James Pethokoukis
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FACTBOX-Tools to predict market shocks

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May 25 (Reuters) - How do you calculate the probability of an event that is unprecedented?

Zari Rachev, Bulgarian-born mathematician, says he uses a variety of mathematical and statistical tools. His company FinAnalytica runs scenarios that can incorporate each of these approaches separately or combine them.

One comes from the work of French mathematician Benoit Mandelbrot on fractals, complex geometric shapes that are similar no matter what scale of observation.

As applied to a market, the price graph of a day's trading can look the same on a smaller scale as one for a year's or 100 years' trading. Assessing extremes that are possible on a small scale can give a picture of potential extremes on a larger scale.

Mandelbrot's theories on fractals enabled Rachev to factor in "fat tail" risk or the chance of an event falling outside the classic Gaussian bell curve of probability, named after 19th century mathematician Carl Friedrich Gauss.

Rachev said he combined fractals with the work of U.S. mathematician Robert Engle on clustering of volatility.

Engle had developed models that take into account the tendency of stock prices to move between periods of low volatility, such as in 2003 to 2006, and high volatility -- 2007 to date.

"I combined the work of two geniuses -- Mandelbrot and Bob Engle -- because they are both right. You have to use a model that encompasses both the clustering of volatility and fat-tail distribution," Rachev said.

Another tool came from Andrey Nikolaevich Kolmogorov, Rachev's professor at Moscow University who analysed probabilities around earthquakes.

Neither an actual earthquake nor a market quake happen completely in isolation, Rachev said.

Kolmogorov's model takes into account that a big shock is preceded by smaller shocks and followed by aftershocks, and his theories can also be used to analyse the probabilities of shocks on the stock market, Rachev said.

For example, the standard statistical correlation of the behaviour of the Dow Jones industrial average and Nasdaq stock indexes began to break down around 80 days before the 1987 crash, he said. "These relations leave the Gaussian world before a crash happens."

He took his fourth tool, which he calls joint tail dependencies, from survival analysis of the late 1970s. This branch of statistics deals with the modeling of data on the time to events such as deaths in a population. These tend to cluster together during famines and epidemics.

In extreme situations in the financial markets, asset classes that are seen as normally independent or only marginally related start to move in tandem.

"We needed a structure that can capture the fact that huge losses tend

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