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ASSET BUBBLES AND RATIONALITY: ADDITIONAL EVIDENCE FROM CAPITAL GAINS TAX EXPERIMENTS

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1. Introduction

The remarkable phenomenon of bubbles and crashes in laboratory asset markets was first discovered and reported in Smith et al (1988). Subsequent research inquired about the robustness of the phenomenon and how it might be explained. One interpretation of the data is that public knowledge of rationality is lacking in the subjects, which leads to a type of individually rational, bubble creating speculation as part of an attempt to acquire capital gains. A different interpretation is that subjects begin with a type of confusion or mistaken understanding about this particular environment and that such "irrationality" at the individual level initiates the bubble, which could be sustained by a lack of common knowledge of rationality even after all confusion becomes removed during the process of participating in the market. This paper explores these two ideas through the study of experiments in which a capital gains tax is imposed that makes speculation for capital gains unprofitable except under extreme circumstances.

The experiments of Smith et al. created continuous double auction markets for assets with a lifetime of a finite number of periods (typically 15 or 30 periods). Each unit of the asset paid a dividend in each period, and the dividend was typically the only source of intrinsic value. The dividend paid was identical for each trader and the dividend process was common knowledge to all traders. Smith et al. (1988) observed that these long-but finitely lived assets tended to trade at prices much higher than their fundamental values for much of the life of the asset and that their prices tended to crash as the end of the asset's life approached. This pattern was observed despite the fact that there were no rational expectations equilibria in which prices could deviate from fundamental values. Subsequent experimental studies (King et al., 1993; Van Boening et al. 1993; Camerer and Weigelt, 1993; Porter and Smith, 1995; Fisher and Kelly, 2001, Lei et al., 2001 and Noussair et al., 2001) have replicated the bubble phenomenon and shown it to be robust to changes in the structure of the dividend process, the rules of exchange, and the number of assets traded in the market.

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Such price bubbles have been attributed to the lack of common knowledge of rationality of market participants and the resulting incentive to speculate (Smith 1994; Plott, 1991). Alternatively, Lei et al. (2001) claim that errors in decision making contribute to bubble formation. The claim is that even after traditional amounts of training and testing residual confusion can remain in some subjects and leads to mistakenly believe that aggressive buying of the asset for profitable resale is a good strategy. The Lei et al. argument rests on the fact that in markets in which purchase for resale is not possible, the bubble and crash pattern also occurs. Higher than predicted transaction volumes suggest many of the errors arise from the fact that the asset market is the only activity available in the experiment, and that subjects have a tendency to participate actively in the experiment in some manner, even when they do not fully understand the decision situation.

In this paper, we report further evidence that errors in decision-making are a primary source of bubbles. We construct markets similar in structure to those in which bubbles and crashes are observed. The only difference is that a capital gains tax of 50% is in force. The tax is in effect a tax on speculation. There is no reason to suppose that the tax would reduce the number of decision errors. On the contrary, if it serves to complicate the decision task before the subjects, it might indeed increase the incidence of errors. If the tax eliminates or substantially reduces bubble formation, it would provide strong evidence that bubbles are predominantly speculative in nature, rather than caused by errors. However, the presence of bubbles despite the tax would be consistent with the conjecture of Lei et al. (2001) that errors are an important factor in bubble formation.[1] As we report below, bubbles do arise in the presence of the tax, and traders pay taxes that are very substantial relative to their total earnings.

2. Procedures

The procedures we employ are identical (except for the presence of the tax) to those used in the OneMarket treatment of Lei et al. (2001) and are known to produce market bubbles and crashes when no capital gains tax is in effect. The data reported here consist of three sessions, conducted at Purdue University between November and December 1997. Subjects, who were all undergraduates recruited from introductory economics courses at Purdue University, were

[1] Unlike the robustness tests considered previously, a capital gains tax, set at 50% in our experiment, creates a specific disincentive to purchase for resale. Although an individual trader may be able to make a profit by speculating, the existence of the tax and the constant-sum payoff characteristic of the market meant that the group as a whole received lower earnings when speculation occurred. Note that a capital gains tax differs from a tax on each transaction, as implemented by King et al. (1993). Unlike our capital gains tax, their tax penalized every transaction without regard to any capital gain a price appreciation might have caused.

inexperienced with asset market experiments. Subjects were free to buy and sell an asset, called X, in a continuous double auction market. The market was created using the MUDA computer program developed at the California Institute of Technology by Hsing Yang Lee and Charles Plott. Transactions were in terms of an experimental currency called "francs," convertible to US dollars at the end of the experiment at a rate of 130 francs to 1 dollar. The three sessions are labeled here as Captax1-3. In Captax1 and 2, seven subjects, and in Captax 3 eight subjects, were present.

At the beginning of each session, subjects received instruction in the mechanics of making purchases and sales with the MUDA computer program. Afterward, the experimenter read the instructions describing the asset market, and administered a quiz to verify subjects' comprehension of the dividend process. There followed a practice period, which did not count toward subject earnings. After the practice period, inventories of X and working capital, the cash balance available to make purchases of X, were initialized to 10 units and 5000 francs respectively, and the asset market was opened. Sales of X added to working capital and purchases reduced working capital.

Excluding the practice period, there were 12 trading periods in each session. Each period lasted 4 minutes.[2] The inventories of both X and working capital were carried over from period to period starting from period 1 (we refer to the practice period as period number zero). Each unit of the asset paid a dividend at the end of each period. The dividend depended on a coin flip and in each period had a 50% chance of equaling 20 francs, and a 50% chance of equaling 40 francs. The coin was flipped in each period and thus the dividend draws were independent. Therefore the expected dividend paid on each unit of X was 30 francs per period and 360 francs over an entire twelve period session. In addition to the above information, each subject had a sheet indicating the expected total dividend from holding a unit of X from the current period to the end of the experiment. In period t, the expected dividend stream equaled $30*(13 - t)$, where $t \in \{1,..,12\}$ denotes the current period.

Subjects' earnings came from two sources: dividend payments and capital gains. Capital gains were equal to the difference between the end-of-period and beginning-of-period working capital. In the Captax sessions, a tax on capital gains was imposed at the end of each period. The tax rate was 50% if a subject's capital gains were positive, and zero if they were negative. Since there was no tax levied on dividends, each subject's period earnings were equal to dividends on all units of X in his inventory plus the after-tax capital gains or minus capital losses. The capital

[2] Period 12 in CapTax2 lasted only two minutes.

gains tax was levied "on paper" and thus did not reduce the working capital available for purchases.

3. Results

The principal result of our study is that the capital gains tax does not eliminate price bubbles. Figure 1 shows the time series of median transaction prices in each period of the three sessions compared to the fundamental value, and to the maximum and minimum possible realizations of the dividend stream. All three sessions have at least six consecutive periods in which the median price is greater than the fundamental value, and two of the sessions have at least five consecutive periods in which the median price is higher than the maximum possible realization of the dividend stream.

[Figure 1: About Here]

The magnitudes of the bubbles under Captax are comparable to those observed in previous studies. King et al. (1993) suggest several measures to measure magnitude. Three of these measures are *Price Amplitude*, *Normalized Deviation*, and *Turnover*. The Price Amplitude is defined as the difference between the peak and the trough of mean period prices relative to the fundamental value, normalized by the initial fundamental value. In other words it equals $max_t\{(P_t - f_t)/f_1\} - min_t\{(P_t - f_t)/f_1\}$, where P_t and f_t equal the average transaction price and fundamental value in period t, respectively. In our markets $f_t = 30*(13 - t)$. The normalized deviation is the sum, over all transactions, of the deviations of prices from the fundamental value, divided by the total number of shares outstanding. It equals $\sum_t \sum_i |P_{it} - f_t|/(TSU*100)$, where P_{it} is the price of the ith transaction in period t and TSU equals the total stock of units.[3] Turnover is defined as the total volume transacted over the session divided by the total stock of units. In our sessions, all three measures reach levels that are comparable to those observed in other studies (see Porter and Smith, 2002, for a summary of the values of the measures in other studies).

[Table 1: About Here]

[3] We use the formula $\sum_t \sum_i |P_{it} - f_t|/(TSU*100)$. In contrast, many other authors do not divide by 100. This is because their prices are measured as dollars and f_t typically takes on values between 0 and $3.60. In our markets, in which trade takes place in experimental currency, f_t takes on values in the range of 0 to 360 francs. Thus, to have a comparable measure of the normalized deviation, we divide by 100 for our data. .

In the three sessions, overall revenue from capital gains taxes equaled 24.9%, 47.0% and 53.4% percent of the overall expected dividend stream of the total stock of units in sessions 1-3 respectively. Thus the tax failed to prevent price bubbles, even when it imposed very substantial costs on traders.

4. Concluding Remarks

We find that the imposition of a capital gains tax fails to eliminate the possibility of a bubble.[4] Two of our three markets exhibited sustained transaction prices far in excess of fundamental values. Furthermore, the observed measures of the magnitude of bubbles yield values typical of markets without a capital gains tax. While we report behavior of only three markets, the data are sufficient to establish the point. The possible existence of bubbles in the presence of the capital gains tax is clearly established. We are in agreement with previous authors who have shown the bubble phenomenon to be robust to changes in trading rules thought to discourage bubble formation. The presence of bubbles and crashes and the high revenue generated by the tax in our data is consistent with the conjecture of Lei et al. (2001) that errors are an important factor in bubble formation.

When taken with experiments reported elsewhere, these data are part of what appears to be an emerging pattern. The robustness of the bubble phenomenon appears to be in fact a reflection of the robustness of the decision errors to different treatments. Given the nature of the issue it is not clear what information would be gained from additional experiments conducted in the same way as those reported here. The exact source of subject confusion is not likely to be exposed by more data gathered under the same procedures. Instead, changes in instructions and procedures might produce more insights.

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[4] We recognize that there are many alternative methods of implementing a capital gains tax, other than the one we chose. One possibility is to have the tax paid on each individual sale rather than on changes in overall cash balances. The purchase price of a unit could be calculated on either a first-in-first-out or a last-in-first-out basis. However, a system of this type would place a far greater computational burden on the subjects, and we do not see how such a system might be more effective in suppressing price bubbles than the system we have studied. We believe that the empirical patterns we observe here are so strong, and the robustness of the bubble phenomenon so well established, that altering the structure of the tax would not qualitatively change the result.

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Table 1. Bubble Measures, All Sessions

	Turnover	Amplitude	Normalized Deviation
Captax1	1.357	0.988	1.876
Captax2	3.614	2.124	7.914
Captax3	3.563	1.647	8.607

Figure 1. Time Series of Median Transaction Prices by Period, All Sessions