation in the Chinese real-estate market of major cities.

Next, we explain our cap choice of 18 units. Recall that our baseline consists of 11 sessions with initial endowments of 10 units per trader and no constraint on individual asset holdings. Figure 1 provides average prices for each of the 11 sessions. Note that average prices closely track the fundamental value in some sessions, while they significantly deviate from the fundamental value in others.

We classify our data into bubble and no-bubble sessions, following a criterion similar to Noussair et al. (2001). A session is classified to exhibit positive (negative) bubble if a price deviation of +30% (-30%) from the fundamental value is observed for at least five consecutive periods.[21]

In order to control for the number of traders in each session, we normalized the concentration measures CR_1 and CR_2 by the minimum possible CR_1 and CR_2 for each session, respectively. For example, given our endowment of 10 asset units per trader, the minimum possible CR_2 in a session with 9 traders is $\frac{2}{9}$, the normalized CR_2 is then $CR_2/\frac{2}{9}$. Figure 5 shows the normalized CR_1 and CR_2 for the first four

[18] For the definition of these and other measures, please see Section 4.

[19] Recall that the Concentration Ratio CR_n is the sum of the asset units of the top n traders with the largest asset holdings.

[20] The results are available upon request.

[21] For more detailed definitions of these and other bubble measures please see Section 4.

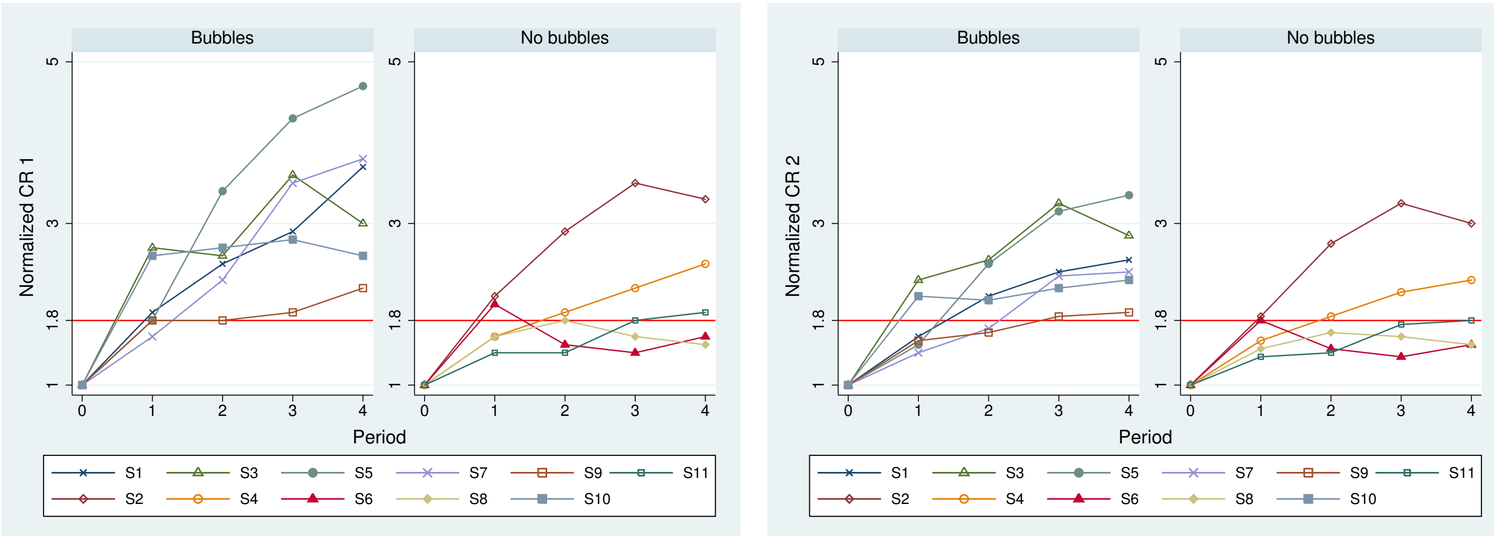

Figure 5: Normalized concentration ratios (CR_1 and CR_2) in the initial periods of Unconstrained sessions.

periods of each session. Period 0 denotes the beginning of period 1 before any trade took place. Given the symmetric endowments, clearly, both normalized measures are equal to one. Our goal is to propose an asset-holdings cap that tends to be binding for the initial periods of bubble sessions but not binding for no-bubble sessions.

In Figure 5, the normalized $CR_1 = 1.8$ corresponds to the top owner holding 18 units and normalized $CR_2 = 1.8$ corresponds to the top two owners holding a total of 36 units. Note that by the end of period 3, the normalized CR_1 and CR_2 exceed 1.8 in *all* six bubble sessions, while they are below 1.8 in the majority (three out of five) of the no-bubble sessions. A more restrictive cap than 18 would be binding for the majority of the no-bubble sessions, while a less restrictive one would be non-binding for some of the bubble sessions.

5.2 The Impact of Permanent and Short-Term Caps

In this section, we discuss the effect of the permanent and short-term asset-holdings caps on bubble formation. Our results are summarized in Table 4. The upper part of Table 4 presents median bubble measures, defined in Section 4, for each treatment. The lower part provides the corresponding results from the Mann-Whitney-Wilcoxon test, where the unit of observation is each individual session's bubble measure.

Result 2. *The permanent asset-holdings cap reduces the magnitude of positive bubbles. Furthermore, in the Permanent-Cap treatment we observe a positive bubble only in one session out of five.*

Group	Treatment	N of Sessions	Median Bubble Measures							
			Turnover	Positive Duration	Negative Duration	Amplitude	Relative Deviation	Relative Absolute Deviation	Haessel R^2	Normalized Absolute Deviation
G1	Unconstrained	11	0.21	6	1	0.58	0.18	0.26	0.78	0.05
G2	Permanent Cap	5	0.19	0	5	0.53	-0.12	0.24	0.92	0.03
G3	Short-term Cap	6	0.16	0	2	0.23	-0.07	0.11	0.96	0.01

Group Comparison	Mann-Whitney-Wilcoxon Rank-Sum Tests (unit of observation = session bubble measure)							
	Turnover	Positive Duration	Negative Duration	Amplitude	Relative Deviation	Relative Absolute Deviation	Haessel R^2	Normalized Absolute Deviation
z-Value G1=G2	-1.19	-1.79*	2.22**	-0.4	-2.1**	-0.85	0.85	-1.42
z-Value G2=G3	-1.1	-0.27	-1.75*	-2.01**	-0.18	-1.46	1.64	-2.01**
z-Value G1=G3	-2.61***	-2.34**	1.25	-2.31**	-2.51**	-2.31**	1.71*	-2.91***

Note: *10%, ** 5%, and ***1% significance levels.

Table 4: Comparison of bubble measures across treatments.

Support for Result 2: Recall that the positive duration is defined as the maximum number of consecutive periods in which the average price exceeds the fundamental value by at least 30%. As shown in Table 1, the median positive duration is equal to 6 in the Unconstrained treatment while it is 0 in the Permanent-Cap treatment. The Mann-Whitney-Wilcoxon test confirms that the positive duration is significantly higher under the Unconstrained treatment than under the Permanent Cap.

In addition, the relative deviation indicates that assets tend to be overvalued in the Unconstrained treatment, while they tend to be undervalued in the Permanent Cap. The Mann-Whitney-Wilcoxon test confirms that the relative deviation is significantly higher in the unconstrained treatment. □

The previous result shows that a permanent asset-holdings cap successfully reduces positive bubbles. However, it introduces other price distortions, namely negative bubbles.

Result 3. *The permanent asset-holdings cap generates negative bubbles (in later periods). In particular, in the Permanent-Cap treatment we observe negative bubbles in four out of five sessions.*

Support for Result 3: Recall that the Negative Duration is defined as the maximum number of consecutive periods in which the average price falls below the fundamental value by at least 30%. As indicated in Table 4, the median ND is equal to 1 in the Unconstrained treatment while it is 5 in the Permanent Cap. The Mann-Whitney-

Wilcoxon test confirms that the ND is significantly lower under the Unconstrained treatment than under the Permanent Cap.

In addition, the Relative Deviation indicates that assets tend to be overvalued in the Unconstrained treatment, while they tend to be undervalued in the Permanent Cap. The Mann-Whitney-Wilcoxon test confirms that the RD is significantly higher in the Unconstrained treatment.

Finally, we observe negative bubbles in four out five Permanent-Cap sessions and in zero out of eleven Unconstrained sessions. □

As shown by Result 3 negative bubbles are observed in later periods of the Permanent Cap treatment. Intuitively, caps bind aggregate demand thus limiting the upward price trend and potentially creating a downward price trend. At some point the price drops below the fundamental value which attracts new buyers, but eventually caps become binding even for these new traders and the price stays below the fundamental value.[22] The Short-Term Cap treatment addresses this problem by relaxing the asset-holdings cap in later periods.

Result 4. *The short-term asset holdings cap reduces the magnitude of positive bubbles. Furthermore we observe no positive bubbles in six out of six sessions. Finally, the short-term asset holdings cap does not generate negative bubbles.*

Support for Result 4: As shown in Table 4, the median of the Positive Duration (PD) is 0 for the short-term asset holdings cap and 6 in the Unconstrained treatment. The Mann-Whitney-Wilcoxon test confirms that the PD is significantly higher in the Unconstrained treatment. Moreover all bubble measures other than Negative Duration (ND) indicate that bubbles are significantly reduced under the Short-Term Cap compared to the Unconstrained treatment. The ND in the Short-Term Cap treatment, on the other hand, is not significantly different compared to the Unconstrained treatment and it is significantly lower than in the Permanent Cap treatment. This confirms that negative bubbles are mainly prominent in the Permanent Cap treatment (recall that a high ND indicates the presence of negative bubbles).

Finally, as shown in Figure 3, there are no negative bubbles in six out of six sessions under the Short-Term Cap treatment. □

Thus, imposing appropriate caps on individual asset holdings helps to reduce or eliminate bubbles by constraining demand based on momentum trading. Under the Permanent Cap treatment, as asset-holdings caps become binding for more and more traders, they generate downward price dynamics which lead to negative bubbles. The

[22] As we show in Appendix B, the average number of new traders with large asset holdings in later periods is 2.2 times higher in the Permanent Cap treatment than in other treatments.

price falls below the fundamental value and tends to stay low, since the permanent cap restricts the aggregate demand even when the price falls below the fundamental value. As new large asset holders emerge in the market they quickly face the cap's binding constraint (see Appendix B for evidence of this phenomenon). Importantly, permanent caps do not have a statistically significant effect on the overall trading volume (see Turnover in Table 4). Thus the reduction of positive bubbles cannot be attributed to a lower number of transactions.[23] A short-term cap, on the other hand does not result in negative bubbles. After the cap is removed, both new buyers and the largest existing net buyers have the opportunity to buy thus contributing to higher aggregate demand and preventing negative bubbles.[24]

6 Conclusions

This paper explores the effect of individual-trader asset-holdings caps on price dynamics and bubble formation in laboratory double-auction markets. We conclude that permanent caps reduce positive bubbles by imposing a constraint on the most aggressive (net) buyers, but these caps introduce negative bubbles in the latter half of the trading horizon by limiting demand at prices below the fundamental value. More importantly, with short-term caps neither positive nor negative bubbles are observed.

Concentration-control policies via caps were imposed in the real-estate market in major cities in China in 2010 in an attempt to bring house prices to reasonable levels. The empirical results presented in this paper suggest that policymakers should monitor house prices and lift caps if prices exhibit sudden drops in order to prevent the formation of negative bubbles. That is, the implication for field environments, where the relevant time horizon are unknown and presumably very long, is that caps should be appropriately introduced and lifted endogenously in response to sudden increases and decreases in prices. Indeed, there is evidence that caps respond to economic conditions as in Shanghai at the beginning of 2012 when purchase restrictions were eased and then tightened again in June 2012.

[23]The short-term cap should not restrict trading volumes more than the permanent cap, since it has shorter duration. Thus, the fact that we observe a lower turnover in the Short-Term Cap treatment is due to endogenous factors, e.g., trading prices close to fundamental value

[24]As shown in Appendix B, the new large asset holders do not appear as often in the Short-Term as in the Permanent Cap treatment. However, the existing large asset holders now also have the opportunity to buy more.

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Appendix A.

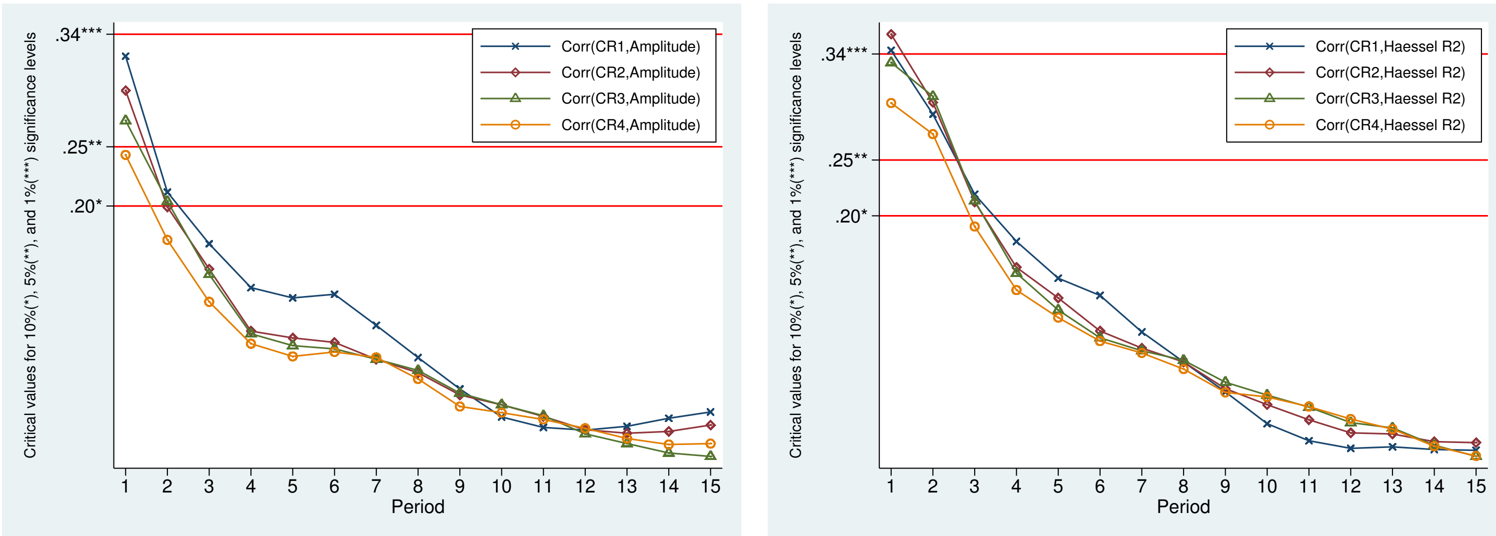


Figure 6: Kendall correlations of concentration ratios with amplitude (left) and Haessel-R^2 (right).

Appendix B.

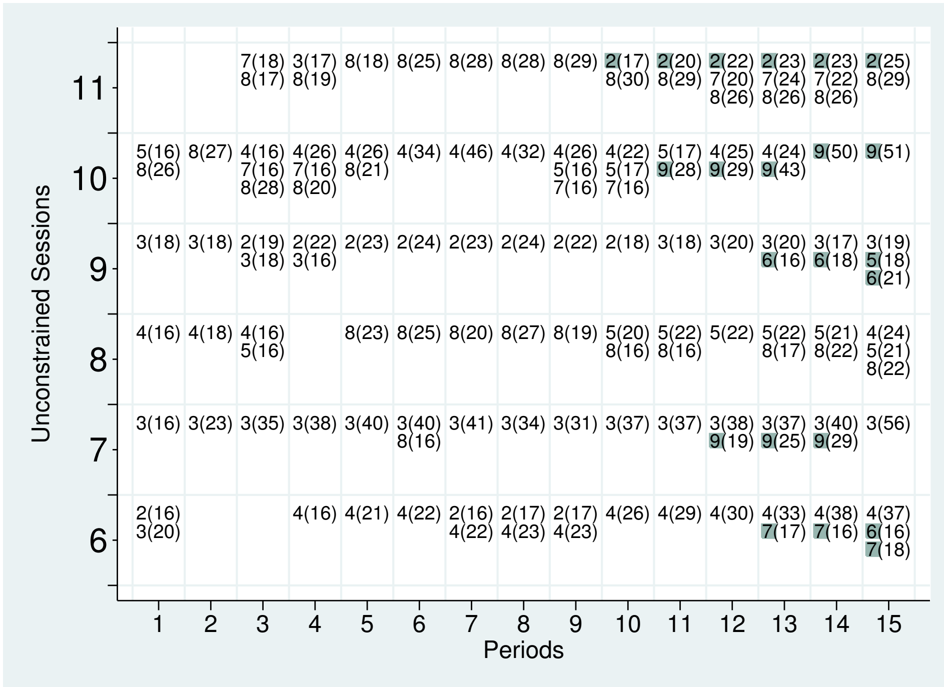
In this section we provide evidence that asset-holdings caps were binding. The figures below report the identifiers of subjects with "large" asset holdings for each period and each session of all treatments. The horizontal axis is indexed by periods while the vertical axis is indexed by session numbers. For every period, in addition to the identifier, we also report in parenthesis the actual asset holdings. The figures report identifiers of subjects with holdings greater than or equal to 16. We decided to focus also on holdings slightly less than 18 (which is the actual cap employed in the permanent and short-term treatments) because some subjects tend to avoid reaching the cap so as to leave room for one or two units if a good low-price buying opportunity occurs. Nonetheless, these subjects contribute to strengthening the demand for asset units.

The identifiers that are shaded in the cells corresponding to the latter half of the markets (i.e., after period 7) denote new traders with large asset holdings. In other words, these are traders who did not have large asset holdings in the first half of the experiment.

In the Unconstrained treatment some subjects accumulate large asset holdings very fast. Figure 7 shows that already in initial periods there are several traders with relatively large holdings. For instance, in Session 5, the asset holdings of subject 7 are equal to 34 in period 2 and 43 in period 3. Also, on average, there is only 1 new trader per session with large holdings in the latter half of the experiment.

In the Permanent Cap treatment, on the other hand, there are on average 2.2 new traders per session reaching large holdings in the latter half (see Figure 8), i.e., a higher number than in other treatments. Note that more new large asset holders are attracted in the Permanent Cap treatment, because prices fall below the fundamental value in the latter half of the market, However, since both new and existing traders are constrained, prices are prevented from tracking the fundamental value. Figure 8 shows that the cap is binding also in the first half of the experiment, as several traders asset holdings are equal to 18.

In the Short-Term Cap treatment, the average number of new traders reaching large holdings in the latter half is the same as in the Unconstrained treatment, that is 1 per session. This is due to the fact that some of the traders constrained at 18 in the first half of the market increase their holdings after the purchasing limit is removed (see Figure 9). Thus, both existing and new large asset holders contribute to sustaining the demand and preventing negative bubbles. Moreover, many traders hold much more than 18 units in the later half of the market.



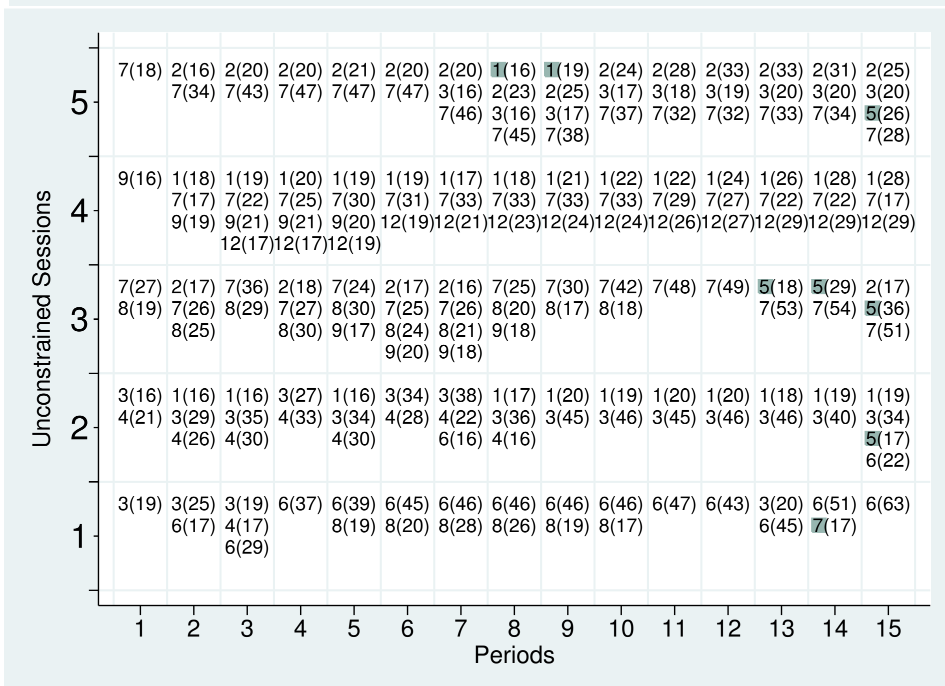


Figure 7: Identifiers of subjects with 16 or more units in the Unconstrained treatment (number of units in parenthesis).

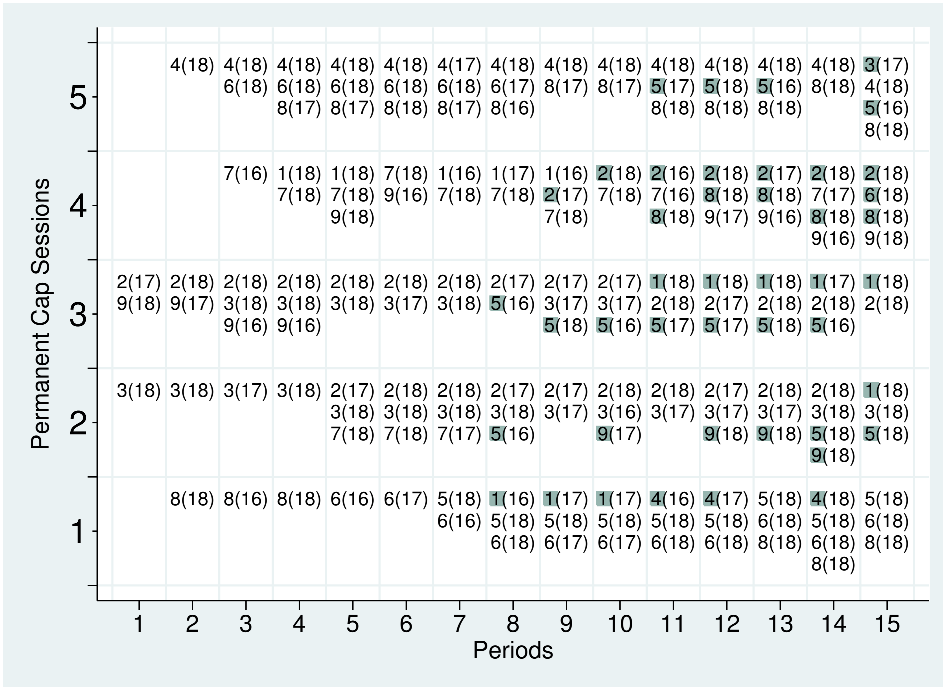


Figure 8: Identifiers of subjects with 16, 17, or 18 units in the Permanent Cap treatment (number of units holdings in parenthesis).

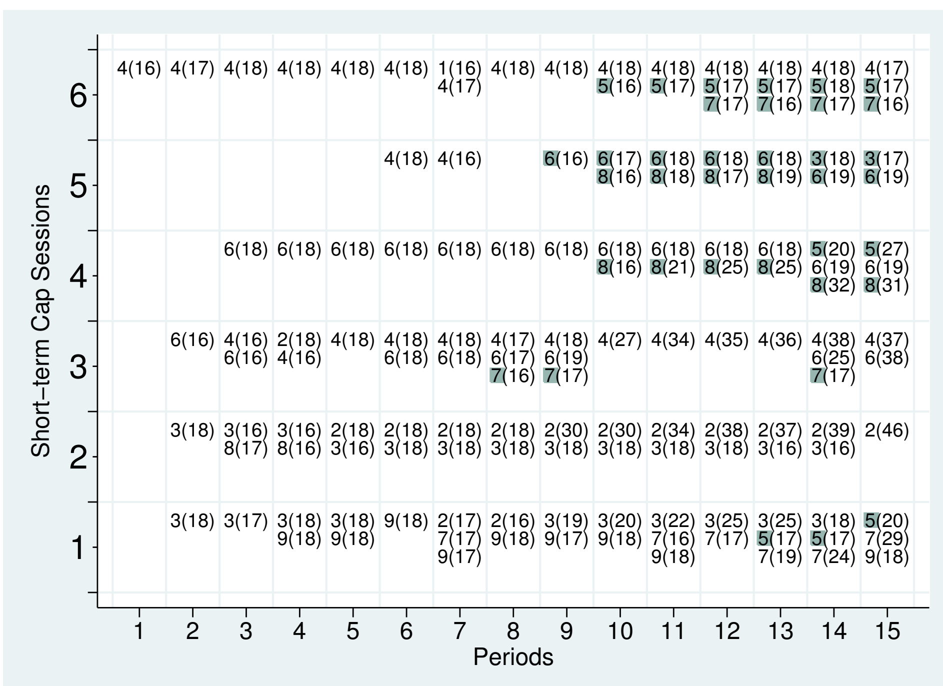


Figure 9: Identifiers of subjects with 16 or more units in the Short-Term Cap treatment (number of units holdings in parenthesis).