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The father of fractals dissects financial market moves

The (Mis)behaviour of Markets: A Fractal View of Financial

Turbulence was published in 2004 and written by the late Benoit Mandelbrot and Richard L. Hudson. Mandelbrot was a renowned mathematician often referred to as “the father of fractals”, and the book is written in his voice. He has a long list of accolades, and even an asteroid (diameter 11km) was named in his honour, the 27500 Mandelbrot. Hudson, meanwhile, is a journalist and currently editorial director at Science|Business.

The book comprises of three parts: *The old way*, *The new way* and *The way ahead*.

In *Part I: The old way*, Mandelbrot warns that we have been mis-measuring risk in financial markets. He describes the different states of randomness as mild and wild. Mild randomness occurs in the world of normal (or Gaussian) distributions, described by the familiar bell curve, where big changes are the result of many small ones. Wild randomness occurs in a world described by the less-familiar Cauchy distribution, where major events “loom disproportionately large”. He explains the differences between these distributions by comparing two games of chance, the mild and simple coin-toss vs the wild blindfolded archer shooting at a target on an infinitely long wall, where the distance of the miss determines the score. In the Cauchy distribution a single miss can easily be the size of all the other misses combined.

Mandelbrot dedicates a chapter to Louis Bachelier, the first person to apply the concept of Brownian motion, a stochastic process used in physics to describe the way heat spreads, to modelling

price changes. Within the assumption that price changes follow a Brownian motion lies a subset of critical assumptions, including that each change in price is independent from the previous prices in a series of prices (thus a price has no 'memory' of previous prices), as well as that price changes follow a normal distribution.

He then follows the use of Bachelier's theories through the 20th century by Markowitz, Sharpe, Black and Scholes, some of the greatest influencers in financial market theory. In the concluding chapter of *Part I, The Case against the modern theory of finance*, he dissects four assumptions underpinning the theory of finance, and illustrates how they differ to reality. These are: people are rational and aim only to get rich; all investors are alike; price change is practically continuous; and price changes follow a Brownian motion. This book was written in 2004, so many models have been adjusted and new models created to move away from these assumptions.

“A fractal is a pattern or shape whose parts echo the whole, only scaled down.”

In *Part II: The new way*, Mandelbrot develops a Multifractal Model of Asset Returns. This section is written as if he is a detective stumbling on clues, where each clue is a mathematical tool from a different field or from a different age. He introduces the concept of long memory, and shows how using a similar approach as Brownian motion but using what he calls the Hurst factor, to create a price series that has some form of memory (i.e. not independent). He also introduces the concept of multi-fractal time. The chapters in this section are quite technical, but his explanations are clear – he often adds relatable comparisons in his explanations. Chapter 8, the mystery of cotton stood out to me.

The mystery of Cotton tells the story of how Mandelbrot came to notice a fractal pattern in a large set of cotton price data. This chapter gets quite technical, but to summarize, Mandelbrot plotted the frequency and the size of cotton price changes on a log-log scale. From here he observed that the size of price changes consisted of many small moves and a few, very large jumps, not as scary as a Cauchy distribution, but a lot less tame than the normal distribution. He then creates the same plot using different time periods and scales – and these all look the same – there is a fractal pattern in the cotton data.

In *Part III: The way ahead* Mandelbrot lists what he calls the 10 heresies of finance. These are to him, obvious facts that often contradict received wisdom. Some of the more controversial include:

- Market “timing” matters greatly. Big gains and losses concentrate into small packages of time.
- Markets in all Places and ages work alike.

For the final chapter, *In the Lab*, he lists areas where he believes fractals can be of use in finance.

I would highly recommend this book to anyone interested in financial markets and/or fractals. The style is light; Mandelbrot himself describes the book as pop science. He includes many images that provide a visual aid to concepts. The fractal gallery – a set of images of famous fractals included in Part II – was quite a treat, especially the very dramatic 1893 quote from Charles

Hermite, a French mathematician, when he is introduced to the Koch curve: “turning away in fear and horror from this lamentable plague of functions with no derivatives”. It is key to keep in mind that this book was written in 2004, so some of the critique will be outdated. □

Janneke joined M&G Investments in July 2012 and is currently a Quantitative Analyst in the Multi-Asset Team. She is responsible for ensuring that the M&G Investments multi-asset funds are kept in line with their asset allocation models. With 20 years of industry experience, Janneke has worked in a range of Investment Specialist and Data Analyst roles both locally and abroad. She holds a Bachelor of Science degree in Mathematics and Applied Mathematics from the University of Stellenbosch and a Bachelor of Science (Hons) degree in Financial Mathematics from the University of Pretoria.