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Nonspeculative Bubbles Revisited: Speculation *Does* Matter

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Abstract

Research in Finance has long been intrigued by the causes of price bubbles. It has been argued that investors having doubts about the rationality of others may speculate on future capital gains. However, in an important contribution, Lei *et al.* (2001) argue that speculation is not the driver of bubbles in the absence of common knowledge of rationality, suggesting a focus on mistakes and confusion. Indeed, interventions that reduce confusion, reduce the incidence of bubbles. Yet, it has been shown that this effect is likely due to these interventions also establishing common knowledge of rationality. This leaves a puzzle, when both speculation and confusion are excluded as an explanation for bubbles. We revisit Lei et al.'s (2001) design, confirming the existence of bubbles. However, we argue that, although their design removes the ability to speculate, it introduces several unintended design artifacts, inducing bubbles. We design a condition that eliminates any incentives for speculation without these effects. Bubbles are indeed eliminated in this treatment. We conclude that speculation plays a critical role in bubble formation, and thus *does* matter.

Keywords

speculation
bubbles
cognitive ability
asset market experiment

JEL Classification

C91, G13

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1. Introduction

The history of financial markets is filled with many episodes of bubbles and crashes. Understanding the causes of bubbles is important, for their subsequent crashes often result in severe and long-lasting macroeconomic disruptions, affecting the real economy (see for example, Brunnermeier and Schnabel 2016 for a comprehensive review, or Shiller 2015). Research in finance in the past decades has shown significant progress in this regard. For instance, Brunnermeier and Oehmke (2013) offer a broad survey on various reasons for bubble formation, such as limits of arbitrage and heterogeneous information, etc. However, bubbles remain a recurrent phenomenon that is hard to avoid. People seem to always find reasons to believe 'this time is different' (Reinhart and Rogoff 2011). The urge to ride the bubble is difficult to avoid, and perhaps hard-wired in human nature (De Martino *et al.* 2013; Smith *et al.* 2014).

However, studying bubbles using naturally occurring financial data is difficult, as the fundamental values of the assets are often hard to estimate. Smith, Suchanek, and Williams (1988, hereafter SSW) published a seminal paper that initiated experimental research on long-lived asset markets in a controllable setting, where fundamental value can be pre-defined. The principle result from the considerable research that followed is that markets consistently produce price bubbles. Prices typically start below the fundamental value and then rapidly soar for a prolonged period of time, until they collapse towards the end of the life of the asset. The SSW paradigm has subsequently triggered a large experimental literature studying factors associated with bubble formation, in a controlled way that is not be feasible with observational data (for reviews, see Plott and Smith 2008, Noussair and Tucker 2013, Palan 2013).

Regarding the existence of bubbles, both SSW and Plott (1991) conjecture that they occur because common knowledge of rationality cannot be established. When traders doubt the rationality of others, they are more willing to engage in speculative activities. Lei, Noussair, and Plott (2001, hereafter LNP) are the first to experimentally test the role of speculation in bubble formation directly. They proposed a design that eliminates the ability to engage in speculative behavior via restricting trader roles to a specific side of the market. More specifically, traders were prevented from buying low and selling high as it was impossible to resell an asset. If speculation is the main factor for bubble formation, this design should remove bubbles. However, this was not supported by LNP's results. Bubbles continue to be observed when the ability to speculate is effectively removed.

In the wake of these results, a literature emerged that suggests that decision errors and confusion are the main drivers of bubbles (Oechssler 2010; Kirchler *et al.* 2012; and Bosch-Rosa *et al*. 2018). Lei and Vesely (2009) and Huber and Kirchler (2012) support this argument by showing that instructions, training and procedures intended to reduce confusion, reduce bubbles. However, Cheung *et al.* (2014) show that these methods also lead to common expectations among traders. In other words, bubbles are attenuated if all traders recognize that the dividend process is understood by all traders. A broader literature supports this argument, showing that establishing common expectations reduces bubbles, potentially by reducing speculation (Noussair and Tucker, 2006; Baghestanian *et al.* 2014; Noussair *et al.* 2016; Deck *et al.* 2020). However, if interventions reducing decision errors in fact reduce bubbles by establishing common expectations, then the question remains, what is driving bubbles in the absence of common expectations? If LNP's claim that speculation is not necessary for bubbles to occur is valid, what else is driving bubble formation?

The current paper aims at resolving this puzzle. In particular, we argue that LNP's design, while eliminating speculative motives, introduced several unintended design artifacts that led to bubbles despite the absence of speculative gains. We argue that these artefacts may be related to the artificial asymmetric design that restricts traders' roles as either a buyer or a seller within a given period. This unnatural feature may have provided motives to purchase assets at relatively high prices. First, the market has extreme initial asymmetric endowments with buyers having only cash but no assets and sellers having assets but no cash. This leads to artificial 'scarcity' of assets on the buyers' side. The scarcity principle in psychology suggests that that buyers are willing to pay more to obtain the asset when they perceive the asset as scarce (Cialdini 1993). Moreover, it has been shown that traders attempt to achieve a mixed portfolio (Weber and Camerer 1998), pointing in the same direction.

Secondly, each successful transaction reduces the number of stocks in circulation by one, making the asset even scarcer. Sellers are also affected by these same factors. More specifically, as units are traded and sellers' inventories decrease, the desire for mixed portfolios and inability to repurchase may make sellers reluctant to sell, and thus induce scarcity. Thirdly, there are effectively fewer traders on both sides of the market when their role is restricted, compared to the standard SSW market, making it easier for the sellers to collude on prices and hindering information dissemination.

Our current design eliminates these potential design issues, but leaves all aspects of the SSW design intact. Our design indeed eliminates any bubbles in the SSW paradigm, showing that speculation *does* play a critical role in bubble formation. Our result is consistent with theoretical work arguing that the speculative intention of smart investors is critically important for the formation of bubbles. De Long *et al.* (1990a) argue that sophisticated traders attempt to exploit the less sophisticated traders' actions for greater profits.[1] For instance, the uncertainty about the behavior of irrational noise traders makes it worthwhile for rational traders to ride the bubble. It may even pay for rational traders to push up prices initially in order to stimulate interests for trend-following noise traders to buy in the next period (De Long *et al.* 1990b). Abreu and Brunnermeier (2003) offer an alternative argument for why rational traders ride a bubble instead of attacking it in the presence of boundedly rational traders. In their model,

[1] It has indeed been shown also in experimental markets that sophisticated traders exploit the less sophisticated and achieve greater profits in bubbly markets (for example, Corgnet *et al.* 2014; Noussair *et al.* 2016).

rational traders sequentially are made aware of the fact that 'prices are too high', but it is never common knowledge that a bubble exists, making the market correction more difficult. Less sophisticated traders do not realize that the fundamental value does not keep up with the growth in stock price. It is, therefore, reasonable for smart traders to ride the bubble for some time before it bursts, even when they are well aware of the bubble. The model has been experimentally tested and supported by Brunnermeier and Morgan (2010).

Observational data also support the importance of speculative behavior. Brunnermeier and Nagel (2004) provide empirical evidence that during the dot-com bubble, hedge funds (considered as the smart/rational investors) were speculating and riding the bubble instead of short-selling overpriced firms. Similarly, Temin and Voth (2004) show that a well-informed institutional investor (the Hoare's Bank) rode the south sea bubble, knowing that a bubble was in progress. More recently, Hardouvelis and Stamatiou (2011) find evidence that hedge funds ride and profit from the U.S. housing bubbles prior to the subprime mortgage crisis. Xiong and Yu (2011) argue that the constant inflow of new investors is responsible for the prolonged bubbles observed in the Chinese warrant market from 2005 to 2008. More specifically, the incoming traders made it difficult to establish common knowledge of rationality and thereby provide opportunities to speculate, which was supported by Gong *et al.* (2017) using account-level data.

The current paper proceeds as follows. We first revisit LNP's results to establish that their finding is robust. We replicate their original conditions, and also provide updated versions that are more in line with current practices in the study of experimental asset markets (described in detail in Section 2). We confirm that bubbles still regularly occur with LNP's 'no speculation' designs, possibly due to the design artefacts discussed above. Next, we resolve the problems with LNP by introducing a new condition involving a 100 percent capital gains tax in their basic paradigm. This setup is not meant to add to the discussion of how taxation restrains speculation. Rather, the condition aims to achieve two goals. First, we do not want to change the basic SSW design: all trades are permitted as in the basic condition, and thus no asymmetry or scarcity induced. Second, all benefits of speculation are removed; only fundamental values and the anticipated dividend streams matter for trade. We find that bubbles are effectively eliminated in this condition. Lastly, we also make use of information on the traders' cognitive ability to shed light on the underlying mechanism. We find that high ability traders bid more conservatively than low ability traders, but only in the 100 percent capital gains tax treatment. That is, speculation was effectively eliminated in the tax treatment, but potentially replaced by other motives in the LNP no-speculation treatments. We conclude that speculation must be a key ingredient in the emergence of bubbles in the basic SSW paradigm.

Our results support the importance of theorizing in terms of speculative trading in markets and emphasize the role that sophisticated traders play in bubble formation. They also suggest a focus on institutional designs that manage bubble-promoting behaviors, complementing the recent literature of market mechanisms to induce common expectations.

2. Experimental Design and Procedures for Replications of LNP

2.1 General Information

Subjects in our experiment have the opportunity to participate in an asset market, trading an asset called X. The market is organized as in Smith *et al.* (1988), using the double auction rules such that all traders are free to place bids and asks at desired prices and can accept other traders' existing offers. The trading platform is computerized using the z-Tree software (Fischbacher 2007). Endowments of experimental currency, called francs, are provided to the traders, either as a loan in some conditions or as a gift in others, together with units of the asset. Assets traded in the market have a finite life of either 12 or 15 periods, depending on the treatment. Cash balances and inventories of the asset can be carried over from one trading period to the next.

At the end of each period, each asset pays a random dividend that is independently drawn from a known distribution, allowing for the expected value of the dividend payment to be easily calculated. Dividend earnings are saved in a separate account, and thus do not impact the cash to asset ratio in the market. The value of the dividend payment is the same for all traders. After the final dividend payment in the last period of the market, the asset is worthless. Therefore, the fundamental value of the asset in any given period equals the expected value of the dividend payment multiplied by the number of periods (dividend payments) remaining in the market. It is also useful to define the maximum justifiable price of the asset as the maximum possible dividend value multiplied by remaining number of periods in the market. At the end of the experiment, the accumulated cash balance in francs (including those in the dividends account) were converted to NZD at a predetermined exchange rate that was known in advance for all subjects in a session.

2.2 LNP Replication Treatments

There are two main treatments in LNP that feature the 'no speculation' intervention, NoSpec and TMkt/NS.[2] We replicate these treatments exactly as in the original study, indicated via the subscript R (replication), and introduce updated treatments, indicated via the subscript U (updated replication). The NoSpec condition consists of a single asset market with restrictions on trader roles. More specifically, the ability of traders to speculate in the asset market is removed: subjects are randomly assigned to either the role of buyers or sellers, and resale or repurchase of the asset is prohibited. Thus, there is no possibility of realizing capital gains. Thus, the only source of value from holding the asset is its expected cumulative dividends. Sellers are of course allowed to sell assets at prices above the fundamental values if buyers are willing to pay those prices. The TwoMkt/NS condition has a goods market operating concurrently with an asset market that is identical to NoSpec. The first two rows in Table 1 summarize the parametrization of the replication treatments.

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[2] We use LNP's original notation.

In the NoSpec_R treatment, buyers were endowed with an initial cash balance of 7,200 francs as a gift and no assets, and sellers were endowed with 20 units of *X* but no cash. Given the dividend process and endowments of cash and assets, the initial expected wealth of all traders was equal. In the TMkt/NS_R treatment, buyers were loaned with 100,000 francs, which they were required to pay back at the end of the experiment. Buyers had no endowment of units of either *X* or *Y*. Sellers were endowed with 20 units of *X* and 10 units of *Y*, and zero cash.

Table 1: Treatment Summary

Treatment	Cash	Loan	Assets	Dividend	Periods	C/A ratio	LNP' # of Obs	Our # of Observations
NoSpec_R	7,200/buyer	No	20/seller	20,40	12	1.00	3	7
TMkt/NS_R	100,000/buyer	Yes	20/seller	20,40	12 (15)	13.89	3	5
Baseline_U	10,000	No	10	0,8,28,60	15	2.78		5
NoSpec_U	10,000/buyer	No	10/seller	0,8,28,60	15	2.78		5
TMkt/NS_U	10,000/buyer	No	10/seller	0,8,28,60	15 (18)	2.78		5

Notes: The subscripts '_R' and '_U' indicate the exact 'replication' and 'Updated' parameters respectively.

At the end of each trading period, each unit of the asset *X* pays a dividend of either 20 or 40 francs with equal chance. Every unit of *X* pays the same dividend, regardless of the identity of the owner. Thus, the expected dividend paid on each unit of *X* is 30 francs per period and in total 360 francs over the course of a session, because the asset market runs for 12 periods in NoSpec_R and TMkts/NS_R. As dividends are the only source of value of *X*, the fundamental value is derived from holding a unit of *X* from the current period until the end of the experiment and collecting the stream of expected dividend payments.

In TMks/NS_R, the commodity *Y* has a life of one period, and it is treated as a good or service as in Smith (1962). *Y* does not pay dividends in any period, but it has redemption values for agents who consume it at the end of each period. Buyers are endowed with diminishing personal values for consuming each unit of *Y* (creating a demand schedule). Sellers are assigned increasing private costs for each unit of *Y* they sell (creating a supply schedule). The market for *Y* repeats itself every period, with a market clearing price and quantity found from intersection of traders' submitted bid and ask schedules. Inventories of *Y* are reinitialized after each period and goods cannot be carried over from one period to the next. The goods market *Y* opens three periods prior to the asset market for the traders to be familiar with it, which is why the TMkt/NS_R treatment has 3 periods more than the NoSpec_R. Traders can freely access both markets trading *X* and *Y* when the market for *X* opens after the third period.

Note that we did not include a replication of the original LNP baseline (one-market) SSW condition. In the original study, the no-speculation and the baseline conditions had substantially different cash to asset ratios. Even within the baseline treatment in their study, the cash to asset ratio differ (either 2.78 or 27.8). At the time of data collection, this aspect would certainly be deemed innocuous given the existing literature. Yet, recent literature has shown their importance for bubbles, confounding interpretations.[3] Below we will include a baseline one market SSW conditions for the updated treatments.

2.3 LNP Updated Treatments

LNP changed multiple parameters across treatments, making comparisons to other conditions difficult. To address this issue, we have two additional treatments, NoSpec_U and TMkt/NS_U, that provide better control over parameters employed while keeping the structure of the design the same as in LNP. The two conditions provide two more (conceptual) replications of the NoSpec paradigm, central to the current paper. To offer a benchmark comparison, we also provide a one-market baseline treatment, called Baseline_U, using a standard SSW design. In this Baseline_U treatment, traders' role is not restricted and they are endowed symmetrically with both asset and cash. The parameters employed in the updated no-speculation treatments, NoSpec_U and TMkt/NS_U, are shown in Table 1. The new Baseline_U treatment has the same parameters, in particular, the same cash to asset ratio as in the updated no-speculation conditions. Moreover, in the updated treatments, cash is always given to the traders as a gift endowment, the dividend process is the same across treatments with a four-point distribution, and the cash to asset ratio is kept constant across the treatments.

2.4 Lab Procedures

A total of 214 subjects participated in our experiment. There are 27 sessions in total, which are all conducted in the Waikato Experimental Economics Laboratory in Hamilton, New Zealand. Each session lasted about 100 minutes and subjects earned approximately 35 NZD on average. The experimenter read aloud the instructions for the market experiment, followed by a quiz and private Q&A. Once everyone successfully answered the comprehension questions in the quiz, a practice period was conducted. Profits or losses made in this period did not count toward the final earnings, and both the cash balance and asset inventories were reinitialized before the start of the first trading period.

3. Results of the Replications

To quantify the magnitude of mispricing and facilitate comparisons, we employ three commonly used bubble measures in the experimental finance literature, Relative Absolute Deviation (RAD), Relative Deviation (RD) and Turnover (Van Boening *et al.* 1993; Stöckl

[3] Higher cash asset ratios have been shown to induce greater mispricing (Caginalp *et al.* 1998; Caginalp *et al.* 2001; Caginalp *et al.* 2002; Haruvy and Noussair 2006, Noussair and Tucker 2016). Caginalp *et al*. (2001) estimate that 'each dollar per share of additional cash results in a maximum price that is $1 per share higher.'

et al. 2010). RAD is defined as RAD=$\{\sum_t |P_t - FV_t| / (\sum_t (FV_t) / T)\}/T$, where t denotes period and T stands for the total number of periods in a market session. FV_t is the fundamental value in period t and the term P_t denotes the average price in period t. RAD measures how closely prices track fundamental value. The measure RD is defined as $RD = \{\sum_t (P_t - FV_t) / (\sum_t (FV_t) / T)\}/T$, which indicates whether prices are on average above (RD > 0) or below (RD < 0) fundamental value. Turnover is the total number of transactions in a market session, normalized by the total units of asset available in the market. It is defined as $(\sum_t q_t)/TSU$, where q_t is the quantity of units of the asset exchanged in period t and TSU is equal to the total stock of units. In words, it is the total number of transactions over the life of the asset, normalized by the total stock of units in the market. A high Turnover indicates a high volume of trade, which is typically associated with mispricing in experimental markets of the type studied here.

3.1 Exact Replications

Figure 1 shows the time series of treatment average prices relative to fundamental value for NoSpec_R and TMkt/NS_R, as well as the original conditions of LNP for which we obtained the original data from the authors.[4] The vertical axis shows the difference between prices and fundamental values, and the horizontal axis indicates the trading period. The solid line with solid markers shows prices in LNP's original data, while the solid line with hollow markers shows prices from our replications. We add two reference lines: the dashed line is the maximally justifiable price deviation level relative to the fundamentals in respective treatment, assuming that all remaining periods pay the maximum possible dividend. The only rational explanation to purchase units above the maximum justifiable price level is to engage in speculative trading, which is ruled out by design. If realized transactions are priced as the risk-neutral fundamental value, all price trajectories would coincide with the dotted FV reference line at level zero.

We observe that overpricing is ubiquitous in all four treatments in that assets are traded above fundamental values.[5] In all four conditions, we also observe prices above the maximally justifiable value of the asset (as derived from dividends). In NoSpec_LNP and TMkts/NS_R these deviations are substantial, and maintained over most periods. Table 2 summarizes the bubble measures, confirming overpricing in all conditions. Average RAD and RD in TMkts/NS_R sessions indicate that assets are traded on average even more than 100% above the fundamentals. In sum, these replications strongly confirm LNP's original finding that bubbles are frequently observed in LNP no speculation designs, despite the fact that the ability to speculate has been removed.

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[4] For price trajectories of individual sessions for all treatments discussed in the paper, refer to the Appendix, Figures A1 to A7.

[5] The price deviation from fundamental values in NoSpec_R is not as large as that in the other treatments, which is not surprising given that the cash to asset ratio is merely 1.0 in this particular treatment.

Figure 1: Time Series of the Treatment Average Price Deviations

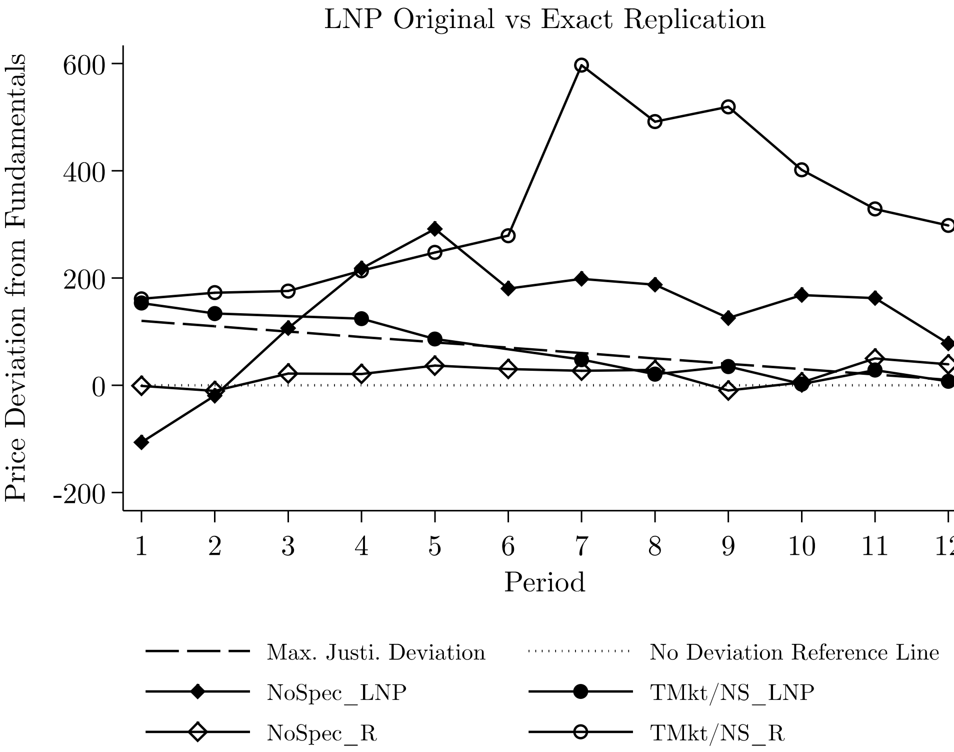


Table 2: Treatment Average Bubble Measures for the Exact Replication and LNP Original Data

	NoSpec		TwoMkt/NS	
	LNP	Exact Rep.	LNP	Exact Rep.
RAD	0.86 (0.43)	0.21 (0.14)	0.46 (0.41)	1.18 (1.07)
RD	0.67 (0.23)	0.11 (0.18)	0.35 (0.52)	1.18 (1.07)
Turnover	0.78 (0.10)	0.91 (0.08)	0.60 (0.30)	0.61 (0.23)

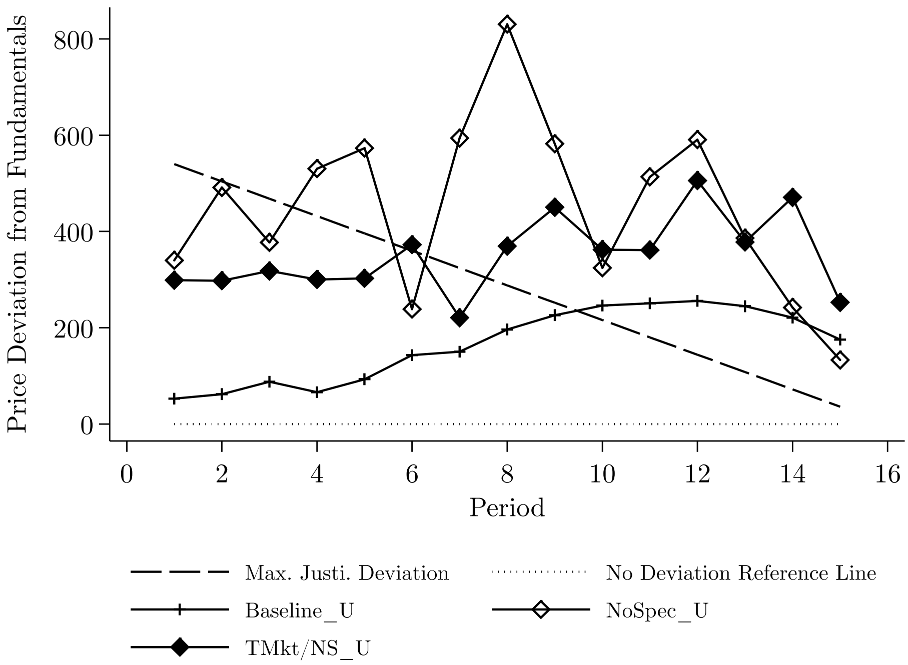
Notes
RAD = Relative Absolute Deviation. RD = Relative Deviation. Notice that in the No Speculation paradigm, the turnover is limited to 1 by design.

3.2 Updated Treatments

Figure 2 depicts the time series of the treatment average prices relative to the fundamental value for treatments NoSpec_U, TMkt/NS_U, and Baseline_U. As before, we add the two reference lines for the maximally justifiable price deviation level relative to the fundamentals (dashed line), and the normalized fundamental value (dotted line). Prices in Baseline_U are consistently above fundamental values throughout the entire lifespan of the asset, and in the last third of the market above the maximally justifiable prices, which is a typical price path frequently observed in the literature (see Palan 2013). Importantly, prices in both NoSpec_U and TMkt/NS_U lie consistently above prices found in the baseline except in the last period. This is despite Baseline_U already being highly bubble prone.

The average RAD is 2.10 and 1.85, and the average RD is 2.08 and 1.85, for NoSpec_U and TMkt/NS_U respectively, suggesting substantial overpricing. As a comparison, RAD and RD for Baseline_U is 0.93 and 0.86 respectively, which are considerably lower than those found in the LNP no speculation treatments (p-value < 0.05 for both measures when comparing Baseline_U to NoSpec_U and TMkt/NS_U). Turnover is 81% and 87% for TMkt/NS_U and NoSpec_U, respectively. That is, sellers typically sold 8 out of the 10 assets endowed to them.[6]

Figure 2. Time Series of Treatment Average Prices Relative to Fundamental Values in the Updated Treatments



3.3. Discussion of the Replications

We have reported results from four treatments with the LNP no-speculation feature. Bubbles are frequently observed, and the magnitudes of bubbles are even greater than the standard SSW environment, despite the fact that the ability to speculate is completely removed. It is puzzling

[6] The maximum possible Turnover is 1 with LNP's no speculation paradigm. It is uninformative to compare the Turnover measure with Baseline_U since this treatment does not impose an artificial limit on trading volume.

that such a strong intervention does not only fail at attenuating bubbles, but may actually worsen the situation. We argue that there are three potentially important design features that may have contributed to the bubbles observed in the LNP no-speculation design.

First, traders in these markets are provided with sharply asymmetric endowments, that is, buyers have only cash but no asset while sellers have only assets but no cash. This leads to artificial 'scarcity' of assets on the buyers' side. The scarcity principle in psychology suggests that '[a]s a rule, if [something] is rare or becoming rare, it is more valuable' (Cialdini 1993, page 239), which means that buyers are willing to pay more to obtain the asset when they perceive the asset as scarce. Additionally, Weber and Camerer (1998) have shown that traders often have a strong preference to balance and achieve a mixed portfolio. Thus, buyers may aggressively compete to initially acquire assets to acquire a mixed portfolio. This can be exploited by sellers, particularly when there are only a handful of sellers in the market due to role restrictions.

Secondly, for every successful trade, the available supply of assets decreases by one unit. This makes the asset rarer by each trade, and may further increase the upward pressure on prices. Note that buyers are typically not cash constrained in our markets due to the high cash to asset ratio (except for NoSpec_R). The average cash balance is 4,684 and 5,250 francs for the buyers at the end of the last period in NoSpec_U and TwoMkt/NS_U respectively, suggesting the buyers still have more than sufficient cash to buy assets even at elevated prices. Furthermore, sellers may be reluctant to sell all their assets because restocking is not possible, inducing perceptions of scarcity, and thereby further reducing supply.

Thirdly, due to the restriction in trader's role, the number of traders in treatments with LNP's no speculation design, the effective number of traders is reduced by half compared to the standard SSW market (as in our Baseline), and thus potentially hinder information dissemination. Indeed, the average number of bids and asks in the order book across periods is 60 when traders' role is not restricted, and it is 29 when the role is restricted, which is more than halved (p-value<0.05, MW-U test, N=39). Additionally, fewer traders can sell the asset with LNP's no speculation paradigm, which may aid sellers' ability to collude at higher prices. We argue that these artificial and unintended design features contributed to the observed bubbles even in the absence of speculation.

While the first issue can be addressed to some extend in the LNP design by endowing traders with a symmetric portfolio, the second and third issues on scarcity-inducing and trade-restricting dynamics cannot, due to the inherent restriction on resale in the NoSpec framework. Results by Janssen *et al.* (2019) provide suggestive evidence in support of our hypothesis. In three market sessions with symmetric endowments, they see less overpricing than in the original LNP NoSpec design.

To fully address these issues, we designed a condition that completely removes any speculative incentives (as LNP's no-speculation), while also eliminating all potential issues of scarcity and asymmetry in endowment and trading that might influence behaviors unintentionally. That is, instead of addressing only parts of the issues in form of symmetric endowments in LNP, our design aims to leave the basic SSW design completely unchanged, except for the elimination of speculation gains.

4. The 100 Percent Capital Gain Tax Treatment

4.1 Experimental Design

We propose a condition in which a 100 percent capital gains tax is levied on resale profits to eliminate any speculative incentives. We call this treatment TAX. The treatment is parametrized as follows, closely mimicking the LNP updated treatments. Each trader is endowed with 10,000 francs as a gift, and 10 units of asset. The asset market last for 15 periods. At the end of each period, the asset pays a random dividend that can take any of the values (0, 8, 28, 60) with an equal chance. Dividend earnings are stored in a separated account, and thus do not impact the cash to asset ratio in the market. The resulting cash to asset ratio in the TAX treatment is the same as in NoSpec_U, TMkt/NS_U and Baseline_U (C/A=2.78), which allows us to make direct comparisons in terms of mispricing. TAX also uses double auction trading rules, where traders are free to buy and sell assets as they wish, but the speculative strategy to buy assets at 'low' prices and then sell them at 'high' prices is no longer profitable due to the tax. Therefore, the only incentive to buy an asset is to receive the dividend payments. If traders rationally respond to the tax intervention, overpricing should be reduced, and prices should also not surpass the maximum justifiable value of the asset. If traders are risk neutral or risk averse, then there is no financial incentive to purchase at prices above fundamental value. In contrast to LNP's design, we focus on traders' speculative motivations directly as opposed to using market mechanisms that prohibit such behavior, which introduce unexpected behavioral anomalies as we argued above.

Taxes incurred due to resale profits are recorded in a separated tax account that is only settled at the end of the last trading period. Therefore, the cash to asset ratio remains intact during the course of all trading periods. Thus, the cash available for purchases will not be artificially reduced by the tax during the experiment. Since the capital gains tax targets only resale earnings, the computer records all purchases made by a trader and sorts purchasing prices from low to high (for example, $p_1 < p_2 \leq p_3 < p_4 <, ...$). If a sale occurs, regardless of the period in which it takes place, the selling price is compared against the lowest purchase price in the record (p_1 in our example). This price is provided to the subjects on their bidding screen.[7] If the selling price is less than or equal to p_1, no tax is imposed on the seller. If the selling price is greater than p_1, then the entire difference (= selling price $- p_1$) is taxed away, and the seller

[7] The text provided to subjects on their bidding screen referencing their lowest purchase price (p_1) is as follows, 'Because of the constraints on resale earnings, the next unit you sell will be taxed for any price greater than [p_1].'

is notified of the tax. The lowest purchasing price then becomes p_2 and the next sale price is now compared to p_2.[8]

Note that the design is not meant to be realistic, or to study the effect of taxes. Just like the artificial asymmetric restriction on trade in LNP, we add an artificial feature to the market that allows control over speculative behavior. We aim to fully eliminate speculative gains without otherwise affecting trading and allocations in the market: (1) We do not tax dividend income. Therefore, a trader with the motivation to solely purchase assets in order to collect dividend payments is not affected by the tax mechanism. (2) The capital gains tax is only levied on resale profit, not against the fundamental value. This means that even if prices are greatly above fundamental value, as long as the resale price is not higher than the purchase price, no tax is imposed on the seller. (3) The tax is not imposed on initially endowed assets. If a trader only acts as a seller in the market, no tax would ever be imposed on her regardless of the selling price. That is, the tax does not prohibit people from trading at prices higher than the fundamental value. Hence, if the tax intervention helps to attenuate bubbles, this is not because it prohibits people from trading at 'high' prices or that it eliminates all reasons to buy the asset.

It is also worth emphasizing that the capital gains tax merely discourages relatively sophisticated traders to engage in speculative trades. Traders who are prepared to buy at any price, for example, the confused traders that do not understand the dividends process, or traders with strong motivation to simply purchase as many units as possible, would not be affected by the tax. In other words, the capital gains tax is not able to prohibit confused traders from trading in the asset market, if they exist.

4.2 TAX Treatment Results

As shown in Figure 3, the time series of the TAX treatment average prices, tracks the fundamental value closely throughout the entire life of the asset. Importantly, there is no single incidence where the treatment average prices rise above the maximum justifiable prices. The treatment average price trajectory does not exhibit any sign of a price surge and crash (as strongly shown in Figure 2 for LNP's design).

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[8] Lei *et al.* (2002) also study the effectiveness of a capital gains tax on dampening bubbles by discouraging speculative motives and find little effect on bubbles. However, their design differs from ours in two aspects. First, their tax is only 50 percent of the capital gains accrued. Second, they calculate the capital gain as the difference between end of the period and the start of period working capital. This has two consequences.

The first is that the sale of initially endowed units, which are not associated with a previous purchase, is also subject to tax. The second is that the resale of an asset in a future period accrues a tax even if no capital gain is achieved, for example a tax is incurred even when the sale price in period *t*+1 is lower than the purchase price in period *t*, as it makes the end-period working capital higher than that in the beginning of *t*+1. It should be noted that it is ex-ante unclear if a 50% tax would encourage or discourage speculative behaviors, as traders with a high aspiration level may speculate harder to make up for the tax obligations.

Figure 3: Time Series of Treatment Average Prices Relative to Fundamental Values in the TAX Treatments

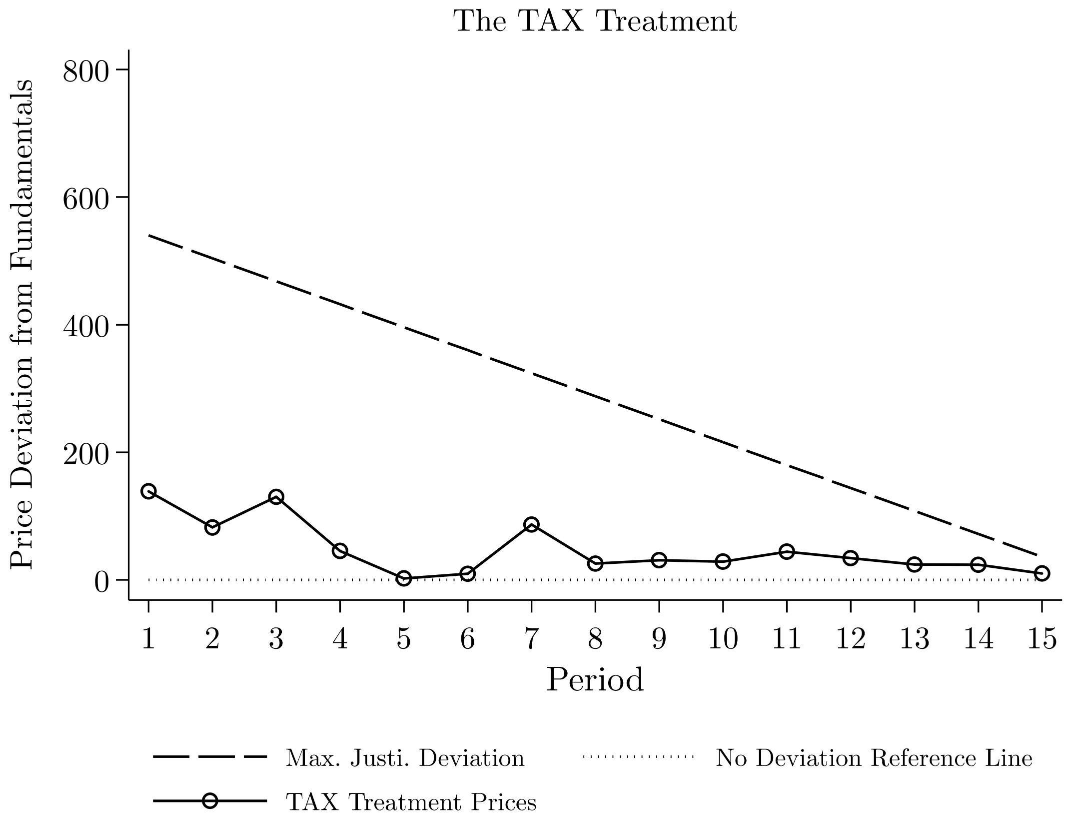

Table 3 presents the bubble measures for all four (comparable) treatments with updated experimental parameters and confirms that price deviations from the fundamentals, as measured via RAD and RD, are substantially and significantly smaller in the TAX condition than in Baseline_U, NoSpec_U and TMkt/NS_U.[9] When both the incentives for speculation and the asymmetric scarcity properties are eliminated, bubbles do not occur even in the presence of confusion and/or lack of common expectations. This provides direct evidence that bubbles are predominantly speculative in nature.

[9] We cannot test for differences in Turnover for treatments involving LNP's no speculation condition, because by design, the LNP no-speculation paradigm (but not the TAX paradigm) has a maximum turnover of 1.

Table 3. Treatment Average Bubble Measures

	TAX	Baseline_U	NoSpec_U	TMkt/NS_U
RAD	0.35	0.93** (0.03)	2.10** (0.02)	1.85*** (<0.01)
RD	0.25	0.86** (0.03)	2.08** (0.02)	1.85*** (<0.01)
Turnover	2.29	4.12** (0.05)	0.87	0.81

Notes
***,**,* indicate significant difference between the bubble measure in the entry and the corresponding bubble measure of TAX at the 1%, 5%, and 10% levels respectively, Mann-Whitney U test. The corresponding p-values are reported in parenthesis.

5. Probing the Underlying Mechanism

5.1 Measuring Cognitive Ability

At the start of each session (including the treatments discussed in Section 3), we measured subjects' cognitive ability using the Raven's Advanced Progressive Matrices (APM, Raven *et al.* 1998). The APM test can be considered as a test on fluid intelligence that predicts the ability to solve problems in a novel environment (Mackintosh 2011), such as a fast-changing asset market. We hypothesize that those who score high on the APM test would also perform well in the market. We employ a short form of the APM test, containing 12 selected items from the original set (Bors and Stokes 1998). We gave subjects 10 minutes for the task and measure the number of questions they answer correctly (we will loosely refer to the IQ score hereafter). The APM test is incentivized such that (1) a higher score yields a higher chance to win a prize of $10, and (2) subjects could never identify their number of correct answers exactly (see Kocher *et al.* 2019). They also do not know their earnings in this part of the experiment until the end of the market experiment.

5.2 Cognitive Results

We argue that sophisticated traders should bid more conservatively than less sophisticated traders in the TAX treatment (no gains from speculation), but not necessarily in the replicated LNP no-speculation treatments where behavioral issues induced by the design may affect even those who understand the market features. We construct two variables measuring bidding behavior using buyer proposed bids in the market. These proposed bids are not necessarily accepted by other traders if they are not high enough. We are interested in both the difference between the proposed bids and the fundamental values of the asset and the proposed bids relative to maximum possible value of the asset, namely ($Bids - FVs$) and ($Bids - MaxValues$) respectively.

If traders are risk-seeking, they might be willing to pay more than the fundamental values. This measure may thus be influenced by differences in risk attitude for people of different IQ (Kocher *et al.* 2019). However, since capital gains are made impossible, there is no valid financial reason to pay more than the sum of the maximum possible dividends ($MaxValues$). We test if sophisticated traders are less likely to post high bids because there are no incentives or behavioral motives to do so in the TAX treatment. Traders are considered to be relatively sophisticated if they scored higher than 50% of the traders in their session on the IQ test.

Table 4 reports regression results clustering at the session level to account for within-session correlations. The differences between buyer-proposed bids and fundamentals (maximally justifiable values, respectively) are regressed on the treatment dummy, the bidder's sophistication dummy, and their interaction. The treatment dummy D_TAX=1 if a bid occurs in the TAX condition, and it is 0 otherwise. We use data from all four replication treatments of LNP with the no speculation design and the TAX condition.[10]

The first regression examines buyer proposed bids relative to the *fundamentals*. It shows that in LNP replication conditions, more sophisticated traders do not bid differently from the less sophisticated. Bids in the TAX treatment are not significantly different on average, but the interaction term is negative, indicating that sophisticated traders in the TAX treatment bid lower than the less sophisticated traders.

Table 4: Regression Analysis of Traders' Sophistication and Bidding Intensity

	Bids relative to FVs	Bids relative to maximum values
Sophisticated = 1	47.87	66.75
	(38.88)	(39.04)*
D_TAX = 1	-37.26	-153.96
	(38.10)	(39.25)***
Sophisticated & D_TAX = 1	-105.12	-116.40
	(52.06)*	(52.86)**
Constant	29.86	-164.82
	(27.38)	(30.23)***
# obs	1,248	1,248
# clusters	29	29
R^2	0.07	0.18

Notes
Results show coefficients from OLS regressions. Robust standard errors, clustering at the session level, are reported in the parentheses. *, ** and *** indicate significance at the 10%, 5% and 1 % significance level, respectively.

[10] Results are qualitatively the same if we include also the Baseline treatment.

The second regression considers buyer-proposed bids relative to the *maximally* justifiable values of the asset. It shows that in LNP replication treatments, more sophisticated traders bid higher than the less sophisticated. Bids relative to the maximally justifiable value in the TAX treatment are lower on average, and the interaction term is negative and substantially larger than the main effect of sophistication, indicating that sophisticated traders in TAX bid substantially lower than the less sophisticated traders. That is, sophisticated bidders show strongly different behavior in TAX versus the LNP's no speculation treatments (NoSpec and TMkt/NS). These results show that the TAX treatment effectively discourages those who are most likely to understand the procedures to engage in speculative trades, which is the key channel to attenuate bubbles. In contrast, even the smarter traders substantially overbid in LNP's design.

6. Conclusions

Economic bubbles are a major destabilizing factor for the economy and often lead to severe consequences (see for example, Brunnermeier and Schnabel 2016 for a comprehensive review). Economists have long been fascinated by the causes of bubbles. Research in finance in the past decades has shown significant progress. For instance, Brunnermeier and Oehmke (2013) offer a broad survey on various reasons for bubble formation, such as rational bubbles, limits of arbitrage and heterogeneous information, etc. In the experimental finance literature, the conventional wisdom has suggested that bubbles are often caused by speculative activities, which result from the lack of common knowledge of rationality (Smith *et al.* 1988; Plott 1991). This interpretation has been challenged by Lei *et al.*'s (2001) results, which suggest that speculation is not a key ingredient to bubbles. We argue that these results can be attributed to design features in LNP that replaced speculative motives by other motives to buy assets at elevated prices. To overcome these issues, we introduce a condition with a 100% capital gains tax on traders, meaning that all resale earnings will be completely taxed away.

All other aspects of the basic SSW asset market are retained. We find that prices track fundamental value very well, suggesting that speculation is an important ingredient for bubbles. Analyses of the bidding behavior of traders show that the TAX treatment discourages relatively more sophisticated traders to engage in speculative activities, while they still make high bids in the LNP no-speculation paradigm.

Our findings, thus, offer direct and strong evidence that speculation does *matter*, and lend support to policy interventions that aim to stabilize the market by targeting directly speculative activities, such as a capital gains taxes or a speculation and vacancy tax in the housing market. It would be interesting to examine how different, realistic tax rates affect pricing in asset markets (which was not the goal of our current design). This is certainly not a trivial question, as people may be become speculative and attempt to make larger capital gains, to make up for taxes paid. More research is certainly needed in this area.

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Appendix

Time Series of Transaction Prices byTreatment

Figure A1: Time Series of Transaction Prices Relative to the Fundamental Value: Nospec_LNP

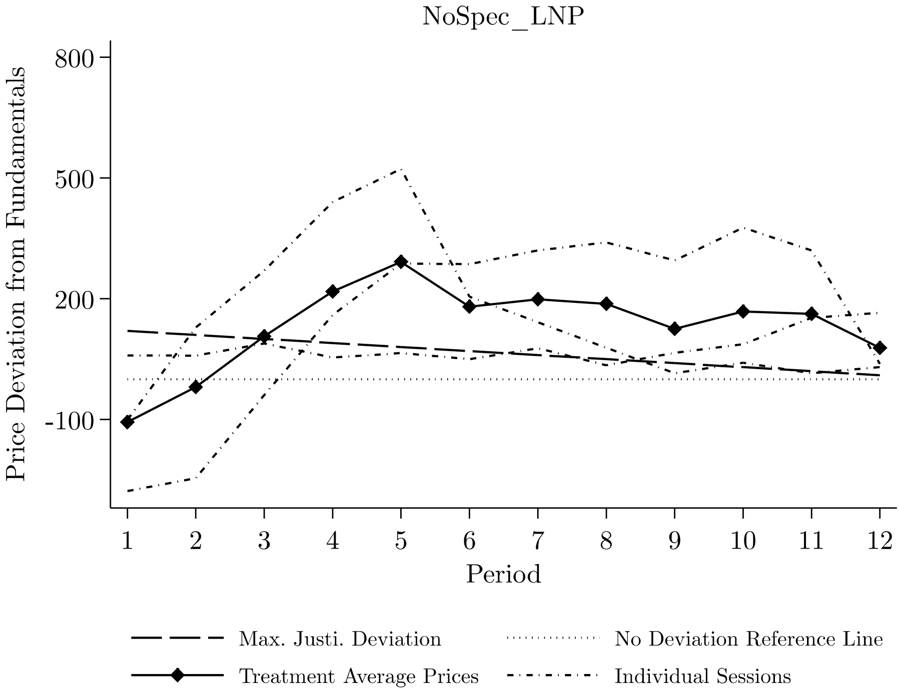

Figure A2: Time Series of Transaction Prices Relative to the Fundamental Value: Tmkt/NS_LNP

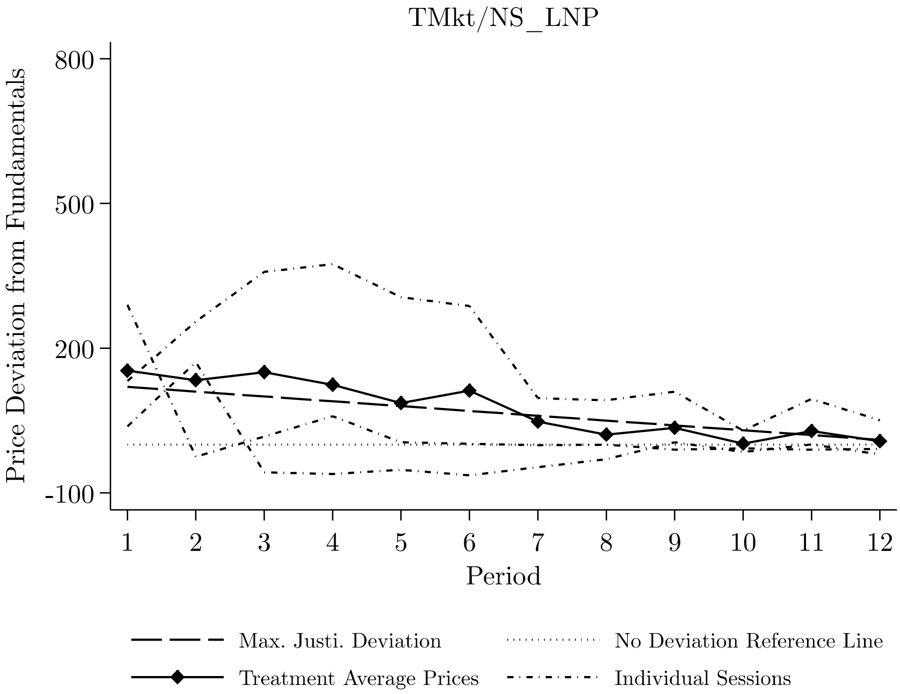

Figure A3: Time Series of Transaction Prices
Relative to the Fundamental Value: Nospec_R

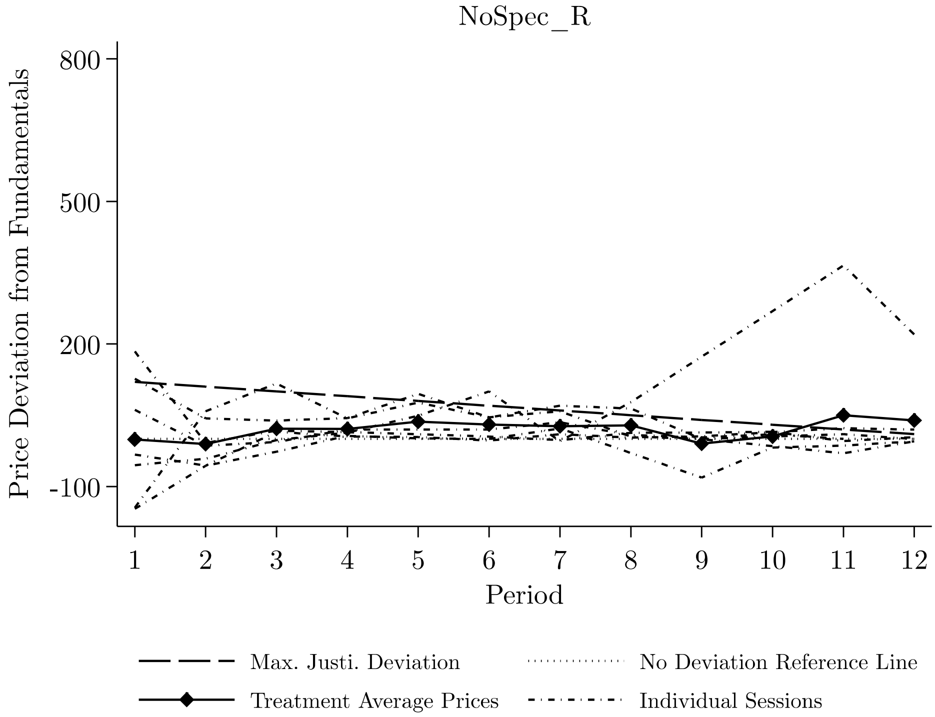

Figure A4: Time Series of Transaction Prices
Relative to he Fundamental Value: Tmkt/NS _R

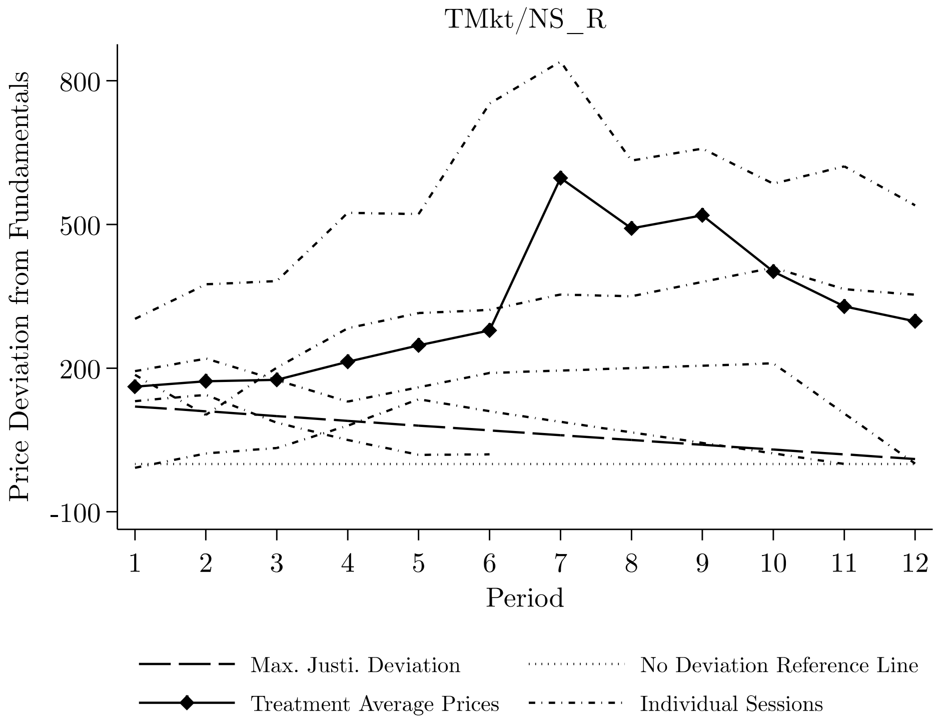

Figure A5: Time Series of Transaction Prices Relative to the Fundamental Value: Nospec_U

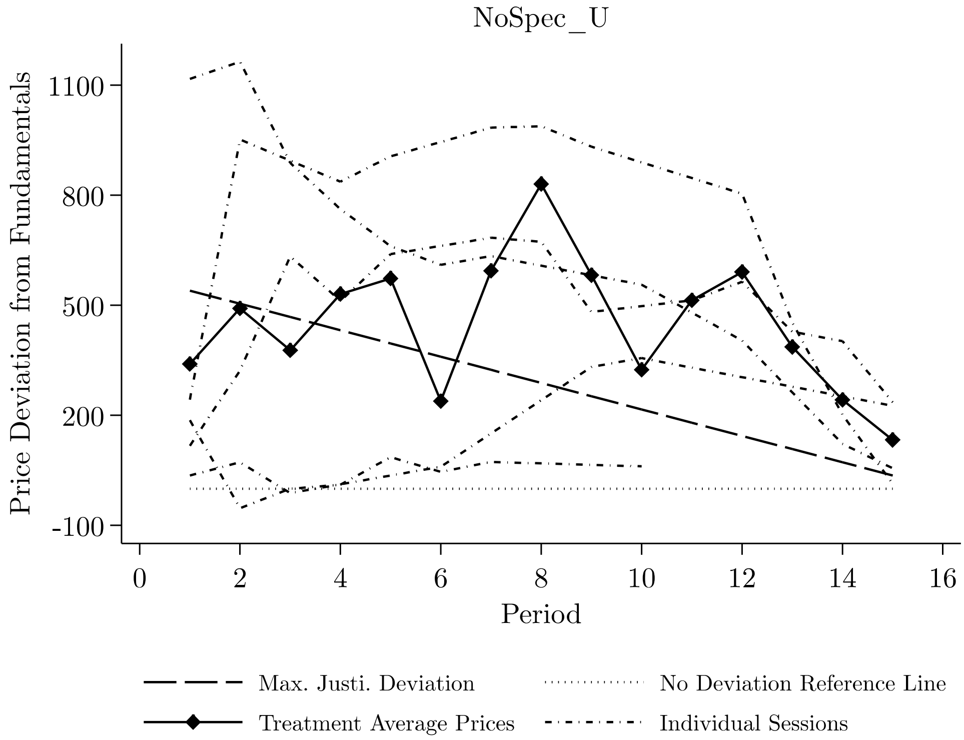

Figure A6: Time Series of Transaction Prices Relative to the Fundamental Value: Tmkt/NS_U

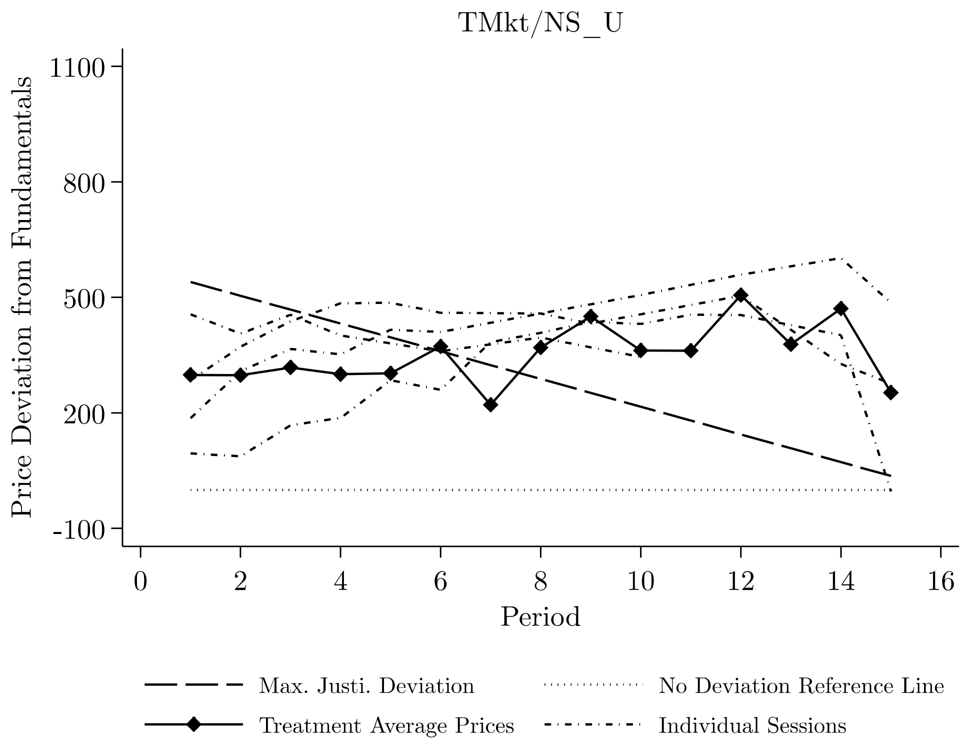

Figure A7: Time Series of Transaction Prices Relative to the Fundamental Value: TAX