

MIND GAMES

The field of quantitative behavioral finance continues to yield explanations for market events that classical economics can't adequately account for. Dan Tudball speaks to Gunduz Caginalp, who has taken point on this mission into the mind of the markets ...

Gunduz Caginalp is Professor of Mathematics at the University of Pittsburgh and was the editor of the *Journal of Behavioral Finance* from 2000 to 2004. His background is in applied mathematics and mathematical physics, and up until 1987–1988 was professionally focused on analyzing mathematical problems that originated from the physical world, physical

mathematics, liquid–solid transitions; areas in which he still continues research today. He now divides his research between that type of problem and questions in mathematical finance and economics.

“I got into this field as a matter of curiosity around 1988 or so because I’d been an investor for many years,” says Caginalp. “I’d bought my first stocks when I was 12, and so I had some experience as an investor. I

went away from it for many years, but once I’d got my Ph.D., I started investing again. What I found was that the study of markets was very interesting, because from what I knew about economics and finance, the ideas that academicians hold very sacred don’t really seem to be taken very seriously in the practical world of markets and trading.”

With the crash of 1987 and the experiments of Vernon Smith, Dave

Porter, and other collaborators, Caginalp saw that there was a possibility to do something mathematically, and also to tie it to some hard science, where he could put in the real finance that market practitioners talk about within an academic and mathematical setting.

“I’ve always been curious about the markets,” Caginalp recalls. “The reason I got into it as a 12-year-old was that I saw all these numbers



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[stock market prices] in *The New York Times*, which was probably the most intellectual thing that I was exposed to at that stage.” Caginalp had come to the USA from Turkey when he was seven years old; his parents are medical doctors who had nothing to do with finance whatsoever, and the young Caginalp was trying to make some sense out of these numbers. His parents couldn’t offer very much insight, but one day, at a friend of the family’s house, Caginalp’s father mentioned that the host worked on Wall Street and that the stock market could be discussed with him. “I had been assuming that these numbers were just some cash flow or something, and after some time it became clear that people were trading a tiny fraction of the company. To me, this was a mind-boggling event because in a country like Turkey at that time – it’s very different now – even the price of gasoline, the price of bread were fixed by the government. So, this concept that people would trade a millionth of a company was just wild to me!”

A precursor to his later career arose at this point, as the boy Caginalp’s bias was that the prices would not reflect the reality, and somehow he felt that he would be able to do better than what the market indicated. Almost immediately, Caginalp started writing to companies for their annual reports and following the news, and he invested his life savings of \$300 shortly after that. Among the stocks he first invested in were Air Products and RCA. “I think we all come into this area with a bias,” Caginalp explains, “so I think my bias was that people are not going to be that rational in the aggregate.”

It was the mid-1960s, a time of controlled economies in many parts

of the world. “I think a lot of people who emigrated from Turkey at the time were marveling at the fact that the government doesn’t control the price, but just lets the people charge what they want. To us now, it just seems obviously the right way to price goods, but it was just not as obvious at the time.” This was the era of the great standoff between economic models, controlled economies versus free markets, and there was a tendency to claim that the market pricing was so far superior that it would apply to everything and it was perfect. “Maybe nobody questions that market pricing is better than controlled economies, today, but I don’t think that everybody would agree that pricing is perfect, even for consumer goods. So, basically, I did some investment, and then we went back to Turkey. Then there was college, graduate school, etc., and I didn’t really get back into it until 1979, shortly after my Ph.D.”

WILMOTT: One thing about that period in the 1960s, there was a



Gunduz Caginalp

great deal of optimism about perspectives like the efficient market hypothesis. Your own personal sense was that psychological biases and things related to that could actually be creating skews in the market as well, and then you had the opportunity after your Ph.D. to return to this idea. So then, in the early 1980s, what was the situation there for you at that point?

Caginalp: I was doing research on mathematical physics, and just continuing to do the investments in the background, taking an interest from a practical science perspective. Obviously, one has only so much time for investments.

WILMOTT: With the advent of quantitative finance taking hold in the investment market, from the late 1980s and then really ramping up through the 1990s to the present day, over that period of time, how was your view point becoming consolidated, in terms of observations on the market and the increasing reliance on quantitative methodology within investment institutions? Naturally, this had an effect on the way the market operated, the volumes that were involved, the levels of movement, etc. What were your observations over that period of time? You would have been aware of the increasing reliance on mathematical and physics methodology in finance; how did you see that playing in with your interest?

Caginalp: For most of the early 1980s, I was just interested from the more practical point of view of improving my returns, doing well without spending that much time. At that time, of course, a lot of companies had access to inexpensive trading, but for individuals, it was relatively expensive still, with big bid/ask spreads, commission, etc.

But I think, of course, a lot of the derivatives business and quantitative methods were really taking hold throughout that time, but my main interest was just participating in the great bull market. In 1982 we hit bottom and it was straight up from there for many years.

WILMOTT: What’s your personal recollection of the crash in 1987? Did that again inform your own perspective on things?

Caginalp: The crash of 1987 highlighted the fact that people weren’t as calculated or rational as one might suspect. The causes of 1987 are still being debated, but perhaps part of it was because Greenspan, who was new on the job, jacked up the benchmark interest rates by one-half percent, which was actually a very dramatic change, but I’m not sure he realized that. There was a lot of speculation before that; overvaluations weren’t extreme, but they were there. I also think that derivatives exacerbated the declines. There were people who were warning about derivatives for some time before that. There was the use of portfolio insurance, which was founded on the idea that for every buyer there’s a seller, and that there is infinite capital.

That’s one of the things that is a problem with a lot of classical finance; the idea was that when the market went lower, you sold – for example, taking some actions with options that had the effect of selling large quantities. It just kind of snowballed. The difference between the crash of 1987 and recent problems is that, at that time, banks and other institutions that were hard hit had lots of cash, so they simply said, we’ll buy our stocks at these low prices. For example, Citicorp had sold a lot of stock [i.e., secondary offering], I

think, in the mid-20s just before the crash, and after the crash their stock was like 17 or something; they simply bought more stock. For them, it was a great deal and that gradually convinced people that there wasn't really a big problem.

Also, fewer people owned shares – like in Pittsburgh at the time, people were kind of oblivious to it; it was a curiosity affecting other people. There wasn't much of a chance of an economic decline based on the crash. At the time, the only reference people had for something like that was 1929; that was clearly not going to be the case because of the very different nature of the economic environment.

Even for 1929, I believe one of the causes of that episode was the hike in the interest rates to curb speculation. Overall, when you look at the crash with big up-and-down oscillations, it showed that whole idea that everybody is perfectly rational and that they rely on the rationality of others was very far from accurate. I think seeing that was not a big surprise to me. And, furthermore, I felt that at that stage, economists and finance professors would have to recognize that reality. One of the big surprises of the past 20 years to me and some other people in behavioral finance, is the extent to which the community of economists and finance professors can be largely oblivious to very major events. For the 1987 crash, they can say, well, this is kind of a fluke; it wasn't that long, etc., but what about the big bust in 2000–2003 in high-techs – which by some people's estimates wiped out \$6 or \$7 trillion – and if you look at the literature, there's barely a mention of this in terms of real analysis. There are some historical accounts and so on, but in terms

Classical Finance in Theory

- Prices of financial instruments are essentially a random walk (direct studies of price history confirms).
- The variance (volatility) can be predicted to some extent.
- All investors have access to the same information and seek greatest return with minimum risk which they measure in terms of volatility.
- With large numbers of investors optimizing the same way, the market is efficient. It is not possible to have investments that provide a risk-free abnormal return due to *infinite arbitrage capital*. (Foundation for Black-Scholes option pricing)
- Basic risk-reward relationship; risk \approx volatility

....in application

Consider measuring the volatility in the example: 4% each quarter for 12 quarters, e.g., subprime...

Here is one way of generating those returns. Put money in the bank except on the last day of the quarter. On that day play roulette by betting equally on all numbers except 13. Most likely outcome is $30/29 = 1.0345$ of investment on that day.

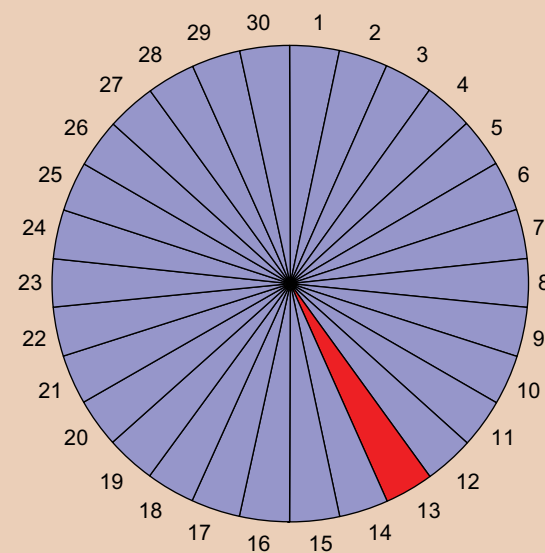
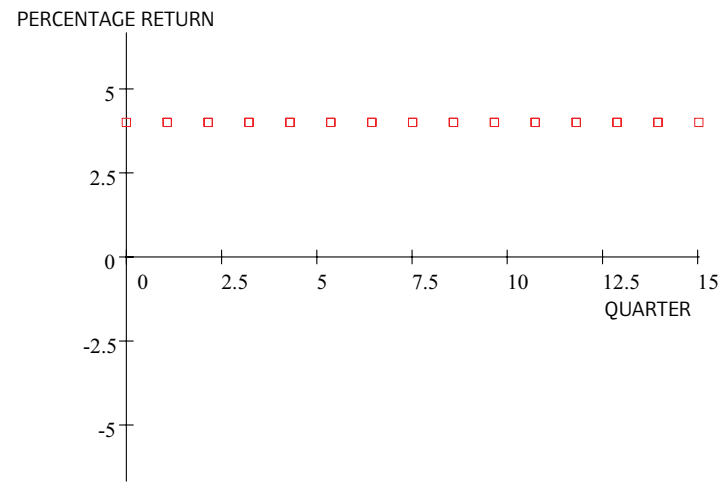
In practice we don't always know the underlying probability distribution!

BASIC DEBATE:

IS "THE MARKET" EFFICIENT?

Fisher Black (1986): Markets are efficient 90% of the time, where efficiency means "the price is more than half of value and less than twice value."

of modeling and things like that, there's a negligible amount of work devoted to that, whereas if labor strikes had caused \$7 trillion in losses, we would probably see a lot of research papers on that topic. So, that's the real surprise; we had the crash of 1987, Japanese boom-bust of 1990s, the US high-tech bubble; for all of those, we know how many [research] papers have been written focusing on that, and it's a tiny fraction of papers written, I believe.



WILMOTT: Once you began your academic career, in parallel to that as a personal investor, your personal predisposition was an intuition that behavioral aspects were going to have some sort of effect on the way the markets operated and the efficiency of pricing. In terms of the efficient market hypothesis, had you already formed a sort of robust opinion on that, or was it just something that you felt you had doubts about?

Caginalp: I had doubts on it from

the very beginning, even as a 12-year-old. Before I bought RCA, I look at their annual reports; their profits were going up steadily, but the stock price was constantly moving between 30 and 50. I had never heard of the concept of anchoring, which hadn't been invented back then. It was clear that people just did things by habit, not looking at the key quantitative issues and so on. From the beginning, I felt it was difficult for a large mass of people to behave

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as rationally as the efficient market hypothesis would have them do. I felt that there were always times for bargains and so on.

In 1982, it seemed that the whole world was going to collapse, if you look at the market and the gloom and doom. By realistic measures, in 1982, the US stocks were valued lower than during the 1930s, in terms of P/Es and book value, or when the USA looked like it might lose WWII. So, whatever problems we had in 1982 were not that bad. What was happening, if you recall 1982, was that the interest rates were very high – 18 percent or so. Hence, people felt, why would I lose my money in stocks when I can make 18 percent in money markets? Of course, these interest rates weren't going to stay high; inflation had been beaten, basically, by early 1982. In 1982, I was waiting for this huge amount of money to pour in as interest rates started to go down. That's one of the uses of this idea of liquidity – in the way that newspapers use the term, rather than academic circles – the idea that there's this excess cash coming into the market to push prices up. That's been my bias throughout as an investor: that people aren't going to be all that rational. When they have the money, some of it will go to stock; when they see stocks moving up, more of it will go in, and so on.

WILMOTT: Let's talk about the research you've done in behavioral finance. What was the progression there, was it a gradual move or was there a distinct point in time when you thought, this is where I want to devote myself in terms of research?

Caginalp: I think it is more gradual, as data became more available and also these experiments. The



At University of Pittsburgh

idea that experimental economics in asset markets got moving, that to me meant that a mathematical model could be tested with some experiments. For example, I have some graphs on the PDF of typical bubble experiments, where experimenters can define an asset, and they can then see what happens to trading. Unlike the world market, one can repeat the experiment, etc. So, I think that the fact that one has asset experiment laboratories meant that you can develop theories and equations, and test them against something. That was one of the reasons why it became more interesting; otherwise, suppose one writes down some differential equations or any kind of mathematics to model something, in the absence of quantitative comparison, if one only has qualitative predictions, it can be ignored. As one of my professors (a Nobel Laureate in physics) said, "A theory that makes only qualitative predictions can be ignored." Many people have qualitative predictions and it's very difficult to distinguish what's

right and what's wrong. The advent of large-scale computing meant that data had become much easier to process. As the years went by, with more data being available, we were able to do more of these studies involving market data.

WILMOTT: With data becoming more available, in terms conducting the bubble experiment, what's the process for you there?

Caginalp: When we had these differential equations, Dave Porter suggested that maybe I should bring my laptop to Arizona, where they were located at the time. As the experiments were going on, in real time, I would make some forecasts, not after the fact. He suggested that to some other people, but had no other takers. That's how I got into doing the experiments, first doing differential equations and statistical models, and trying to forecast what was going to happen in the next time period. Gradually, I became more involved in designing the experiments to determine how the different factors entered into the price dynamics.

WILMOTT: What would you say in a summary of the divergence between classical finance ideas and behavioral finance ideas; what is the shared foundation and what is the point at which there is a parting of the ways?

Caginalp: The shared foundation is the concept of market and supply and demand. I think everybody agrees that when the demand for shares exceeds the supply of shares, prices go up. The shared foundation is mainly that. And the point of departure involves a couple of assumptions in classical finance. One of them is that there's infinite arbitrage capital to take advantage of any deviation. I didn't recognize, at

first, how important the assumption is and how far from reality it is. In our differential equations, we came to realize that there's an important issue. Suppose we look at the typical bubble experiment. Let's look at it like a physical scientist. What is in that experiment that has units in dollars per share? One is the trading price, another is the fundamental value which the experiment defines. For example, in one of these experiments, where the payout is \$1 per period, after 15 periods the value goes to zero. There's a third price that has never really been discussed. We introduced it in the special issue of *Philosophical Transactions of the Royal Society of London* (1999) that Paul Wilmott asked me to contribute to. That is what we call the liquidity price; that is, by taking the total cash in the system and dividing by the total number of shares, we call that L ; that's a third entity with the same units. That concept will never come into the classical setting because it's assumed that there will always be dollars coming from somewhere, if there's some bargain. So, that's a major point of departure; that's a major issue for us: what is that liquidity price, how many dollars are there, how is it changing, and so on.

Of course, moving beyond that liquidity or excess cash concept, there are issues like trends and resistance that analysts talk about. For most people who are in the practical investing trading business, there's no doubt that when it moves your way, you feel like investing more; if you bought something that has gone up, it feels great, you feel like buying more. If you bought something and it's going down, you begin to worry and lose confidence in whatever made you buy that. So, this trend concept is also not there [in classical

finance]; this is part of a long list of behavioral concepts, and we don't know the full list yet.

For example, if you look at practitioners, another concept is resistance, for example. Brokers will say that if a stock hit a peak at \$100, and moves lower to \$60, the next time it comes near \$100, they believe there'll be resistance – hence, there will be a lot of sellers. They even have a contemptuous name for people who buy at a particular price and then wait until they break even before selling. They call these people “eveners” because they don't make commission on them until the price comes back up. So, there are a number of concepts like trend and resistance. Trend is maybe the most important one. With the concept of resistance, one can think of it as part of anchoring. If a stock hits 100 and then moves lower, the price of 100 becomes an important issue for many people psychologically because they might think, I could have made that much money if I had sold at that price.

For me, the idea of the lack of infinite cash, the behavioral effects that manifest themselves in terms of how investors perceive an investment, what price they bought it at, and what the stock price has been doing, are key departures from the classical theory. Classically, whether I bought a stock at one price or another shouldn't make any difference; the only question is, what is the best return for me in the next year – but every broker knows that it makes a profound difference. The volatility is in classical finance, that's certainly part of the picture. As a hedge fund manager I spoke to said, the biggest flaw in classical theory is that risk is identified with volatility. That could be another

departure point for the two theories.

WILMOTT: Do you feel that, in the case of trending and resistance, these are basically fundamental parts of human nature manifesting themselves, just a reliance on past experience, similar to basing your faith in historical data?

In a sense investors will just go on past experience, rather than anything else. The classical theories assume a completely rational market place, with rational participants reacting purely on the basis of perception of advantage gained from a temporary disconnect between price and value. Information is the only thing that gives anybody an edge.

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Caginalp: They understand that a large number of people are not very rational; however, they feel that the amount of capital controlled by the rational few – they may not be so many in number but they control enough capital that a small deviation from a rationally correct price would be quickly exploited – suggests that the market would be restored to the same price as if all investors were rational. That's how they might say it. So, the market acts as though all participants are rational, even though it may be that only a minority are, but they control a very large sum of money.

WILMOTT: Could you elaborate a bit more on the limits of capital available for markets, the sense that there is an infinite supply? Could you elaborate more on your observations?

Caginalp: In the finance world, it is hard for anyone to take this infinite capital very seriously. For example, if they are going to have an IPO, they start off by thinking, how much money can we raise for this? So, they're very much aware that there will be so many investors and so much money, and just because they are offering something at a bargain, there wouldn't be billions for an IPO. In the closed-end funds, we see that if a particular country is not in vogue at the moment, then it becomes very difficult for them to raise more than a couple of hundred million dollars, for example. When they issue more shares, we see examples where they

leverage depends on the type of stock so that with \$ 100,000 one can buy between \$ 200,000 and \$ 300,000 worth of stock. If one has a portfolio of S&P 500 stocks, for example, one can use more leverage. Of course, for some stocks margin is not permitted. However, many of these hedge funds can get four to seven times their basic investment as leverage. That means that even with a 10 percent fluctuation, if they don't get out quickly enough, they lose huge amounts of money. So, that's one of the things I've noticed: people with information aren't necessarily in a better position because they are often so much more aggressive. They

issue 30 percent more shares and the discount gets bigger because the market can't absorb that many new shares. We have seen many examples where the question of how much capital exists is evident. During this crisis time, we see this a great deal, as prices are really falling through the floor and there's no magical group of investors stepping up to the plate, as we say in the USA.

One of the things I've noticed anecdotally is that a lot of the people who have the knowledge and information are often out further on a limb in terms of leverage because they are able to get more and more leverage. For an individual investor, usually, if you have \$100,000, there's something like \$200,000 that you can invest with, but even that is too much leverage for most people. The

can't say, these are just irrational fluctuations – they're often forced to sell. This infinite capital, the huge amount of capital coming in, this tends not to happen.

One of the games that's been played over the years – as the emerging markets have done better, and the dollar and yen haven't done that well – is that people have borrowed in yen or dollars and then bought emerging market stock. This turns out great because what you borrowed is smaller each day and what you invested in gets bigger each day. As more and more people play this with more and more leverage, at some point there's a small fluctuation, forcing the most leveraged to sell. Subsequently, the emerging markets decline about 30 percent. The most recent one was sharper. We

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have seen 35 percent sharp declines for no reason, without that much economic change in these countries. That's a big limiting factor in this infinite capital arbitrage idea: people who have that capital are heavily leveraged, and as soon as things start going the opposite way, they may be the first to bail out because they are the most leveraged, unlike the less informed individual investors, who might take it philosophically and say, I'm not going to need the money for the next 15 to 20 years; I don't have to worry about this."

WILMOTT: Is it the case that, to a certain extent, the information advantage and access to larger amounts of financing can in certain ways temper the absolute advantage

high-tech-type stocks. Roughly what happened – this started in the mid-1990s – was that we had policies and demographics where a lot of people acquired money that they were not immediately going to spend. For example, right after WWII, there was a boom; people were acquiring money or having kids, and they were spending on consumer goods. In the 1990s we had tax policies that were favorable to investments and economic growth; a lot of money came into the system, and once this money started going, it tended to push prices up – and, of course, as prices moved up, a trend developed and got steeper.

People began looking for bigger and bigger returns; 15 to 20 percent

stock where the CEO was going to look for possibilities to make money on the internet. Generally, IPOs became less mature companies; there was almost no focus on what the real valuation was, and people looked at the trend and what the prices had been. There were some value-minded people, who would say that such a stock is worth only \$5, and the stock which was at \$200 would go up \$5 as he was speaking. When people see the prices going up, anybody who says otherwise is ridiculed basically. Then there were some articles, like "Burning Up" in *Barrons*, that observed that there were companies that were burning through cash so rapidly, within so many months, that they would not

also expanded, and it's really the ratio that matters. The cash perhaps could have gone on for some time, but, ultimately, if the number of shares issued keeps increasing, then price per share, with our liquidity idea – the total number of dollar divided by total number of shares – that number begins to fall. As prices started to fall, the value investors weren't interested until they fell perhaps 90 percent, so there was nothing to stop the free-fall in many cases. Throughout that period, we also had a relatively easy monetary policy; I think that this has been a problem with these bubbles. The high-tech bubble ended, then the bubble became one in commodities, housing, and property prices. A lot of these are really a reflection of the relaxed monetary policy, where the interest rates are often lower than the real inflation.

For most people, with all due respect to the government CPI and all of that, the inflation numbers are highly skewed. So, for an affluent person, the CPI is meaningless because it includes a lot of manufactured goods that affluent people don't buy all that frequently. How many TVs does a person buy in a year? What happens is that they perceive their own inflation as 5 to 7 percent, because they are paying big education bills and healthcare, etc. This idea of getting 1 to 3 percent – right now it's 0.07 percent – on treasuries or money markets is very unsatisfactory. So, that money has nowhere to go, so it fuels different classes of asset bubbles.

The biggest irony is that we have gone from the high-tech asset bubble to the housing and commodity bubble, and now we have a bubble in treasury bonds. Everyone's been shell-shocked from all these other

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that a large investor might have because they are not actually able to play the long game?

Caginalp: If they are very heavily leveraged, they can't; they have to worry about small changes, such as a 10 to 15 percent decline.

WILMOTT: You were talking about this sort of lack of research and study on the high-tech bubble in particular. Having looked at this particular area, what were your own observations and conclusions on what occurred there?

Caginalp: In the high-tech bubble, I think it was very similar to some of the experiments we've done. In fact, we did an experiment where we had the value-type stocks and the

returns weren't good enough for a lot of people, so they went into more speculative areas, which were also helped by this image idea – "affect," as people like Paul Slovic call it. Certain companies live up to this image of a whole new paradigm and ways of making money very quickly, and experience great success. People look at that and they feel that every company is going to be a Microsoft in its earlier days, and pay less attention to what they are buying. Not only were many of these stocks not making profit, but they had no revenue. In fact, there was this IPO I remember reading about, where they didn't even have a product; they were collecting money, they had a traded

be able to pay the bills, and they would have to be insolvent.

For people who were selling short, it became a very difficult game because if you have a stock that's at \$100 and it's really worth \$2, you say, well, if I sell it short, it might go to \$200. At a certain point, it became clear that the game could not go on forever; they were burning through cash, and they had no revenue. Then perhaps people became more confident in short selling and much more worried about buying these shares. Ultimately, the amounts of money flowing into these things diminished. It's true that the amount of cash in the system continued to increase, but the amount of shares

debacles; they say, let me just find something safe, and they buy these 10-year bonds. And in my mind, they are very overvalued because the inflation rate is much higher than the interest you'll be getting for that, particularly after you pay tax on it. Meanwhile, many of the things that people buy, such as education and healthcare, are still increasing at 4 to 6 percent, even during this deep recession.

WILMOTT: So, basically, it's not necessarily a flight to safety that is occurring, it is in fact a flight from low interest rates, which fuel a series of bubbles until eventually you get to this point where you get people investing in perceived safe long-term products?

Caginalp: Yes.

WILMOTT: I had a discussion last September, which was slightly psychologically focused. I was talking to a guy at the University of Georgia, Keith Campbell, who recently came out with a book on narcissistic personality disorder. The book puts forward a view that contemporary society has a culture of entitlement; to some extent, this had been fueled by things like access to easy credit, the increased efficiency of the financial system, etc. As you observed earlier, in 1987 the effects of the crash were not as greatly felt by the average guy in the street, whereas this time around, this effect has been universal and struck directly. Twenty years ago, people still looked at property purchases as a cheap and easy way to provide yourself with a roof over your head and, eventually, when you retire, you cash that in and use that towards your retirement income. Over the past 20 years, it has become more prevalent to see property as an investment purchase and something you can take advantage of in terms

of fluctuations in the market and so on. Do you think that observation, that there is a greater sense of entitlement, which to some degree has been exacerbated by easy access to financing for the average person in the street, has to a certain extent also fueled or provided fuel for bubbles, because it has actually given people a sense that the market is a place that you can make a quick buck – I've got an easy place to make those investments, so I go in there and go for my piece of the pie – what's your view there?

Caginalp: There is no doubt that these factors have added a great deal of cash into the system, thereby inflating asset prices. In terms of consumer purchases, we had the same process. In the USA, you see a major transition – for example, credit cards are only a generation old. In the 1970s, they wouldn't give credit cards that easily; they would really examine your credit and the limits weren't very high. It's got to the point that we have to call up a certain number to avoid getting lots of credit card offers in the mail. So, they've become very lax, in that we used to have limits on credit card interest, and now there are no limits. There was a proposal on that, which was fought. Some of these interest rates can go very high, like 30 percent.

You hear stories of people who have a credit card and the interest rates goes up for some mysterious reason. The old-fashioned concept that you work for some money and then you spend it has become, what I can borrow? They are borrowing at a rate to be determined by the lender; they might be borrowing at a very low rate, and then all of a sudden it is jacked up to 24 to 29 percent. It's a big instability in the national

economy, in the sense that this can be done to a lot of people unilaterally. If you don't have money to buy one car today, what's the probability that you'll be able to buy two of those in two and a half years, which is what these interest rates amount to. It's a really bad deal; it seems like it's exploiting a lack of quantitative thinking and planning on the part of the borrower. Or maybe they are exploiting wishful thinking more than anything else. For most of us, our salary is not going to go up by 35 percent for the next few years. So, it's really unfortunate that the housing and the credit card business has become a major problem in the USA.

In terms of housing, a lot of the Alt-A mortgages, which are just one notch above the subprime mortgages, are due to be reset in 2010, so we're going to see a repeat of this. Maybe by then they'll take care of some of these problems – hopefully it won't be as bad, we'll see. I view a lot of this as a liquidity shock also. I wrote that, as an example, if a person invests \$100,000 with a firm and that firm lends that to somebody at 30 percent, knowing that person doesn't have much of a chance of paying it back, they can claim that your \$100,000 now becomes \$130,000. If you believe that, you have a certain idea of your wealth, but at some point you realize that \$100,000 is gone and you're not going to get it back. And your asset value is not \$130,000, but just \$30,000. So, there are these shocks based on liquidity that people felt they had a certain amount of money; in fact, it's only a fraction of that, which is bad for the whole economy and asset prices as well.

The whole idea of a mortgage on a large scale was really initiated in the 1930s by Roosevelt. For many

years, the agencies that guarantee these loans had strict criteria, they were totally Federally run. Typically, in the USA we would have to put down 25 percent of total value as an initial payment, and the total payment per month would have to be a certain fraction of your income, etc., which would be proven with documents, like IRS tax returns, etc.

In the 1990s, these things became private corporations. There was a government guarantee for loans, where standards were made by people with the incentive to give more loans. So long as housing prices were going up, it didn't make that much difference. It's this trend idea that when there's an uptrend, people rely on it more and more. I remember people quoting various things like, "Housing always goes up, there's only so many times that housing prices went down in American history." That reminds me of students taking a certain exam, where it's said that nobody failed this exam last year, so the next year there's less studying; 10 years from now, they say nobody has failed this exam in 10 years, and then it gets to be totally ridiculous and everybody fails.

More and more people were relying on this uptrend in housing prices, that no matter how bad the borrower is in terms of his credit, the housing prices will increase, so that even if the lender repossesses it, he can resell it and still make a profit; even though the borrower may lose a little bit of the down payment, the lender feels he's in good shape. Furthermore, a lot of this is guaranteed by federal agencies; it's a really precarious system.

WILMOTT: The irony is quite massive. It does seem like a big thought experiment, the fact that it seems



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quite obvious that in doing this, you're ultimately devaluing the very asset (which would be the housing rather than the loan) class that you are hoping to profit from because there is going to be an eventual release of a huge amount of inventory at the same time, which will drive all the prices down. You're ultimately losing out on the thing you are counting on in the first place.

Caginalp: As these bubbles go on, people are basing beliefs on less and less analysis. In the USA, it's well known what the demographic is and who tends to buy houses. Even though the population is aging, the baby boomers are getting closer to the stage where maybe they are more likely to sell a house than buy

start from is that the market price shouldn't be regarded as something that reveals as much information as the classical theories would have us believe. In other words, there will be bargains, there will be overvaluations, and it's impossible to know exactly when these things will materialize and change, but if one is patient and one is not forced to buy or sell, then I think that's kind of a start in the right direction.

A lot of the work is probably too technical to discuss in detail now. But, particularly, this recent work with Mark Desantis, which is going to be published soon, shows there are basically ways for short-term traders to extract fundamental value and the noise in fundamental value,

our assessment and evaluation. The study with **Duran** tends to show that big price gains, in the absence of the similar changes in fundamentals, tend to be reversed. In the academic financial circle, they can't even believe that the differences we've found can be that big.

In a closed-end fund, everything is so precise. For example, the Templeton Russia and east European fund (TRF) is a closed-end fund investing in Russia and Eastern Europe, and today it went up by 19.67 percent in the US market; the Russian market went up only 2.5 percent and the underlying net asset value went up 4.92 percent. That's a 15 percent difference. It's difficult to discuss these things in academic

trading, this is an important concept of overreaction that we can quantify.

There's a lecture by Fischer Black from 1986 that we quote sometimes, where he says that noise makes it very difficult to test theories. So, one way of dealing with this is by trying to extract noise. That's what I would say to anybody who is trading in the short term: what you can do is make a model of valuation, subtract that out and then examine the forces. So, for example, with this TRF and this valuation, the valuation went up 5 percent today, and the stock went up 20 percent; where is that extra 15 percent coming from?

Beyond that, I think in a lot of these studies, what's called technical analysis, there are a lot of good sound concepts, but the way it's presented, it doesn't sound scientific so it's easy for academicians to dismiss it. I've heard a number of lectures where people just ridicule technical analysis, but gradually people who ridicule it are now writing papers concluding that maybe some of it is okay, and maybe some of it is scientifically valid. I think that using the concepts of technical analysis and trying to refine them and test them scientifically is probably a good idea for technical people.

The other thing I would say as an example is the roulette wheel. An idea that Nassim Nicholas Taleb has pushed for some time, which I can illustrate with a few easy examples, is the idea that just because someone looks like he's providing us with steady returns doesn't mean that it's risk free. In that way, these two graphs illustrate this idea that the biggest mistake of classical finance is to define risk as volatility.

This is an example of a very risky investment. Let's say a fund manager takes your money and puts

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a house. Many of these things are overlooked because they notice the uptrend and can't seem to resist it.

WILMOTT: With that in mind, how can we apply observations and results from behavioral finance experiments and the set of fundamental points there? And how can we harness that in an investment strategy as an individual or perhaps in terms of investment bank? Our readership is predominantly quantitative traders in banks; how might they incorporate findings of behavioral finance in their own investment strategies, do you think?

Caginalp: I think a good place to

in order to understand how each of the behavioral effects has an impact, and to measure precisely and quantitatively the impact of the trend, if the volume increases or decreases, the volatility, and what each of these concepts does for the change in price tomorrow. A lot of this can be implemented.

As a data set, we use the closed-end funds; we have some studies with over 100,000 data points. Also, the paper with **Ahmet Duran** used the closed-end funds in part because the valuation is very precise and we can do studies where we don't have to worry if somebody will accept

circles because they think there must be something there. There's something there because there's a big rally worldwide; Russian stocks are going up, and people are enthusiastic about Russia when things are moving up because things are more volatile; nevertheless, there's a 15 percent difference here. The study with **Duran** suggests that tomorrow it will reverse itself. In other words, if someone is buying at the end of the trading day today, there's at least a two-thirds chance that this will go the other way tomorrow. If you are holding on to this for a long time, it may not be crucial, but in terms of

it in a bank for three months, and collects an interest of 1 percent. On the last day, he goes to a roulette wheel, which has 30 slots, no zero, double zero, not much trading cost, and he bets on every number except 13. The number 27 comes up, for example, and he has a return of about 3 percent. So, he says, this quarter I earned 4 percent for you, and the same thing happens in the next quarter. So, the number 13 may not come up for 10 to 20 times if he's lucky, so there are perfect returns for maybe 12 or 15 quarters, but one day he comes and says, you know what, something really unexpected happened and I lost all your money!

This is what the situation was with the housing bubble. This idea of mortgages is only a couple of generations old; this idea of giving a mortgage to somebody with no down payment and a very unreliable income is only a few years old, and is very similar to this example above. It may work well for 12, 13, or 15 quarters, but it's a very dangerous idea because as soon as we hit a rough spot, all of these people are in the same boat. It has a vicious cycle kind of development; basically, as people start defaulting, the housing industry tanks and causes other industries and banks to have problems. So, this subprime lending is very similar to these two graphs. This is another thing I think that investors have to be wary of when they look at data – it's an issue of the underlying distribution data; if these data were generated by tossing a coin, it would be one thing, but if we don't know the underlying distribution, the idea that you have 15 quarters of 4 percent return doesn't really say as much as someone who is not quantitative might think.

WILMOTT: You've made some

mentions about the current situation in commodity, and how this was similar to the situation during the late 1970s as well; do you have anything you'd like to add, particularly with what's happening in China at the moment with commodities?

Caginalp: In general, commodities are seen as an inflation hedge. In the USA, there's been a real loss of confidence in stock markets and stocks of large companies, which started in 2000 or a bit earlier with all of these accounting gimmicks, Enron, etc. That led people to the hard assets and, for a lot of sophisticated investors, to look at energy with the support of knowing that in the long term these things are going to go up. Some people are just trading these energy-type securities, but some people also feel that it's a good long-term investment. They feel that the price of oil would at least match a realistic rate of inflation they feel they are exposed to, but often when you have a big bubble and it collapses, the idea of things like oil moving up significantly may take some time.

There is another quantitative aspect of speculation and liquidity. In commodity trading, for example, there is the tendency to look positively on investors and speculators as providing funds that facilitate trades. In the very short term, this means a smaller bid/ask spread and the ability of a supplier or wholesaler to buy or sell a large quantity without sacrificing price. However, from my perspective, the arrival of a large group with ample cash immediately increases the L equals total cash divided by total units of the commodity. This means that prices will tend to rise significantly. At some point, the momentum trading will push the price up, even above the liquidity price, L . As the trend levels



out, prices move downward toward the liquidity price. The negative price action at this point discourages some of the speculators, who cease to become active. This means that L is now lower. The vicious cycle involving trend and the cash of the speculators drives the prices lower. This is one of the factors that moved oil prices from about \$20 to \$147 and then to \$35. As money flows into the trading of a commodity or other assets, this possibility is often overlooked. It may sound paradoxical that this increase in trading and cash may make the market more stable on an interday basis, but much more unstable on a monthly basis.

WILMOTT: It was driven up so wildly by speculation and not demand really until the middle of last year. Certainly, now everybody is feeling rather sober about the whole situation. Just to round things off, what are the areas of research which are interesting to you the most at the moment? You've mentioned a new paper coming up; in what direction are you going?

Caginalp: One of the things that

I'm very excited about is just using large amounts of data with some sophisticated statistical methods, to uncover a quantitative way, the underlying forces in the market. We're doing this work with Mark Desantis; we've done related work with a former graduate student, **Ahmet Duran**, who is now at the University of Michigan, and also with Vladimira Ilieva.

The nice thing about the statistical methods is that they provide very clearly the evidence for a lot of these behavioral features in the markets, but ultimately I would like to use that as a stepping stone to utilize these concepts within the differential equation setting that we have, and to develop more sophisticated optimization methods. In other words, when you write some differential equations there are a bunch of parameters and if you don't know what those parameters are, some could give you something chaotic, another might give you something very stable. The question is, what are the parameters that characterize the investor population?

One of the things we did with **Duran** is try to use sophisticated optimization methods – for example, the coefficients of trends and valuations, the timescale, and so on. I'd like to continue to develop those sorts of ideas. I'd like to have a better marriage between the statistical methods and the differential equation. There are very powerful statistical methods, if we can incorporate them within the differential equations; this will give a real tool for understanding what is going on beyond valuation. For example, TRF went up 15 percent more than its net asset value today; how could we have predicted that yesterday, or, at this stage, what do we expect for tomorrow? For

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example, if I knew what was going to happen in Russia in the underlying net asset value, what would I expect from that fund tomorrow?

The closed-end funds for us are giant laboratories. Sometimes in reviewing and so on, people make a big fuss about this. If you look at the volume and structure and the trading of closed-end funds, it's not much different from medium capital stocks in terms of trading; they trade with less volume than Microsoft, for

trading strategies. So, basically, they are extracting data from newswire reports, all of that qualitative stuff that floats out there, along with traditional tick data on performance, etc. Now they're presenting that data in a way to be used in quantitative strategies, where a trader can actually, to a certain extent, define which types of information they find more important by categorizing a sort of hierarchy of information sources; this makes a difference on the market or has a greater

quantify; when you're publishing a paper, there's more debate about it. To the practitioner, if it works, if you can quantify an event such as a company buying back shares, earning disappointments, political instability, etc., a lot of these things can be quantified and put in as a dummy variable. Just like we're doing in our studies, we put in a dummy variable for a particular type of feature; one could have overbought a class of stocks, showing an earnings disap-

data set. However, this often means that we look further back in time, which is possibly irrelevant. Many quantitative features of the market differ significantly before and after September 15, 2008 (the day Lehman Brothers declared bankruptcy). Hence, for many quantitative studies one can perhaps do better by using fewer data that are more relevant.

Also, I feel that much of the asset dynamics research involves either the long term (e.g., several years) or very short term (within one day). It seems to me that there is significant opportunity in the intermediate term between the day traders and the investors. We don't even have a name for it. Perhaps we should call it "travesting," to describe the use of behavioral concepts in order to trade on a timescale from one week to one year. Many of the major sentiment changes, as well as adjustment to new events, happen on this timescale. A typical correction in the emerging markets is about six weeks, for example. In the aftermath of the September 2008 events, a local bottom was reached within about four weeks. This seems to be an important timescale for a psychological adjustment, so that the influences of over- and under-reaction are perhaps maximized. When we look at major events such as Pearl Harbor or September 11, 2001, the market typically hits bottom within a few weeks.

Working within this timescale allows one to adjust valuation in an approximately linear way for many assets.

In addition, the concept of quantifying information, as we discussed above, and integrating it with already quantified information such as price changes, volatility, and volume presents interesting opportunities and challenges. This is something we hope to present soon.

For example, one of the challenges we face is the need for a larger data set. However, this often means that we look further back in time, which is possibly irrelevant

example, but the volume is comparable to a lot of stocks out there. So, this is great testing ground because if the concepts work here, they certainly can work on other companies.

One has to build a valuation model, which is just part of basic finance. The only thing is that, scientifically, if you want to convince someone, then the valuation model that you will build is subject to some criticism, whereas the closed-end fund is more clear-cut. So, I think with the large-scale data that are available, the way we can model with differential equations is an exciting area. I also hope to do more experiments with Vernon Smith and Dave Porter [both now at Chapman University] on hypothesizing and establish in laboratories various behavioral aspects of trading.

WILMOTT: Thomson Reuters is running a service under their QED unit, which basically extracts data from news feeds to be fed into algorithmic

level of veracity to what has happened in the market historically, etc. Do you think there are any sort of points of conjunction between your own research and trading strategies that can operate off a technology like that?

Caginalp: Absolutely – a lot of the things we have are already suitable for trading strategies. But if you want to quantify events, Jeff Madura and collaborators in Florida, for example, have done some studies like this, and they try to quantify certain types of events and see what the effects are. Something like that would work well with what we're doing. In a certain group of stocks, we've already found six or seven factors – one of which is valuation, another is trend and resistance, and so on. If one hypothesizes that, for one stock or one group of stocks, a certain type of event causes a certain amount of price change, then that could be the eighth or ninth variable.

Events are a little bit difficult to

pointment of x percent, and these methods should work well with that. I think that kind of thing is compatible with what we're doing, certainly.

I believe that the key idea in quantifying events (e.g., the monthly unemployment number) is to obtain two impact numbers through data analysis. One number measures the extent to which the value of the asset has been changed as a result of the news. The other is the immediate effect that it will have on the market based on similar events in the past. We are working on a precise mathematical formulation of these ideas. Experiments done by David Grether years ago suggest that most people place too much emphasis on recent news, rather than integrating the recent change with the overall picture.

In general, I feel that the quantitative methods need to be used in conjunction with an understanding of markets. For example, one of the challenges we face is the need for a larger