Relative Wealth Concerns and Asset Bubbles: An Experimental Approach

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ABSTRACT

This study offers empirical support for a recently proposed theoretical model of asset market bubbles in which relative wealth concerns cause rational investors to choose to participate in a finite horizon bubble. I find that laboratory asset market bubbles are larger when participants are given upward social information, i.e. are informed of the highest payoff in their market, as compared to downward social information. This finding can be explained by the influence of social comparisons in the formation of prospect theory reference frames; upward comparisons may cause participants to construe their outcomes as losses and become more risk-seeking.

The dramatic rise and fall of Internet stocks, followed by the dramatic rise and now falling price of residential real estate, has heightened the interest of financial economists in bubbles. Though their precise definition is the subject of debate, bubbles are generally considered to occur when the market price of an asset is not equal to the expected value of its future cash flows discounted at an appropriate rate. Smith, Suchanek and Williams ("SSW", 1988) originated a methodology for studying bubbles in the laboratory by having individuals trade a risky asset with an easily calculated, common knowledge expected value. They found, and copious research has confirmed, that prices in experimental markets with inexperienced players rarely track expected value, but instead typically display a bubble-like pattern; market prices begin below expected value and then exceed expected value for much of the experiment before collapsing near the end.

Despite the robustness of these results, this research has had relatively little impact on the debate among financial economists about bubbles, primarily because the vast differences between laboratory and real-world asset markets make it difficult to determine whether the apparent similarity between observed price patterns results from the same underlying dynamic or is coincidental. The goal of this paper is to help address this question by empirically testing a motivational explanation for laboratory bubbles based on concerns about relative outcomes similar to one recently proposed by DeMarzo, Kaniel, and Kremer (2008) to explain bubbles in real-world markets.

SSW attributed laboratory bubbles to players' uncertainty about the rationality of other players. Lei, Noussair, and Plott (2001) demonstrated that doubts about the rationality of other players are often justified, but they echo SSW's argument that bubbles are not solely due to the behavior of irrational players, but also to rational players who choose to speculate in the hopes of deriving capital gains from the irrational players' mistakes. Caginalp, Porter and Smith (2001) model such speculation as being based on a momentum strategy, i.e. a belief in the persistence of price trends. Players using this strategy buy (or do not sell) shares for more than expected value in the expectation that they will be able to sell the shares for even more in future periods.

None of these researchers, however, offer an explanation of how, or whether, such speculation succeeds in increasing players' expected outcomes. While momentum strategies are commonly used by real-world investors, they are of questionable effectiveness (Pettengill, Edwards and Schmitt 2006). In order to use a momentum strategy successfully, experimental market participants must be able to predict when the momentum-driven increase in price will reverse, which Caginalp, Porter, and Smith (2001) note is generally not predictable even by experimenters using sophisticated mathematical models based on a more complete set of information than the players typically have. In the absence of either theory or evidence for how the speculators infer, and then take advantage of, the irrational behavior of others, this line of reasoning implies that speculators are either hyper-rational and understand something about the bubble pattern that has eluded investigators, are irrational and believe they can exploit the mistakes of others only to end up making the same mistakes themselves, or are motivated by something other than maximizing expected outcome.

While maximizing expected outcome has long been assumed to be the only relevant motivation in the vast majority of economic experiments and models, a longstanding alternative hypothesis is that people care at least as much about relative outcomes as they do absolute outcomes (Frank 1985). Abel (1990) was the first to incorporate relative wealth concerns into asset pricing models, an approach also followed by DeMarzo, Kaniel, and Kremer (2008), who specifically linked this motivation to bubbles. In their model, a concern for the affordability of future "scarce goods" induces investors to herd to avoid the risk of poor relative performance. As a result, rational players in financial markets will choose to participate in a finite-horizon bubble even when they are aware it is a bubble.

James and Isaac (2000) provided empirical support for the impact of relative wealth incentives on bubbles by conducting laboratory markets where payoffs were explicitly linked to above-average performance. They demonstrate that in this situation, below average players have an incentive to pay above expected value for the asset in the final period of the game in the hope that a high dividend payment will move them above average, thus fracturing the backward induction argument that equates fundamental value with expected value. As predicted, whereas in "standard" (i.e. absolute payoff) markets even a minority of thrice-experienced players diminishes the likelihood of bubbles (Dufwenberg, Lindqvist, and Moore 2005), bubbles are not eliminated by experience in relative payoff markets.

To be sure, the reasoning of DeMarzo, Kaniel, and Kremer (2008) and James and Isaac (2000) does not apply in standard experimental markets, where the strategy of buying for less than expected value or selling for more is, by definition, the optimal strategy for the average player wishing to maximize expected outcome regardless of whether her goal is relative or absolute. Nevertheless, a plausible hypothesis is that the decision to speculate is mediated by concerns about relative outcomes even in the absence of direct incentives. In order to test this hypothesis, one must devise an experimental manipulation to increase players' motivations for relative performance without explicitly linking relative outcomes to payoffs.

An obvious possibility offered by the extensive research literature on social comparison processes is the distinction between the motivations for and consequences of upward vs. downward comparisons (Buunk and Gibbons 2007). People who compare themselves to superior, as opposed to inferior, performers are more interested in improving performance and also more likely to succeed in doing so, both because upward comparisons may reveal useful information about how to improve and because they may increase the motivation to improve (Blanton, Buunk, Gibbons and Kuyper 1999). A motivation to improve caused by social comparison is conceptually indistinguishable from a desire to improve one's relative performance,

> Hypothesis: Experimental asset market bubbles will be larger when players are given upward, as compared to downward, comparison information.

Methods

Participants in 14 groups of 8 to 10 (N=131) participated in an experimental asset market in which they traded a stock-like asset (Smith, Suchanek, and Williams 1988). The experiments were conducted over a roughly thirty month period as part of a larger set of studies; additional methodological details not directly relevant to the analyses reported below are included in Appendix A.

Participants were recruited from the student population at a large research university via a combination of posters and e-mails. Approximately half were undergraduates and half were from an assortment of graduate and professional schools. Ages ranged from 18 to 59, with an average of 23.1 and a median of 21. 48.0% of participants were male.

Participants sat at computer terminals in separated individual cubicles and were given oral instruction (Appendix B) on the structure of the market, which had 15 trading periods during which participants could buy and/or sell shares of the stock. They were informed that the end of each period, each share would pay a dividend in cash, determined by a computerized random draw from four equally probable values (0, $0.08, $0.28 or $0.60), with an expected value of $0.24. Participants were initially endowed with one, two or three shares of the asset plus a cash account of $9.45, $5.85 or $2.25, respectively, so that all participants began with the same expected value payoff ($13.05). At the end of the experiment, participants were paid a $5 show-up fee plus an amount of money equal to their starting cash account plus the total value of the dividends they received plus any amounts received from sales of shares, less any amount paid for purchases of shares.

Participants were next instructed in the use of a multiple unit double auction market process (Plott and Gray 1990) programmed and conducted with the software Ztree (Fischbacher 2007), using an interface developed by Haruvy and Noussair (2006). Participants were given a reference sheet that showed the expected value of each share at the beginning of each trading period, along with an explanation of how it was calculated (Appendix C). Participants then played a two-round practice game to experience the trading process (see Appendix D for an example of the trading screen). Finally, their accounts were reset to their initial values and the actual game commenced.

After each period of the market, participants viewed an "account status" screen (Appendix E) which included the following information about the current state of their account:

- Total Cash
- Total Shares
- Stock Price (defined in the verbal instructions as the highest "bid" made for a share in this period)
- Account Total (defined on the screen as cash plus market value of shares)

The only manipulation that differed between markets was the type of information available for social comparison. In seven markets (the "upward" groups, comprising 66 participants), the “account status” screen included the largest account total of any player in the game, while in the other seven (the “downward” groups, comprising 65 participants), it included the smallest account total of any player in the game.

After the market was completed, participants received their payments. Final payments (including the $5 show-up fee) ranged from a high of $73.55 to a low of $5.00 (since subjects could not purchase shares unless they had sufficient funds, they were generally protected from the possibility of a negative account balance; nevertheless, for reasons explained in Appendix A, the one player who received only the show-up fee had a final account balance of negative $0.10). The average payoff was $18.54, and the median payoff was $14.20.

Results

Figures 1 and 2 show average trading price for the asset during each period of the seven upward markets and seven downward markets, respectively (interruptions in the lines represent periods when no trades occurred). The straight, downward-sloping line represents the expected value of the asset during each period. Consistent with prior research studies, there is as a strong tendency for prices to exceed expected value for a large portion of the game. In fact, all of the upward markets here show considerable bubbles (including one too large to fully display, Market 11, where the average price peaked at $8.53 in Period 10, $7.09 above, or 592% of, expected value). By contrast, while some of the downward markets also show bubbles, in two of them prices track expected value quite closely for much of the game (in Market 5, no greater than a 9% deviation from Period 4 on and in Market 13, no greater than a 13% deviation from Period 8 on).

The game’s wide range of payoffs meant that players in the upward and downward markets observed widely different social comparison information. The average value of the highest account across all periods of all upward markets was $45.27 vs. an average value of the lowest account across all periods of all downward markets of $2.27. The highest account totals were particularly extreme during a bubble, when the use of market price ascribed a high notional value to shares; for example, the highest account value was in excess of $100 for four periods of Market 11.

Figure 1
Average Trading Price for Upward Markets

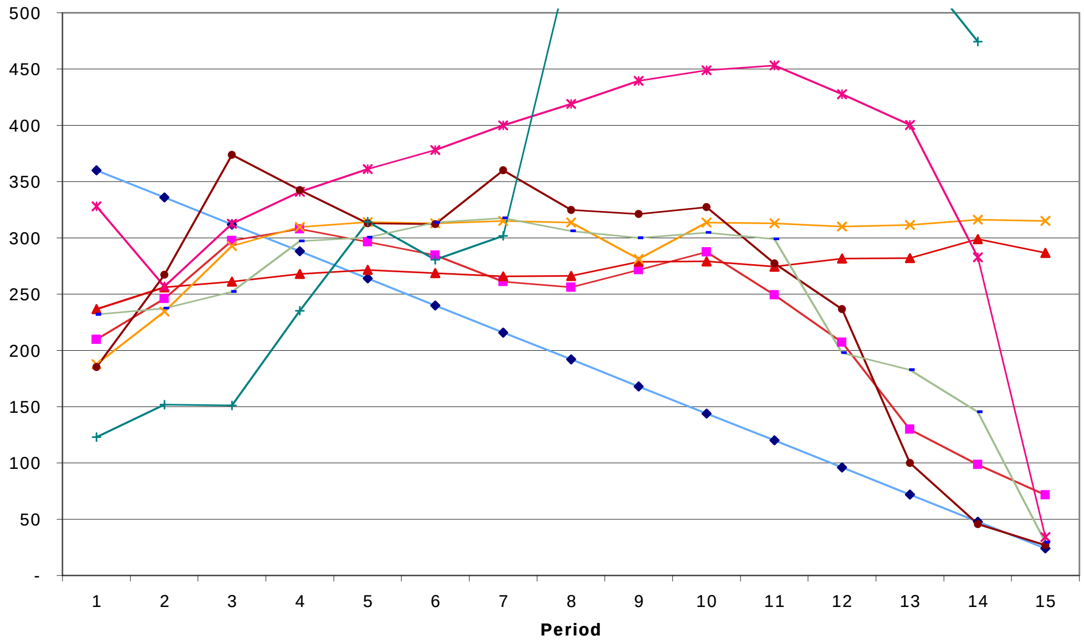


Figure 2
Average Trading Price for Downward

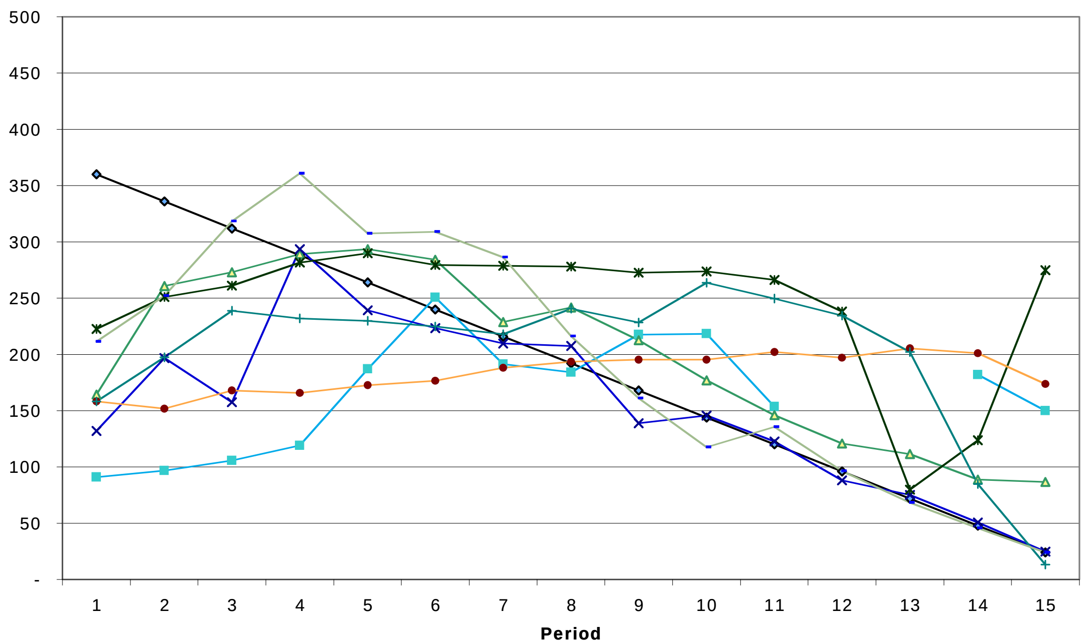


Table 1 shows averages across all upward and downward markets for nine metrics used in the research literature to measure the severity of bubbles (Haruvy and Noussair 2006, Haruvy, Lahav, and Noussair 2007):

- Price Amplitude, a measure of the magnitude of overall price changes relative to the fundamental value over the life of the asset: $\max_t\{(P_t-f_t)/f_t\} - \min\{(P_t-f_t)/f_t\}$ where P_t and f_t are the average price and fundamental value in period t
- Turnover, a normalized measure of the amount of total trading activity in the market: $(\sum_t q_t)/TSU$ where q_t is the quantity of units of the asset exchanged in period t and TSU is the total stock of units in the market
- Normalized Deviation, a measure that includes both transaction prices and quantities exchanged: $\sum_t q_t|P_t-f_t|/TSU$.
- Average Price of all transactions
- Maximum Deviation between a given period's fundamental value and average trading price: $\max_t\{(P_t-f_t)\}$
- Average Bias, the average deviation of period price from period fundamental value: $\sum(P_t-f_t)/15$
- Total Dispersion, the sum of the absolute values of deviation of period price from period fundamental value: $\sum_t|P_{it}-f_t|$
- Boom Duration, the maximum number of consecutive periods where $P_t>f_t$
- Upward Trend Duration, the maximum number of consecutive periods that the price increases from one period to the next

Table 1
Measures of extent of bubbles, by market type

Measure	*Units*	*Downward Average (Standard Deviation) N=7*	*Upward Average (Standard Deviation) N=7*	*Wilcoxon rank sum test*	
				p-value	*W*
Price Amplitude	None	4.4 (3.7)	6.5 (4.6)	0.38	32
Turnover		9.0 (3.8)	9.9 (3.2)	0.46	31
Normalized Deviation		826.5 (341.0)	1218.0 (439.1)	0.26	34
Average Price	Cents	191.1 (39.0)	277.3 (38.6)	0.002**	47
Maximum Deviation		118.2 (76.5)	300.2 (192.6)	0.007**	45
Average Bias		-3.6 (33.6)	105.1 (69.3)	0.001**	48
Total Dispersion		1,085.9 (434.7)	2,183.0 (1272.1)	0.04*	41
Boom Duration	Periods	7.3 (3.5)	11.6 (1.0)	0.02*	42.5
Upward Trend Duration		3.7 (2.0)	4.6 (2.3)	0.60	29

*p<0.05 **p<0.01

Consistent with the Hypothesis that bubbles are larger in upward markets, the upward markets have higher average values on all nine metrics, with five showing statistically significant differences based on a Wilcoxon rank sum test: three at $p<0.01$ and two at $p<0.05$.

Market 8 included three participants (of ten in total) who had played in a previous market. Since this high a percentage of experienced participants may well have impacted the evolution of market prices, averages were also calculated excluding Market 8. This lowered the average value for upward markets on three metrics (Price Amplitude, Average Price, and Boom Duration), but had only a negligible impact on the statistical significance of the latter two in comparison with downward markets (from $p=0.002$ to $p=0.005$ for Average Price and from $p=0.02$ to $p=0.04$ for Boom Duration).

Discussion

Market bubbles have generated considerable research interest and debate because they call into question not only market efficiency but also the broader issue of when rational agents dominate market outcomes. But tests of both efficiency and rationality depend critically on assumptions about the underlying goals of economic agents.

The standard assumption of experimental (and traditional) economists is that agents are solely motivated to maximize average expected earnings, subject to some degree of risk aversion. Following this logic, experimental market researchers have attributed trading prices above expected value to some combination of players who are irrational and other players who believe that they can predict, and thus exploit, the behavior of the irrational ones (a belief which may itself be irrational).

Thus, the central element of this story is the irrational behavior of confused and inexperienced players. This attribution offers a natural explanation for the fact that experience with the game eliminates bubbles (Dufwenberg, Lindqvist, and Moore 2005): players learn not to be irrational, eliminating the incentive for speculation. Given the general presumption among economists that real-world markets are dominated by experienced investors, this argument implies that bubbles in laboratory markets with inexperienced players have little relevance for real-world markets.

This study provides clear evidence of irrational behavior by confused and inexperienced players; in over half of the markets, trades occurred in the final period at prices above the asset's maximum possible value. But this particular form of irrationality is observed equally in upward and downward markets (see Table 4 and the further discussion of this phenomenon in the section immediately following), and so cannot explain the difference in the magnitude of bubbles between conditions.

Thus, it is more likely that upward social information affects the decision to speculate. Recall that past research has demonstrated two channels by which upward comparisons may affect behavior: either by revealing useful information about how to improve performance or by increasing the motivation to improve. It is hard to see how awareness of the nominal account value of the best performer conveys useful information about how to speculate successfully, which past research strongly suggests depends on trends in bids, offers and trading volume (Caginalp, Porter and Smith 2001). Furthermore, if the critical information underlying the decision to speculate was the observation of irrational behavior, downward comparisons ought to have at least as great, if not a greater, impact on the decision, since they allow players to observe directly that at least one player in the game is clearly confused.

Therefore, the most plausible impact of social comparison is on the motivation to improve performance. While this motivation might itself be irrational if, in the absence of an ability to actually improve performance, it results in lower expected earnings, it would not *necessarily* be irrational if the motivation to improve were also linked to a change in risk attitude. That is, a risk-seeking player would rationally be willing to speculate in the hope of very high earnings even at the cost of having lower average expected earnings.

Why might upward comparisons be associated with greater risk-seeking? Prospect theory (Kahneman and Tversky 1979) proposes that decision makers are likelier to make risk-seeking choices when trying to avoid outcomes which are encoded as a loss relative to some reference outcome. Though relatively little research has been done on how individuals establish reference outcomes, Tversky and Kahneman (1981) note that social norms are likely to be influential. Thus, if an individual bases his reference outcome on the highest outcome in a market, he may construe his current outcome as a loss, and be more risk-seeking.

Risk-seeking behavior offers a parsimonious explanation for the most obvious feature of the bubble pattern, trading which occurs above expected value. While past researchers have attributed this primarily to speculative motives, i.e. a focus on resale value, rather than to individual risk preferences, this ignores the risk inherent in pursuing a speculative strategy. After all, if even researchers are uncertain of their ability to predict when momentum-based trading will reverse, a rational speculator would presumably also be aware of the strategy's riskiness. Based on this line of reasoning, we would predict that average trading prices ought to be particularly affected by upward comparisons, as indeed they are. As reported in Table 1, upward markets have a higher average Average Price of 277.3 cents vs. 191.1 for downward markets (p=0.002 on a Wilcoxon rank sum test).

DeMarzo, Kaniel and Kremer (2008), who model purely rational agents, point out that "an outside observer that does not account for relative wealth considerations might be tempted to conclude that some of the agents in the model are actually risk-loving." (p. 47). In a similar vein, while this data cannot exclude the possibility that what appears to be risk-loving choices are actually the result of underestimation of risk due to overconfidence (as in, e.g., Camerer and Lovallo 1999), it is not clear how meaningful the distinction would be for predicting behavior. While further research might be able to distinguish these two possibilities by eliciting speculators' beliefs about prospective returns, social comparison based reference frames appear to offer a promising avenue to pursue in asset pricing models, even if only on an as-if basis.

One consequence of this alternative explanation for laboratory bubbles is that it shifts the focus from irrationality, which is presumed to be less relevant to real-world markets, to relative wealth considerations, which many believe are highly relevant to real-world markets. As noted by a Goldman, Sachs financial institutions analyst, “the real business of [professional] money management is not managing money, it is getting money to manage,” and the key to this is superior relative performance (Basak, Pavlova, and Shapiro 2007). Even aside from this important agency issue, there is considerable evidence that individuals care a great deal about relative outcomes (Diener and Biswas-Diner 2002, Luttmer 2005).

One question this interpretation raises is what mediates the importance of relative vs. absolute performance concerns in real-world markets. Specifically, in terms of the mechanism proposed here, why might upward comparisons become more salient during bubbles? One possibility is that the mass media focus more on top performers during a bubble than at other times, an idea consistent both with anecdotal observation and with Shiller’s (2000) comments about the key role played by the mass media in propagating bubbles. Another possibility is that more attention is paid to upward comparisons when top performers are garnering larger returns. This is conceptually similar to the impetus for rational participation in bubbles in DeMarzo, Kaniel and Kremer (2008), where the scarcity of a desired good means that its price will be determined more by the resources held by the top performers than by those held by average ones.

Further comments on social influences in asset markets

There is one unusual feature of the markets in this study that requires further comment. In the final market period of seven of the fourteen markets, at least one and as many as seven players bought shares for more than their maximum possible value ($0.60), while in an eighth market, three players with shares declined to sell even though there was an open bid at $3.50. While this phenomenon has been observed in other studies (e.g., Lei, Noussair, and Plott 2001), the extent of the confusion was extreme: in Market 3, seven players paid prices ranging from $2.80-2.90 in fifteen trades in Period 15. As a result, following Market 3, the experiment’s instructions were changed in order to further emphasize that the shares would be worthless at the end. Nevertheless, the phenomenon occurred in nearly half of markets following the change. Table 4 shows how widespread decision errors were in both upward and downward markets; overall, 28.8% of the players in these eight markets bought a share above maximum value in period 15 and 45.2% held shares at the end despite opportunities to sell for above maximum value (these percentages are virtually identical across the two conditions).

Table 4
Period 15 Statistics for Selected Markets

Market (# of players)	*# distinct buyers above max value (# trades)*	*Avg trade price*	*# players holding shares at end*	*Final Spread (Highest open bid – lowest open offer)*
Upward				
1 (8)	2 (3)	0.72	3	0.50 – 0.90
3 (10)	7 (15)	2.87	6	2.87 – 2.75
8 (10)	2 (5)	3.15	6	3.15 – 3.18
11 (10)	0	N/A	3	3.50 – 3.90
% of players	*28.9%*		*47.4%*	
Downward				
2 (9)	1 (1)	1.50	4	1.32 – 1.50
6 (10)	2 (3)	0.87	3	0.80 – 0.80
9 (8)	2 (3)	2.75	3	0.10 – 2.46
10 (10)	5 (7)	1.74	5	1.50 – 1.70
% of players	*27.0%*		*40.5%*	

Clearly many participants misunderstood or forgot the instruction that the asset was worthless at the end of the game. Why did so many make this mistake, and what did they think the shares would be worth? An unusual feature of the experimental protocol suggests the answer: calculating the "Account Totals" that were used to provide social information to participants required the determination of a value for stock holdings while the market was in progress. Given the desire to create a reasonable analogy to real world markets, a market value was used for this purpose rather than expected value. Thus, the status screen provided to participants at the end of each period of the Game included the "Stock Price," defined in the verbal instructions as the highest bid in the period just completed. The most plausible explanation for the willingness of participants to pay more (or not sell for more) than the asset could possibly be worth is that they came to believe that the "Stock Price" represented the actual value rather than merely a market price of the shares.

Consider the game from the participants' point of view. The instructions at the beginning of the experiment are long and complicated; along with the game's basic structure, players must also learn to use unfamiliar computer-based trading software. In the absence of any explanation as to why the Stock Price is being given, it is not surprising that some participants, assuming the information must be relevant in some way, either forget the initial instructions or wonder whether they misunderstood them.

This confusion is likely reinforced by the observation that *other* people seemed to also place a high value on the asset. In other words, the market price becomes a social norm. Figure 3 shows the complete trading history for Market 6 (each point represents a single trade, while the stepped straight line represents the expected value at the time of each trade). Note that from Period 7 onwards, trading prices stabilize within a very narrow range, with very few exceptions; 58 of 60 trades (96.7%) occur at prices ranging from $2.96 to $3.20. The arbitrary social norm established was sufficiently powerful that 6 of

10 players still held shares at the end of the game despite an open bid at $3.15 (vs. an offer to sell at $3.18!).   Markets 4 and 13 (Figures 4 and 5, respectively) show similar trading patterns: initial volatility followed by convergence to a price that remains remarkably stable through the end of the game.

Figure 3
All Trades Market 7

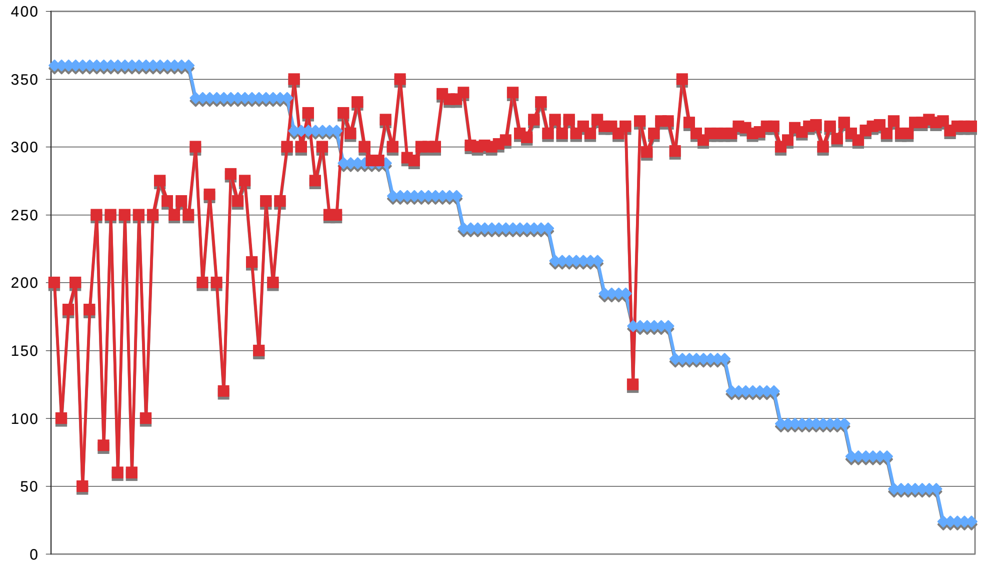


Figure 4
All Trades Market 3

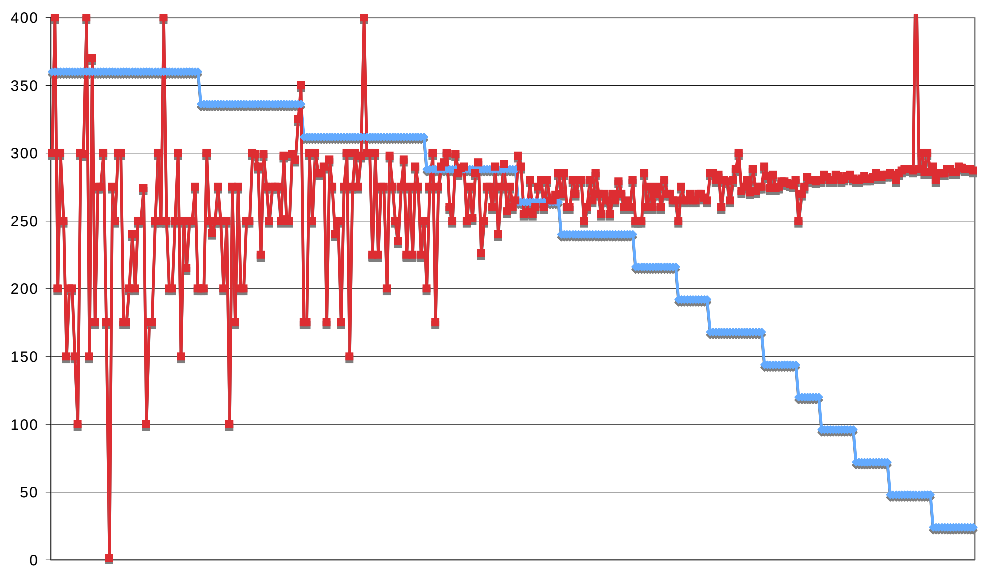
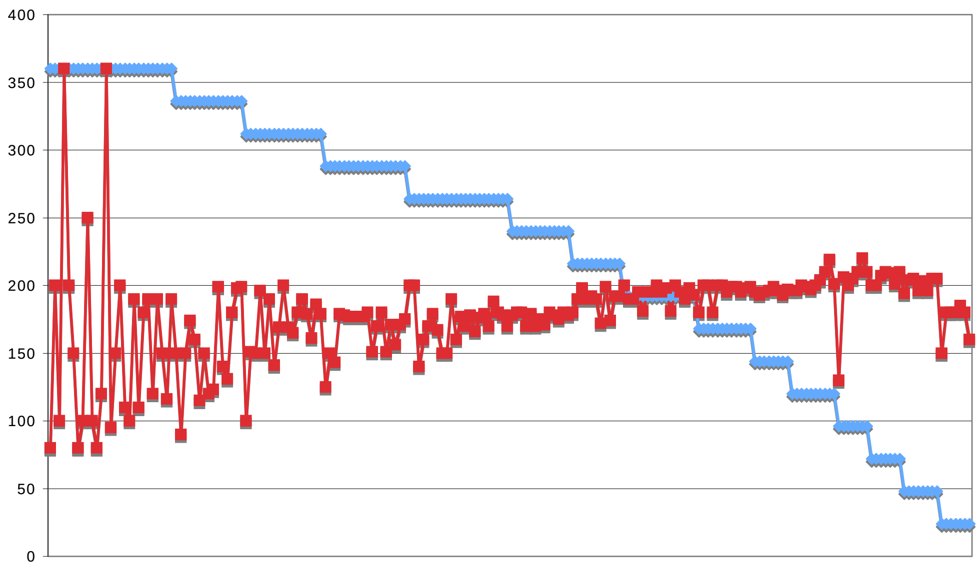


Figure 5
All Trades Market 10



Given that experimental asset markets were expressly designed to test for market efficiency in situations where the traded asset's "objective" value was easily calculated and common knowledge, the failure of 50% of markets to collapse might be viewed as indicating a basic flaw in the experimental design that could be rectified by further effort to ensure that all participants understand, and don't forget, the rules of the game. The motivation for this research, however, is not explaining what happens in experimental asset markets per se, but understanding patterns observed in real world markets. The most obvious and important difference between the two is that in real world markets, the knowledge needed for calculating objective asset values is "fluctuating, vague, and uncertain" and often without any "scientific basis on which to form any calculable probability whatever" (Keynes 1937, p. 113-4). Keynes felt that it was precisely this enormous uncertainty which made it easier, safer, and more sensible for sophisticated investors to try "anticipating what average opinion expects the average opinion to be," i.e. speculating, rather than attempting to calculate the inherent value of assets (Keynes 1936).

Thus, one might reasonably question whether the feature that makes experimental markets analytically tractable – an asset with a known value – also makes them a poor analogy for real world markets. From this perspective, laboratory markets with inexperienced players who are confused and uncertain may be more psychologically similar to real-world markets than ones with experienced players. The convergence of price to an arbitrary value (Figures 3-5) is highly reminiscent of classic experiments by Sherif (1936) in which he shows that individual judgments of a purely subjective phenomenon converge upon exposure to the judgment of others, an effect which is greater in ambiguous or uncertain situations (Deutsch & Gerard 1955) and when the task is important (Baron, Vandello and Brunsman 1996).

Real-world markets are obviously both highly uncertain and enormously important, suggesting that it is well worth studying behavior in markets where confused participants rely on the social norms embodied in market prices as indicating (or perhaps even defining) objective value (which both efficient market theory and modern accounting and regulatory standards instruct them to do). To be sure, there is already an extensive economics literature on the consequences of individuals rationally relying on social information even when it contradicts their own private information (Bikhchandani, Hirshleifer and Welch 1998). But there is an equally extensive literature in psychology showing that rational, information-based aspects of imitative behavior are only one facet of a broader set of social motivations underlying conformity (see Prislin and Wood 2005 for a review).

Consider, for example, the critical role that risk preferences play in determining the objective value of the experimental asset, which is only equal to expected value for risk-neutral players. Though economic theory usually assumes that risk preferences are endogenous and fixed, there is copious evidence that, consistent with the evidence presented here, risk preferences can be modified by situational factors (Kahneman and Tversky 1979). In particular, individuals are influenced by the risk preferences of others (Blank 1968, Isenberg 1986, Schoenberg 2007), suggesting that increased risk-seeking in experimental markets might be both a cause *and* an effect of a rising price.

This gives rise to an alternative interpretation of what experienced participants learn from repetition: not that expected value is the objectively correct value, but rather that *other* participants consider it the correct value. That is, they have learned a social norm rather than an objective truth, in a process similar to that observed in the markets in this study where price stabilizes at an arbitrary consensus value (Figures 3-5). From this perspective, prices in repeated markets settle at expected value because this serves as a logical focal point for coordinating behavior. The concept of focal points has been much discussed in the economics literature on "sunspot equilibria" (Cass and Shell 1983) and on coordination games (Cooper 1999). A useful experimental approach to distinguish whether participants learn that expected value is a social norm or an objective truth would be to run repeated markets using an asset whose payoff characteristics might suggest focal points other than expected value (presumably an asset with highly skewed dividends).

Keynes recognized the possibility that in the face of enormous uncertainty, market prices might represent social norms rather than objective values:

> "Knowing that our own individual judgment is worthless, we endeavour to fall back on the judgment of the rest of the world which is perhaps better informed. That is, we endeavour to conform with the behavior of the majority on average. The psychology of a society of individuals each of whom is endeavouring to copy the others leads to what we may strictly term a conventional judgment" (Keynes 1937, p. 114)

The markets where the asset price stabilizes at an arbitrary level and remains there through the experiment's end represent a powerful manifestation of the process of creating a "conventional judgment."

Conclusion

The results reported here demonstrate that social comparison processes affect the evolution of experimental asset market prices, most likely by influencing the motivation to improve relative performance. I have proposed that the accentuation of bubbles by upward comparisons might result from an upward shift in reference outcomes, so that players perceive themselves to be in a situation of potential loss which causes them to become more risk-seeking. Though this research is by no means conclusive, it suggests that future laboratory research ought to more closely examine factors impacting players' motivations and the connections between those motivations and market outcomes. This research also suggests that work on asset pricing models would benefit from a greater consideration of the impact of relative wealth concerns.

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Appendix A
Additional Notes on Methods

The fourteen markets reported in this research were conducted over a roughly thirty month period as part of a larger set of studies. Four additional markets comprising a total of 38 participants were aborted due to computer technical problems and were entirely excluded from the reported analyses. A small number of participants participated in more than one market, but in only one case (identified in the Results section) was there more than one experienced participant in a given market.

In addition to the standard market procedures outlined in the Methods section, participants completed a number of surveys before and after playing the game. Also, after each market period, participants were offered the chance to buy a lottery ticket which cost \$0.06 and offered a 1 in 20 chance of winning \$1.20. The one participant who ended the experiment with a negative \$0.10 account balance achieved this result by buying lottery tickets without having adequate funds to pay.

There were two minor changes in market procedure over the course of the experiment. In Markets 1, 2, and 3, the average price paid in the market's final period was above even the highest possible value of the asset (\$0.60). In Market 3, seven of the ten participants bought the asset for prices ranging from \$2.80-2.90 in fifteen transactions in the game's final period. Concerned that participants were misunderstanding the experiment's payoff structure, after Market 3 the instructions were modified by adding an additional reminder, verbally stressed by the experimenter, that the shares were worthless at the end of the experiment.

Nevertheless, even after the addition of this warning, similar behavior was observed in nearly half of the subsequent markets. To check whether the change in instructions decreased the severity of bubbles, I compared the markets before and after the change in instructions on the nine metrics defined in the Results section used to measure the severity of bubbles. Markets following the change actually had higher values for all of these metrics, but none of the differences were significant. For only upward markets, markets after the change had higher values on all but two of the nine metrics, and none of the differences were significant. Thus, no distinction is made between markets before and after this change in the Results section.

A second minor change occurred beginning with Market 10, when for administrative reasons, the length of each period of the game was shortened from 3 to 2 minutes. It was presumed that this change would have little impact on behavior since most market activity took place in the first two minutes of each period. Indeed, average turnover (a normalized measure of the amount of total trading activity in the market) was actually lower in the longer period markets than in the shorter (8.9 vs. 9.8, respectively), a statistically insignificant difference. None of the other bubble metrics showed any statistically significant differences between longer and shorter period markets (either combined or separated by condition). Thus, no distinction is made between the shorter and longer period markets in the Results section.

Appendix B

Stock Market Game Instructions (as revised after Market 3)

This is an experiment in the economics of market decision making. The experiment will consist of a sequence of 15 trading periods in which you will have the opportunity to buy and sell in a market. Your payment at the end of the experiment will be equal to $5 PLUS whatever you earn during the course of the experiment. The average payment is $18.05, but your actual payment could be higher or lower.

You will each begin with a combination of cash and shares. Cash in the experiment is shown in cents. Shares are assets which pay a dividend at the end of each of 15 periods. The amount of the dividend is one of the four following values, each of which is equally likely: 0 cents, 8 cents, 28 cents, or 60 cents. The average dividend in each period is 24 cents. At the end of each of the 15 trading periods, the computer will randomly select one of those four values, and you will receive dividends for each share in your inventory. The dividend is added to your cash balance automatically. Your cash balance and your inventory of shares carries over from one trading period to the next. After the dividend is paid at the end of period 15, there will be no further earnings possible from shares. **In other words, at the end of the experiment, the shares are worth nothing.**

We will now explain how you will use your computer to buy and sell shares, and to keep track of your account through the course of the experiment. There will be 15 trading periods, each of which last for 3 minutes, or 180 seconds. The time remaining in the period is shown in the upper right corner of your screen.

At the beginning of the experiment, everyone receives a combination of shares of an asset plus cash. On the left-most column of your computer screen, in the top left corner, you can see the Money you have available to buy Shares and in the middle of the column, you see the number of Shares you currently have.

The shares can be bought and sold in a computerized market. If you would like to offer to SELL a share, use the text area entitled “Enter ask price” in the second column. In that text area you can enter the price at which you are offering to sell a share, and then select “Submit Ask Price”. Please do so now.

You will notice that nine numbers, one submitted by each participant, now appear in the third column from the left, entitled “Ask Price”. The lowest ask price will always be on the bottom of that list and will be highlighted. If you press “Buy”, the button at the bottom of this column, you will buy one share for the lowest current ask price. You can also highlight one of the other prices if you wish to buy at a price other than the lowest.

Please purchase a share now by highlighting a price and selecting “Buy”. Since each of you had put a share for sale and attempted to buy a share, if all were successful, you all have the same number of shares you started out with. This is because you bought one share and sold one share.

When you buy a share, your Money decreases by the price of the purchase. When you sell a share your Money increases by the price of the sale.
You may also make an offer to BUY a share by entering a number in the text area entitled "Enter bid price." Then press the red button labeled "Submit Bid Price". You can sell to the person who submitted an offer if you highlight the offer, and select "Sell". Please do so now for one of the offers.

Please note that you if you attempt to "Buy" a share listed in the "Ask" table, you must have enough money to buy the share at the offered price, and if you attempt to "Sell" for an amount listed in the "Bid" table, you must have a share to sell. If you do not have enough money, or enough shares, you will get an error message. You will also get an error message if you attempt to buy or sell a share from yourself. *Please be aware that once you post a bid or an ask, you CANNOT change it, so make sure you do not enter the wrong price in error.*

At the end of each trading period, you will have an opportunity to buy a single ticket for a lottery. The ticket costs 6 cents and offers a 5% chance (i.e. 1 in 20) of winning 120 cents. If you choose to buy a ticket, 6 cents will be subtracted from your account, and, if the winning number is drawn, everyone who has a bought a ticket will win 120 cents. Please choose "yes" for this practice round.

After everyone has decided whether or not to buy a lottery ticket, you will receive a status report for the period just ended. The status report includes the following information:

- Your cash account at the end of the prior period
- The dividend payment for this period
- The number of shares you currently own
- The total amount of dividends you receive (that is, the number of shares you own multiplied by the dividend payment for the period).

- The cost of the lottery ticket, if you bought one.
- The payoff of the lottery ticket.

- And finally, you will see your cash account at the end of this period
- The number of shares that you currently own
- The current price of the shares (defined as the best bid in the preceding period, since this represents what you could have sold the share for)
- Your account total (that is, your cash account plus the value of your shares)

In addition, you will also see how much the person with largest[smallest] account has.

Finally, you will be asked a question about how you feel about your current account level. Once everyone has answered that question, the next round of the game will begin. Please wait until I finish the instructions before entering a value.

The *only* earnings you will receive for the experiment will be $5 you receive for participating plus the amount of *cash* that you have at the end of period 15, after the last dividend has been paid. The amount of cash you will have is equal to:

The cash (called “money” on your screen) you have at the beginning of the experiment

+ dividends you receive (when you have more than zero shares)

+ money received from sales of shares

- money spent on purchases of shares

We have provided a sheet of paper to help you make decisions. First, it includes a basic reminder that if you want to sell a share for a particular amount, you enter an ask price, and if you want to buy a share for a particular amount, you enter a bid price.

Second, we provide an AVERAGE HOLDING VALUE TABLE. There are 4 columns in the table. The first column, labeled Current Period, indicates the period during which the average holding value is being calculated. The second column gives the number of holding periods from the period in the first column until the end of the experiment. The third column, labeled Average Dividend per Period, shows the average amount of the dividend. Since the dividend on a Share has a 25% chance of being 0, a 25% chance of being 8, a 25% chance of being 28 and a 25% chance of being 60 in any period, the dividend is on average 24 per period for each Share.   The fourth column, labeled Average Holding Value Per Share, gives the average value for each share from the current period until the end of the experiment.

Suppose for example that there are 7 periods remaining. If you hold a Share for 7 periods, the total dividend for the Share over the 7 periods is on average 7*24 = 168. Therefore, the total value of holding a Share over the 7 periods is on average 168.

You will now have a practice period. Your actions in the practice period do not count toward your earnings and do not influence your position later in the experiment. The goal of the practice period is only to master the use of the interface. Please be sure that you have successfully submitted bid prices and ask prices. Also be sure that you have accepted both bid and ask prices. You are free to ask questions, by raising your hand, during the practice period. Once everyone has entered a rating, the practice period will begin.

Appendix C

STOCK MARKET GAME EXPERIMENT HELP SHEET

"Enter Ask Price" =
I want to sell a share for $X

"Enter Bid Price" =
I want to buy a share for $Y

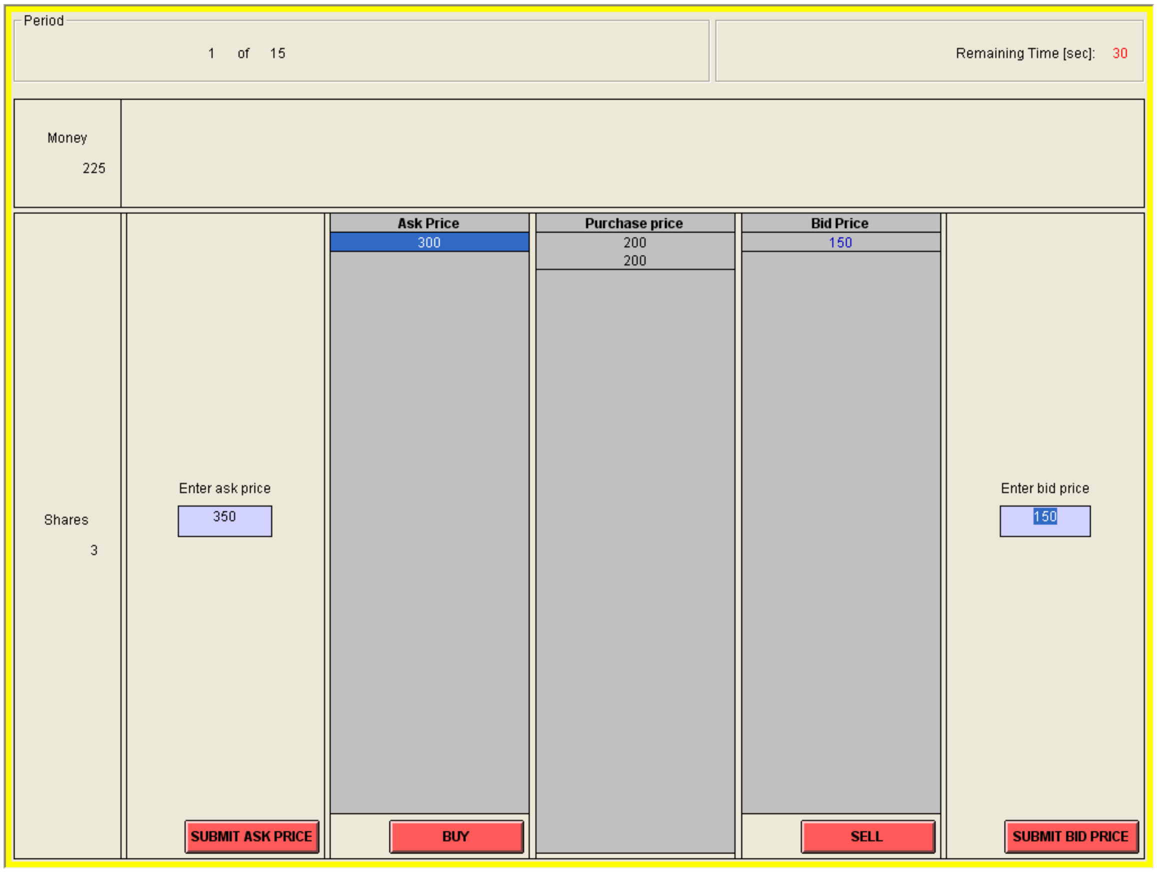
BUY = I will buy a share
for the price highlighted above

SELL = I will sell a share
for the price highlighted above

AVERAGE HOLDING VALUE TABLE

Current Period	Number of Periods Remaining x	Average Dividend Per Period =	Average Holding Value Per Share
1	15	24	360
2	14	24	336
3	13	24	312
4	12	24	288
5	11	24	264
6	10	24	240
7	9	24	216
8	8	24	192
9	7	24	168
10	6	24	144
11	5	24	120
12	4	24	96
13	3	24	72
14	2	24	48
15	1	24	24

Appendix D
STOCK MARKET GAME TRADING SCREEN



Appendix E

STOCK MARKET GAME STATUS REPORT SCREEN