Math of Markets

Predictability, even for bubbles

A few years after moving from Turkey to the United States, a youngster found a hobby in reading *The New York Times.* He read the business section diligently, and the daily-changing numbers relating to stocks baffled his young mind.

When the boy was 12 years old, his father introduced him to a family friend, a financial advisor. Immediately, the youngster asked a nagging question.

"How do the companies calculate their value each day?"

The advisor explained that the numbers are trading prices that go up or down based on people's reactions, and people decide how much they want to pay. External forces such as financial news or world events can change the market without warning or explanation. The boy, Gunduz Caginalp, was riveted. A few months later, he bought his first stocks.

"It was a fascinating game," he says, decades later, in his office at Pitt, where he's now a math professor, teaching nonlinear differential equations and mathematical finance. "At the time," he says, "coming from the controlled economy of Turkey, it was inconceivable to me that markets worked that way."

Today, with more than 100 papers published in leading academic journals, Caginalp is a prolific voice in the realm of finance. His research aims to solve the puzzle of market changes that cannot be explained based on valuation.

"Looking at a chaotic mess like a financial market, you can extract simple principles, investigate patterns, and draw conclusions," he says. "But only if your curiosity exceeds your patience."

In his latest research at Pitt, Caginalp and his former student Mark DeSantis, who recently earned a PhD degree in mathematics from Pitt, set out to explore the behavior of markets. Their hypothesis was that momentum investments—those fueled by overreaction to fluctuation in valuations—threaten market stability. The research team analyzed 111,356 records from 119 funds, corresponding with the daily closing prices of those funds from Oct. 26, 1998, through Jan. 30, 2008.

Technology enabled the researchers to compute mountains of market statistics, a feat that once required a small army to complete. In the data, they found their hypothesized pattern—upward trends attract certain traders who are fixated on prices. Charting the data, they saw that as more price-conscious traders invest in an undervalued stock, the price increases, thereby attracting momentum traders who push prices significantly above valuation.

Contrary to the fundamental assumption in classical finance that the market is designed to work out inefficiencies caused by bad investment decisions, the team's findings suggest that individual actions within the market can have grave, lasting consequences.

The work is important, says Caginalp, "so that, in the future, we can reform, even redesign, markets to be more efficient and possibly avert catastrophic losses like those we felt in the 2008 recession."

When he arrived at Cornell University as a freshman in 1970, Caginalp already had honed a sharp eye for obscure patterns and a mind for rigorous mathematical analysis.

Caginalp

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Throughout his years as a faculty member at Rockefeller University, Carnegie Mellon University, and, since 1984, Pitt, he has remained loyal to his original course of study—mathematical problems arising in physics, economics, and statistics—and has even found time to indulge his childhood hobby, investing.

He sensed flaws in academia's understanding of classical finance. In theory, market participants buy a stake of ownership in a company, believing that their investment will return long-term rewards. In reality, many people buy on a speculator's whim, at the hint of upward momentum, hoping for more immediate profit. Logic told him these investments could have destabilizing effects on markets. But, at the time, only a rogue minority in academia supported his view.

Then, after the 1987 stock market crash, Caginalp read an article in *The Wall Street Journal* detailing the work of Vernon Smith, an economics professor. In a laboratory at the University of Arizona, Smith created a financial market where subjects traded with real cash and the same information. Over time, the team detected the growth of financial "bubbles"—market instability resulting from assets trading above their fundamental values. Analyzing the subjects' performance relative to changes in asset values, Smith's team found that bubbles originate within the market, without external influences.

Smith's groundbreaking studies were an inspiration to Caginalp. Throughout the early 1990s, he assembled a team of researchers at Pitt and used Smith's data to refine their differential equations representing financial markets.

Hoping to accurately predict fluctuations in asset valuations over time to explain Smith's bubbles, the team computed the statistical parameters of the experimental market and then tested their results in Smith's laboratory in real time against the top-earning traders' predictions from previous experiments. Another important theoretical contention that was confirmed by experiment was the revelation that the more money in the market, the bigger a bubble will grow.

Soon, Caginalp began collaborating with Smith's team at the University of Arizona, where he laid a strong foundation for his current research to unfold. In subsequent years, Caginalp published nine articles with Smith, who won the 2002 Nobel Prize in Economics.

Now, more than a decade later, Caginalp continues his own work, slowly, surely interpreting the data to pinpoint missing pieces. Each day takes him deeper into the chaos of markets but also closer to a complete understanding of market mechanics.

—Peter Kusnic

Breakthroughs in the Making

Detecting Ozone

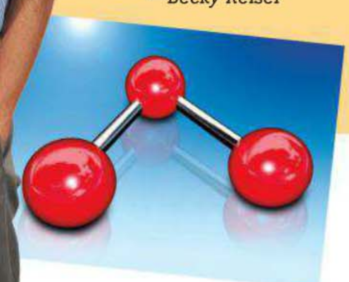
Every day, millions of people are exposed to ozone, an air pollutant emitted by car exhaust and ultraviolet rays. Even those who work inside are not immune—common office equipment such as copy machines and printers may also emit ozone.

Overexposure to ozone can result in irritation in the lungs, especially in those affected by asthma, bronchitis, or cystic fibrosis.

Pitt researchers, led by chemistry professor Kazunori Koide, recently developed a substance that is able to detect amounts of ozone, inside and outside the body. The new substance—a nonfluorescent solution that turns bright fluorescent green when exposed to ozone—will help researchers better understand the effects ozone has on the body. In one study, published in *Nature Chemistry*, the substance was used to determine whether ozone had come into contact with lung cells. Within 10 minutes, the cells began to glow green.

The discovery may lead to devices that prevent overexposure to ozone. For instance, people at higher risk might wear a pin or badge containing the substance to detect unsafe levels of ozone in the air.

—Becky Reiser



Koide and the molecular structure of ozone