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Market Efficiency of Bubbles

Colin Camerer

Arnold Wood: The next section is on the market efficiency of bubbles.

Colin Camerer: I'm going to talk about two meeting topics, price bubbles and something called "spoofing." So, of course, you all know the efficient markets theory. I would characterize it as this: at any time there's no simple way to make money, by using information that's available.

One way to characterize behavioral finance, which many of you are familiar with, is that information processing is cognitively costly and limited because of all the things that happen in the brain. If people are emotional, optimistic, and overconfident and underreact to information, they may be averse to losses, or be conformists in the sense that we heard about yesterday, then things would happen that are inconsistent with market efficiency.

The common complaint you hear from academics is that behavioral finance is not really an alternative theory, which is kind of true. It's an approach and a series of regularities, but clearly theory and evidence are coming together. So first let me talk about bubbles. I'm going to define a bubble in a very precise sense. I'll actually talk about two types of bubbles.

One is price bubble like the NASDAQ; the other is an informational cascade that is sometimes called a mirage. Let's define a bubble as a self-fulfilling escalation in prices, in which prices are above some commonly understood fundamental. Yesterday we heard about some examples like Dutch tulip bulbs, the South Sea Company, perhaps the Japanese economy in the '80s, Internet stocks, and today I'm going to talk about experiments. The point of these experiments is that there are academic economists and even lay people who look at markets and argue that it's very difficult to know in the field whether something is an example of a bubble or not, because we never really know the fundamental value of an asset.

For example, Peter Garber says Dutch tulip bulbs weren't really a bubble because the bulbs that were very expensive during the Dutch tulip bulb mania were special types of bulbs that had breakage and were rare and in short supply, and it might have been that people had an exaggerated taste for these bubbles like Renoir or Van Gogh paintings. So even something that seems obviously like a bubble is controversial because it's hard to know what the true fundamental is.

In laboratory experiments, we're going to try to control the fundamentals as best we can. We create assets. The assets are not fun to play with or look at it on the wall. In fact, there's no physical share of the assets, it's just a claim that's inside a computer recorded on the screen, so there's nothing exciting about owning this thing. It's not like a yacht or a painting or a racehorse; all it does is pay a little cash if you hold it at the end of a period. The value of assets should be linked to the stream of payments they yield. But it could also be linked to what you think someone will pay for it next period in a couple of hours in an experiment. And that might be a source of a possible bubble.

People might pay a really huge price for something because they think somebody else might pay a huge price for it later. When we began these experiments, Keith Weigelt of the Wharton Business School and I hedged our bets. We tried to pick things where any outcome would be kind of interesting. In these experiments, people are going to trade this asset that we've created. If you hold the share at the end of a trading period it will pay a dividend, which is a hundred currency units in the experiment, or 10 cents.

Let me anticipate some concerns about generalizability from experiments. One is that it is expensive to create assets that are like trillion dollar NASDAQ bubbles. Economists often ask us, "Can't you do experiments with very high stakes?" If people would give us the money from granting agencies, we would happily do them. (In fact, I'd rather be a subject than an experimenter!) But until that happens, we'll try to generalize when we can from small-stake experiments to high-stake experiments. And the many studies that have compared behavior at low- and high stakes show little difference.

These shares paid a 10-cent dividend at the end of the period. At the end of the each trading period the shares expire with a probability of .85 (which

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includes discounting of future dividends). The discount rate here is induced not by time value and money value in the future, but possibly the asset may just disappear. An obvious pricing formula is that the price in period T, should be 100 currency units plus 85 percent times the expected price in period T+1. If you do this recursively, you're going to get a discounted dividend value equal to 100 plus .85(100) plus .85(.85)(100), which is 100/(1 – .85) or 667.

However, in any differential equation solution, there's a constant term, which in this case is a potential bubble. Paul Samuelson studied the general class of solutions in the '50s and later by Fisher Black. Prices are going to be at discounted dividend value, which is 667, plus a possible bubble term. The bubble could be any positive amount you're willing to pay, as long as the bubble in period T is .85 times the expected bubble in T+1. Or put differently, to justify paying extra you have to believe the bubble will grow by 4.85 or 18%. So people could say, "I'll pay another thousand currency units for this stuff because I think it will be worth a thousand divided by .85 next time." This bubble is just a theoretical possibility. We were interested in whether this theoretical possibility occurs in laboratory conditions.

Arnold Wood: So you only did one at a time, in other words, one stock?

Colin Camerer: Yes, that's right.

Arnold Wood: Because the interesting thing about the bubble in the market is that everything was priced as if it was going to be there.

Colin Camerer: That's right, that's right. And by the way, the software we used to do these experiments permits you to trade in up to 20 different markets at one time. This is a good time to talk about experiments in general. The guiding principles in these kinds of experiments and economics are in a seminal manifesto or recipe article by Vernon Smith in 1976. The idea is that we're going to create a simple artificial domain in which economic theory and principles should apply. The scientific metaphors we have in mind are something like particle physics. The idea is *not* to create something that's a simulation of complex markets. The idea is to create the simplest artificial market that helps us get at themetical questions.

You should accept these sorts of data as interesting if you think that economic laws apply all across the board. In talking to economists about experiments, particularly in finance, the argument often comes up that these experiments aren't really about financial markets because they're too simple. We're going to have 12 people trading, the assets only pay a dime every period they trade for two or three hours and they're not experienced practitioners.

My counter argument to this is the following: All empirical studies try to generalize across one or more of four dimensions, which are space, time, identity and scale, or as journalists would say where, when, who, and how big? So, for example, if Andy is an empirical finance professor who does an empirical study, he probably looks at the CRSP tapes of stocks up to 1990, for example. And then he generalizes to the future. So that empirical study purports to generalize from one period of time to another. Whether you can generalize is not always so obvious.

For example, when I was studying finance in Chicago, they would get a weird result and Gene Fama would say, well, prewar stocks are weird, let's exclude that period of time. What he was really saying was there was a period of time he wasn't willing to generalize from. Similarly, there are surprisingly few studies about markets like Taiwan and Hong Kong that are thought to be weird and often manipulated, and China, where government regulation and information play a big role. Presumably it's because we don't think those markets operate in the same way as more developed markets.

In order to accept our results as informative about naturally occurring markets, what you've got to do is say we're willing to generalize results from the lab to naturally occurring markets.

Arnold Wood: Are the students allowed to talk to each other?

Colin Camerer: Not in these experiments. And again, what I'm going to describe is a stark and simple experiment, which is meant to be a baseline. So if you had a story, for example, about how talking to one another produced an interesting sort of conformity or social comparison, you could do that and compare the two and see what happens. Critics will say, it's just students, they're not trading for very much money and for very much time and they're not like floor traders.

To me, that's a gap in the theory, not a flaw in the experiments per se. If you look at a finance textbook, it doesn't say, "Oh, by the way, this theory only works at the New York Stock Exchange." Good economic theory should be like physical laws and biological principles, which apply across the planet or the universe.

Perhaps economic laws aren't so universal. But if so, the theory should specify that in the New York Stock Exchange things happen in a certain way and in labs at Cal Tech they don't. Every criticism of this sort is a call for more data. If somebody says, you wouldn't get bubbles if you had a lot of money involved that is a hypothesis. Give us a lot of money and we'll find out. We'll run experiments. The money issue is a flash point for econo-

mists. There are quite a few foreign experiments where people have gone to Indonesia, Papua New Guinea, China, Russia, and Slovenia, where modest sums by American standards have a lot of purchasing power and found similar results to what we see in the states.

Voice: Can they lose money, Colin?

Colin Camerer: It's difficult, although people have done it in various ways. What we generally do is stake them some money up front. We try to create the sense of endowment, that it really is their money to avoid "house money" effects.

Vernon Smith: People have done these bubble experiments where they put up their own money. There's an entry fee of 20 bucks, and if you look at that data, you can't see any difference.

Colin Camerer: Another issue is subject pool. Like in psychology, most of these experiments have been done with college students who are a convenient sample. But there are a handful of experiments that have been done with other sorts of folks. There are experiments on bidding and common value auctions, where there might be a winner's curse that actually uses construction contract bidders. I think Vernon [Smith] has done some with businessmen. A student of mine from Penn, Bruce Weber, was interested in whether traders gravitate to a newer market that has a lower trading cost and used NYSE floor traders to study that. Generally the results are quite robust, to who's in the experiment.

It's kind of like Donald Trump playing Monopoly against you. The rules don't particularly draw on any expertise (or lack thereof) that Donald has about real estate. So let's see what happens. Oh, I left out something important. An important feature of our design that's different than Vernon's [Smith] and Dave's [Porter] is that the dividend scheme rotates. So when I said if you hold a dividend at the end of the period and you get a hundred currency units, I skipped out an important feature. In fact, people are on a rotating schedule that's like a life cycle. In period one the asset might be worth a hundred to me and in period two it's worth nothing and in period three it's worth a hundred and in period four it's worth nothing, and so on. The opposite is true for somebody else in the experiment. So at any one time, the *aggregate* demand is a hundred, but individual demands go up and down. And the reason we did this was we wanted there to be a positive motive to trade. Whatever the price is, there's a period in which the thing is worthless to me and I should sell it then and buy it back when it's worth something.

There is not written much in economics about how we get to equilibrium. Do they go directly to 667? Does somebody calculate it and yell it out? Does it start low and go high? Does it start high and go low? The answer is that they start really low and go high. Here is one session. There are 12 guys trading for a couple of hours. Prices start out around 200 and creep up. The horizontal dotted lines are where the asset expires. When the asset expires, everyone's assets are gone. They have a cash balance and a kind of reincarnation. Everyone starts over with a fresh endowment of shares and some cash. Prices drift up very slowly in the direction of 667. So that the efficient markets type theory that says the price will be 667 takes a while to get right.

Keep in mind that these are Wharton undergraduates who are the smartest kids at Penn. They graduate and go to work here in New York and they're probably at their sharpest when they go to Wharton before they come here to drink martinis and trade. These are generally advanced undergraduates who probably have seen at least one finance course and if they learned anything, it's something like discounted dividend valuation.

In Vernon's [Smith] experiments, which he'll talk about, they actually have a chart that shows if you were to hold this asset, what the dividends would amount to, just to nail down exactly that point. Then we know that they knew the fundamental and they know everyone else does.

Voice: This valuation is similar to some experiments that we, in fact, there have been other experiments before where we tell them simply this asset has the sole function of paying $3.60 at the end of the experiment. And so in the meantime you can trade it as you like, but there's no subtlety about probabilities or whatever that is, just going to pay this sum and it makes that all very, very simple. So there's no ambiguity about the instructions and we found similar evolution.

Colin Camerer: Now I'm just going to show you a flurry of pictures. These are subjects who were context-experienced. That means they've been in this experiment before and they come back and do it again. Again, as you'll see in Vernon's [Smith] data, experience of this special sort has a huge effect. They start out too low like the inexperienced guys and within three or four trading periods, they hop up toward the discounted dividend value. They overshoot a little bit, but not by too much. So if you were writing a finance textbook and want to show how the discounted dividend model of earnings works, this would be the right picture to show. In fact it's one of the few that you could include in your book

Here are some more interesting graphs. Here's a bubble. They just start at a really high price, some Wharton genius just made some miscalculation or something and bids 1150 and that kind of

locks in a price that just lasts and lasts. It might be that somebody is very optimistic that the asset won't expire so they're not dividing by minus .85. But at least it's flat. An interesting point here is that to an economist there is an equilibrium price because it isn't moving, but it's too high by a factor of two.

Voice: Genius didn't do too badly because the length of the period is longer?

Colin Camerer: That's true. And by the way, in order to implement these probabilities, we actually physically use a bingo cage. (This is a Charlie Plott device.) There are 20 balls in there and there are three red ones and 17 black ones, so three out of 20 are the 15 percent. We say we're going to let you spin it and draw the ball out, and if you draw one of the red ones, the assets are going to all expire. We want them to really think there's a 15 percent chance each time. Here's a bubble. They start out pretty low, around 200. Around period 7, the asset buyers reincarnate and start over, and the price just starts to go up. In period 10, the finance guys are like, see, 667, told you! But they keep going, hang on; the price keeps going up to 2000. And then the asset expires.

Here's another one that's a pretty big bubble. Here they start around a hundred. They're trading very myopically. They're just buying and selling for a hundred.

It's puzzling. These are Wharton undergraduates who are told they can sell it to somebody else and yet they buy and sell for a hundred. They act like the asset is going to die for sure. What's shown down here, which I haven't drawn your attention to yet, is the maximum holding by any one subject. We call these guys "entrepreneurs." When prices converge upwards, it's usually when one guy says a hundred is a really low price, I'm going to buy a whole bunch of these until the market comes to its senses. So this guy tries to corner the market and he buys and holds 12 shares out of 24 total and the price goes up and up. Typically what happens is the entrepreneurs get greedy and don't sell quickly enough. He's holding 16 out of 24, he's got most of the market, the price goes up, he makes a big return, but then they all expire. But the market learned that a hundred is too low of a price and a price like this is more reasonable. It starts over again a little lower and pops through the 667, goes up to about two-and-a-half times that—a bubble.

When you talk to the subjects, they say a lot of the things you would hear in more complex markets even though this is simple. They'll say things like, "I knew it was kind of crazy to buy at this price, but I figured it would go up and up," or "well, I see these other guys bought and made a lot of money and I thought I'd jump on the bandwagon and hope it wasn't too late." Or when guys are buying at the top and the asset expires, they say, "I was going to sell the very next period!"

Of course, the big question is, can you forecast a bubble crash? I think if you could, probably it would be some very delicate function of something like trading volume. My colleague, Charlie Plott, has a great software package that enables you to plot points like this in real time. Every time a price was plotted of the screen, a sound is emitted and the pitch on the sound is connected to how high the price is so you can "hear" the market. These markets will start out at a low pitch and then like a teakettle, they start to heat up. The market itself sounds hysterical and high-pitched. It sounds crazy and then there's a break like the lull before the storm. Then the market will drop and you'll here beep, beep, beep, boom, boom, boom, as the price falls. This may sound facetious, but one way to think about detecting bubbles and patterns would be to plot prices and use different senses to find patterns. For example, find people who have extraordinary senses of hearing and play these price time series out. Maybe they can hear things in the sounds that statistical techniques like time series couldn't pick up.

Voice: I think the time series tends to just look at it's a linear—it's linear activity.

Colin Camerer: Exactly.

Voice: But it had been noted, I guess in the Smith, Suchanek, Williams paper and others that there's a drying up of buy orders near the peak. And so the price continues to go up but on thinner and thinner orders, and that was one idea that if they see the whole order—bid ask order book, would they see that there's such thin volume out there that they'd be reluctant to buy? That was one conjecture, but with or without the music you could see that the orders were drying up.

David Dreman: I was saying with a real bubble you tend to have much more trading towards the peak rather than much less. It's almost the opposite.

Voice: But do you see prices going up on very thin volume after a while and also with many assets, it tends to narrow.

David Dreman: I think not, I think the tendency is if you look, for example, I mentioned this yesterday, but if you looked at the Billboard, which is that small part of the NASDAQ, which is usually really very liquid right near the peak of the bubble, it had higher trading than the New York Stock Exchange. So you saw the trading actually increase sharply. Maybe it was a moment at some point where it dried up, but—

Voice: Typically, I'm not sure. What we tend to see is not so much a real drying as opposed to the num-

ber of sell orders that weren't filled are really growing, so the book is getting long over here. So you see that there's—they're still thinking hope springs eternal and there's going to be high prices, but you see these sellers getting nervous and you see the sell orders that didn't get executed because the prices went too high. Their limit orders were too high, but it gives you a clear signal that there's bad news over here coming.

Colin Camerer: Let me shift gears slightly. The basic take-away from this first set of experiments is that there isn't perfect regularity, even though we have one theory that says they should somehow get to 667, but the pathway which they get there is erratic and often produces bubbles. Inspired by a certain particular experiment, we began to wonder about the role of looking back at previous historical episodes in generating bubbles. We began to think, could we create market experiences that would plant a seed or suggest that prices would go up in a way that is self-fulfilling. So we put people in a trading experiment where they just buy and sell a commodity that perishes every period. Think of it as apples. We tell them if you buy this thing, you can redeem it in the market. You can redeem it for a price like two bucks, and if you sell it you can keep what you sold it for, which is a quarter, say. And we give people different demand and cost values. And at end of every period you buy and sell the thing and it's gone. It's not an asset. It is a perishable good. And they do this in a whole series of periods. So here's one we did.

There's just a fixed price, I think it's 175. That's the price at which supply meets demand. You might ask how well does the supply and demand theory work. Prices do fluctuate, but it converges very close to within fractions of a penny of a predicted good price.

So then they come back and trade an asset as I talked about before. They start around 200, drift up a little bit to 400, but they don't quite get to 667. Here's a training experiment in which we created inflation, to plant the idea that prices might rise, and see if that would create a bubble. In the training part, there's just buying and selling this commodity. Prices go up over time, because we're going to shift the demand curve all the time. That is, every period somebody who has a demand value of a hundred, in the next period it's 18 percent higher. They're told now this is period 2. If you buy this thing you can redeem it for 118 units. The period after that, it's 18 percent higher than that, and so on.

We know from other experiments that when you shift the demand curve, prices will generally adjust in an inflationary sort of way. Now, this group of subjects was in an inflation experiment in the previous week and prices went up. Now they come in the lab and they trade this asset. If they say to themselves, I think prices are going to go up 18 percent every period that, in fact, could be a self-fulfilling belief in this new asset experiment. And, in fact, prices do go up. So they are reasoning by analogy to their previous experience. And in these bubble experiments, if you think prices will go up, that is a self-fulfilling belief that causes a bubble.

So here's one in which they go into a commodity training experiment, and prices are flat. So again, the hypothesis here is when they have lived through flat prices, they don't bubble. When they've seen prices go up, we are trying to control or implant by historical analogy the possibility of a bubble, which could be self-fulfilling. This is the frontier of what we think we can do and it doesn't work perfectly, as you can see. Here they've lived through flat prices, then they come into this asset market and there is a spectacular bubble. It starts at 300. This low price goes on for about an hour. Then, they exactly cross this dividend value line, and there's a lot of trading here. Some guy bids 400, the very next trade is something like 800 and it just goes up and up. There's a lot of trading here. These guys are clamoring to buy this for, currency 5,000 units; eight times the efficient markets predictions. This is a huge bubble.

Like David was saying, typically what happens up here is you start hearing this thinning of bids, somehow the market is coming to its senses, a bunch of sell orders, but usually people are reluctant to sell at a loss, so they're just hanging on. They're people that wait here for 6,000. They saw somebody who sold for 5,500. They're just praying, "rally, rally, go back up," so they are reluctant to sell. They might post a sell order at 6,100, make a little bit of money. But nobody's buying. Then some poor guy ruins it by selling for 2,500 and the market goes into a free-fall. And this happens, as you can see, in just two or three minutes. But they don't overreact on the down side, they just correct. And the final price in the experiment is around two times its dividend value.

Vernon Smith: Keep in mind, these are thin markets.

Arnold Wood: Do you get to talk to the person who says I'll do it at 2,500?

Colin Camerer: No.

Arnold Wood: So you don't know what spurred them to do that?

Colin Camerer: Because we want a benchmark where they can't influence each other, we don't let them talk except through the bidding and asking prices.

Arnold Wood: What's going through his mind when he said, "Gee, it's whatever, 4,500. Why would I want to give up 2,000?" He's going to say the markets are thin; therefore somebody's got to pull their thumb out of the dike here or what?

Colin Camerer: The bids are down here and the asks are way up here and this guy thinks, "You know what, I think the market is going to really crash, at least I'm going to get out at a 50 percent loss. I bought at 5,000, I'm going to get out at 2,500." Or maybe it's a guy over here that bought at 2,200 and he gets out at 2,500.

Arnold Wood: I mean it's like guppies. Why do they all swim in the same direction? Who says swim that way and they all do at the same time? What I'm trying to figure out is how these bubbles end? In other words, the bubble is at the top. It came down a little bit and went back up and everybody said we all learned that you're supposed to buy in dips. That was the one big lesson we learned in '82, you buy in dips and that became sort of ingrained in every 28-year-old's brain at the whole thing. Somebody took the legs right out from underneath the bid?

Colin Camerer: We don't know the answer. We need to run a lot more experiments and talk to people and look at other types of data too. That's certainly the trillion-dollar question. Here are a couple of thoughts. One is that public things that happen are very important. So in this experiment, they're all looking at these screens, all kinds of thoughts are going through their heads. The guys that bought at the top are sweating, feeling nauseous. They're in this roller coaster that's heading downhill. They feel terrible. They're desperately hoping for some kind of a price rebound and some guy sells at 2,500 to one of these bottom feeders. Why that guy sells, we don't exactly know. The disposition story would suggest he bought early and is cashing out before the crash, profit-taking while he can. The sale is as if you made a big announcement, "You know what, you suckers, 5,000 was way too high. You should get out of here." And then you see a crash.

Voice: This is somewhat anecdotal, but everybody knows that it's way too high. In fact, when you get to that part where it bottoms many times, you'll see guys whose finger is on the sell button because they think they can get out, and then you'll watch their face as the prices fall and they were ready to sell and now they have no choice. They know they were supposed to sell. They see the price low and they go, "Well, that's it, I'm either out now or I'm not going to get anything." So they know they're supposed to sell. They're sitting there with the finger on the button. It's just that somebody else hit it and it just falls.

Colin Camerer: Yes, in social cognition there's a concept of "pluralistic ignorance," which has been used to explain revolutions. The idea is that everyone in China thinks their neighbor loves Mao, for example, because you don't have demonstrations in the street, but actually nobody loves Mao. A big rally tells people they were wrong about their neighbors loving Mao, which catalyzes a revolution. In the markets, there's no public announcement, so all these guys in the experiment think this thing is worth five thousand. A sale at 2,500 is like a big announcement, "You're all wrong." So there's a difference between the contents of their heads and what they think is in everybody's head. A public trade brings those two into line and pops the bubble.

Arnold Wood: It's a combination of two things, the contemplation of 2,500 by one person, and "Gee, I knew I was wrong at 5,000 and now I'm really wrong."

Colin Camerer: Now I know that everyone else knows we were all wrong. On their screens, there's an ask at 5,500 and, you know, a bid at 2,500. The sellers are thinking, "That's ridiculous. Come on, isn't anyone buying here," and suddenly there's a trade at 2,500 and it's game over.

David Dreman: You see the bids drop and the bids drop very dramatically, very suddenly.

Colin Camerer: Yes, I think that's true in the NYSE as well. The largest percentage changes are almost always drops rather than increases, which is a characteristic of bubbles.

Voice: Have you ever seen the pattern where, you know, the thing fell from 5,000 to say 2,500 and then it reinflated?

Colin Camerer: No, if you have a drop of something like 10 or 15 percent, it isn't coming back up. And again, each of these points you're seeing is one trade so you might see the bubble moving up to 3,000. There's a trade at 2,700 and then back up, like a little airplane drop in an air pocket.

Voice: One of the things, one of the hypothesis I raised in a paper that I published a year ago was the possibility that as an idea or the idea of investing in an Internet company or something crosses a certain threshold, it runs out of potential new converts. So therefore, it gets into the asymptotic phase, which is not at all reinforcing to the people who want to make instant money. Therefore, some of the people who were expecting to make fortunes and, you know, in a few months or whatever, start to sell. Reaching that asymptotic or that point of inflection where you are going from positive to negative second derivative, I think, can have an effect. It becomes centrally visible to everyone, and, you know, I have a suspicion that it may play a role in a mass market where it might not play a

role in micro, you know, extremely small lab markets. I don't know how you would investigate that further.

Colin Camerer: We did one experiment with overlapping generations, which meant there are guys, they trade for an hour and at the end of the hour, three of them are dismissed and paid. Then, three new guys come in at the end of an hour. We did this for six hours. We were tired, but the original subjects from the first couple of hours had all gone home and new guys came in. The idea was to exactly refresh the population with new guys and see if these bubbles could just go on and on because you knew there were a few new guys entering the market a few hours from now.

That experiment was really a dud, but in an interesting way: The price was about for eight hours. It never went up.

A major project recently related to this is statistical models for learning in games, (as in "game theory"), where you're learning what you should do and the other guy is learning at the same time, so they're co-learning. From this theory, we have a story about bubbles in Vernon [Smith] and David's [Porter] setup where you have a finite horizon. In our theory, there are some guys who learn and there are some guys who teach. They know other guys are learning and they teach the learners. There are guys in Vernon's [Smith] experiments who say, "I think these prices are crazy, but if prices go up, those guys will think they'll go up in the future. So I'm going to bid it up to plant this seed that prices will increase." And the puzzle, of course, that we've talked about repeatedly, it's not that hard to get these bubbles started and continue through some momentum progression, and why do they crash? In our theory, they crash because when you get near the end, the "teachers" say, "I've only got a couple more periods to milk this thing," and so they sell which precipitates the entire crash.

David Dreman: The question, I wonder if it can be duplicated or replicated in the laboratory, the fact that with all of the graphs I've looked at over time, there is a crash and then there's a bounce back. If we take the latest NASDAQ bubble back four or five major declines, there were declines of 20 percent or more, and then they bounced back to new highs. So it was all momentum and the momentum is gone, but then somehow it comes back.

Colin Camerer: It's sort of like you're squashing down a sponge and then it springs back. We typically don't see that, partly because in these crashes you typically don't see overreaction where it goes too low.

Vernon Smith: For the undergraduates, the amount of money is very significant. For example, in a lot of experiments we've done there are some students that leave with $15 and some with $65, and so $50 difference to an undergraduate is very substantial. And they also invest two hours. They could have perhaps earned $12 or so just getting some job, however if they can earn $65, that's great, and that $50 is probably more in incremental terms than would be thousands of dollars for any of us.

Arnold Wood: Did you look at issues of what these people were eating when they were making these bets or did you look at any physiological issues or the gender issues?

Colin Camerer: No. One of the unfortunate things about experimental economics is it inherits the things we tend to think about from economic theory. So fairly few studies have looked at gender, although there's good evidence that women are less risk-taking. We have other things we're worried about. We're interested in cognitive activity and I would like to do some emotional experiments involving facial movements, which seem to be one of the best measures of emotion—smiling muscles and frowning muscles.

The second part of my talk, which I will condense, is about spoofing. I'll give you a one-minute version. We did an experiment, in which we went to racetracks and made thousand-dollar bets, which moved the odds, a lot. These are actually large racetracks, but even there it moves the odds from about 10 to 1 or 5 to 1. We see people watching the screens and they say things like "Gosh, what happened?"

We were interested in whether this would be taken as a signal of information and create a kind of cascade. Or bettors could say, "I was going to bet that horse at 20 to 1, and somebody ruined the odds for me." They wouldn't take it as informative; they would take it as, "Now I have to share my winnings with lunatics." We were able to cancel bets, which people don't realize. So we were able to make these thousand-dollar bets about ten minutes before the race and cancel them literally at the last minute. So we were able to bet a lot of money, but it didn't actually cost anything. So we compared betting on the horse we chose with a control group, which is another horse in the race that we didn't bet on which was similar. So we have a kind of pre-bet versus post-bet measure on whether this "spoofing" affects prices. Were people kind of fooled by this money and bet on the horse or was it the other way around, they bet less because we ruined their odds?

In fact, the only exception was maiden races (horses who never won before) in very small tracks. If you see a lot of money in a maiden race

you think somebody knows something, more than on other races, and in those races we were able to move the market. But the basic findings are that these markets are resilient and efficient, they sort of shrugged off this price movement. If you're interested in this, I'll send you a copy of my paper in *Journal of Political Economy*. These horse-betting markets are really efficient even though they're thought of as frivolous.

Arnold Wood: Colin, thank you very much.