The Thinkers: He brings higher mathematics to bear on high finance

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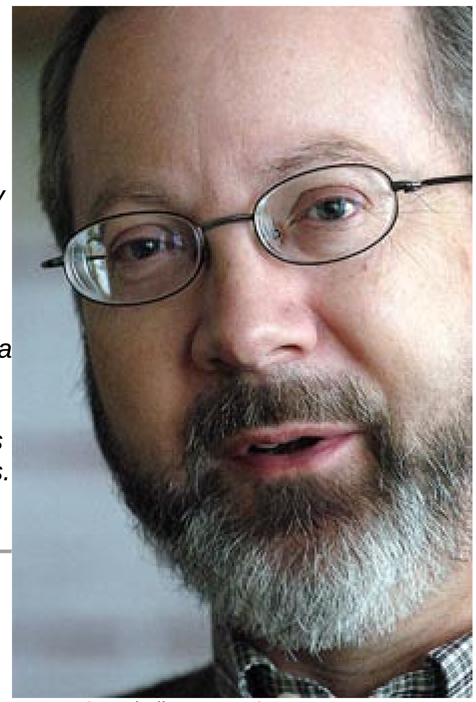
By Mark Roth, Pittsburgh Post-Gazette

In Steven Shreve's world, there is a magical connection between the people who invest in convertible bonds and the ones who get frustrated watching a YouTube video that keeps stopping and starting.

The Thinkers
This monthly series will highlight people from Western Pennsylvania who are on the forefront of new ideas in their fields.


V.W.H. Campbell Jr., Post-Gazette
Steven E. Shreve

Position: Orion Hoch professor of mathematics, Carnegie Mellon University

Age: 56

Residence: Oakmont

Education: Bachelor's degree in German, West Virginia University, 1972; mathematics studies, Georg-August-Universitat, Gottingen, Germany, 1972-73; master's in electrical engineering, doctorate in mathematics, University of Illinois, It's called stochastic calculus, a branch of mathematics that measures what happens in any system that is beset by random fluctuations.

Dr. Shreve, the Orion Hoch Professor of Mathematics at Carnegie Mellon University, does research into both the convertible bond and YouTube problems.

But he spends most of his time overseeing the university's highly regarded program in computational finance.

In the past 25 years, the growing power of computers and an explosion of new formulas have turned the world of high finance into a field that depends on high-level mathematics.

The enrollment in computational finance programs at the nation's elite universities is a clear sign of that.

Dr. Shreve recently counted nearly 400 master's students at the nine leading schools with such programs -- Carnegie Mellon, Columbia University, University of California at Berkeley, University of Michigan, University of Chicago, Cornell University, New York University, Stanford University and Princeton University.

"When we began our program in 1994, I thought we might get up to 25 students a year," he said. "I never expected we'd have 65 full-time students and with part-timers more than 100."

Dr. Shreve's convertible bond research is a real-world example of how important complex math can be in shaping the way financial markets function today.

Startup companies often sell convertible bonds to raise cash. Investors like them, Dr. Shreve said, because bondholders have priority over shareholders, and because they have the right to convert them into shares in the company at a later point.

Bondholders often opt to make that conversion after the company starts to do really well, so they can grab a bigger share of the burgeoning wealth.

1977.

Previous positions: Visiting professor, University of California at Berkeley, 1977-78; mathematics professor, University of Delaware, 1978-80; associate director, Carnegie Mellon Center for Nonlinear Analysis, 1991-94; Senior visiting fellow, Isaac Newton Institute for the Mathematical Sciences, University of Cambridge, 1995

Professional honors: Fellow, Institute of Mathematical Studies; Doherty Prize for sustained contributions to education, Carnegie Mellon, 2000; best new book in quantitative finance, Wilmott.com, 2004

Books and publications: "Stochastic Calculus for Finance, I-II," 2004; "Methods of Mathematical Finance," with Ioannis Karatzas, 2004; "Stochastic Calculus and Brownian Motion," with Ioannis Karatzas, 1990. One other book and 44 articles in refereed journals

The Series

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But the company may want to "call" its bonds and force the conversion at an earlier point, so it can avoid paying additional interest on the bonds until the bondholder decides to convert them.

Borrowing lessons from a branch of math known as game theory, Dr. Shreve's formula calculates the optimal time for both the investor and the company to convert the bonds into stock. If the bonds are being traded in the marketplace, it can also say whether they are overpriced or underpriced.

The YouTube research has nothing to do with finance, but the mathematical challenges are similar.

As amazing as it seems, when a typical two-minute video clip is sent over the Internet, it is broken up into thousands of data packets, which are transmitted on different routes over the network and have to be reassembled at the receiving end.

When you watch a video and it keeps stopping and starting, it usually means that many of those packets didn't get to their destination on time.

Right now, the Internet uses a "first-in-first-out" protocol, which means that the video packets are mixed in with all sorts of other data packets, and each one is transmitted on a first come-first served basis.

But there is another way to do things. The computer could assign a deadline to each packet, and the video packets could get top priority, which means they would be sent out first.

Dr. Shreve's formula is designed to test that possibility. And while he doesn't have a full answer yet, his initial tests show that an "earliest deadline" approach might reduce late-arriving packets by 10 percent to 50 percent.

The upsurge in computational finance specialists on Wall Street and other financial capitals -- they are known in the business as "quants" -- has been driven largely by the development of the often exotic investments known as derivatives.

Derivatives are products that are linked to underlying assets, but can be traded separately.

One of the best-known examples is a stock option, which allows someone to buy a company's shares for a certain price at some point in the future.

Hedge funds deal extensively in derivatives.

And while there have been cases where hedge funds have made disastrous bets on certain derivatives, much of the time they use the derivatives to protect against negative consequences from some other investment.

One common example Dr. Shreve uses is a Swiss bank that has an American branch. It may be doing a fine job of running its American business, he said, but if the value of the dollar weakens against the Swiss franc, the bank could end up showing a loss for that reason.

To hedge against that, the bank may "go short" on a derivative known as a futures contract, which increases in value if the dollar weakens. Just as with an insurance policy, the derivative won't be worth much if the dollar stays strong. But if the dollar slides, the derivative will increase in value and help offset the loss.

In a case like this one, he said, the formulas devised by financial mathematicians are not designed to predict what will happen to the dollar's value in the future, but to tell the bank what kind of hedges to purchase to provide the best possible protection of its assets.

"Hedging is a form of insurance," he said, "and if done properly, it reduces the risk of financial catastrophe. Without it, you could have firms fail because of extreme market events, whereas firms that have a good hedge can survive a market event."

For Dr. Shreve, mathematics not only has had the power to change how the economy functions -- it had the power to dramatically change his life.

He grew up in the small coal-mining town of Rupert, W.Va., near the resort of White Sulfur Springs, the son of a forester and a nurse.

There were 47 people in his high school graduating class, and throughout school, "I always liked mathematics. I just thought it was my ticket out of there."

A high school guidance counselor mistakenly told him he needed two years of a foreign language to get into West Virginia University, and so he took the only language his school offered, German.

When he got to the university, he found out he was actually required to take two years of a language in college to graduate, and so the school put him in third-year and fourth-year German.

"By that time, I thought, 'I'm really close to being able to speak this language,' so he won a Rotary fellowship to study mathematics at Gottingen University in Germany.

He took the courses there in German, of course, and so when he sat for his qualifying exams for graduate work at the University of Illinois in 1973, he sometimes had to give his answers in German because he didn't know the English terms for certain words.

After getting his doctorate, Dr. Shreve taught at Berkeley and the University of Delaware before Carnegie Mellon hired him in 1980.

The computational finance program is a classic example of the collaborative, interdisciplinary approach that Carnegie Mellon is known for.

The program was put together by professors from the mathematics and statistics departments as well as the Tepper School of Business and the H. John Heinz III School of Public Policy and Management.

"One of things that is unusual about Carnegie Mellon is that this is a pretty entrepreneurial place," he said. "The administration here is very good at supporting that concept and getting out of the way when necessary.

"I think this happens because we're like Avis -- we're not an Ivy League school, so we have to try harder and we have to be better to get the same recognition."