
BOOK REVIEW



Mark Kritzman, Senior Editor

NONLINEAR TIME SERIES ANALYSIS (Wiley, 2019)

Ruey S. Tsay & Rong Chen

*(Reviewed by
Alireza Yazdani)*

To put it mildly, Ruey Tsay's latest book, co-authored with Rong Chen, is a landmark success in highlighting the importance of nonlinear time series models and their applications in finance. Both authors have extensively published a number of original research in the field of quantitative finance and first author is widely respected through his earlier books on the study and analysis of univariate and multivariate Financial Time Series. "Nonlinear Time Series Analysis" offers yet another effective set of quantitative tools in the toolbox of researchers and practitioners dealing with increasingly complex time series data.

Early in the first chapter, the authors motivate as to why linear time series models, despite simplicity and good approximation properties, may not be adequate in practice. They argue that many empirical financial time series are likely nonlinear and an indirect manifestation of (unobservable) nonlinear processes. The "well-known autoregressive moving-average (ARMA) models of Box and Jenkins are (causal) linear time series" but "any deviation from the linear process results in a nonlinear time series", hence a potentially "huge" nonlinear world! And there is abundance of such nonlinear cases in finance, including: the changes to the unemployment rate, variations of the price of crude oil, and mostly any financial return series that may undergo structural break, volatility and regime change. Subsequently, the identification

and treatment of such nonlinear cases becomes important in finance research and practice, which constitutes the centerpiece of the book.

In practice, however, it is important to first establish the genuine need for fitting more complex nonlinear models due to the undesirable consequences of "finding spurious structure in a given time series". This can be done using statistical tests that are used to detect nonlinearity. The authors introduce several examples of parametric and non-parametric such tests and demonstrate their utilization by examples. From here, a journey starts by embarking on studying properties and applications of some classical and modern nonlinear models, including parametric (e.g. threshold autoregressive, Markov switching, functional and time-varying

coefficient autoregressive) as well as non-parametric models (e.g. Splines, Wavelets, Nonlinear additive), and their sub-families.

A welcome addition by the authors is the introduction of increasingly popular machine learning methods to the nonlinear financial time series literature. Chapter 4 is dedicated to this subject where methods like feedforward neural networks, deep learning, and tree-based models (decision trees, random forests) are presented and implemented in plain vanilla forms, as a way to assess their suitability and predictive power, when applied to challenges such as next day stock price direction or estimating changes to the price of commodities, and to contrast with those of traditional and linear time series models.

Beyond this point, authors discuss methods for non-Gaussian time series data such as count data, volatility models, and extensions of generalized linear models into time series space through generalized autoregressive and moving average models (GLARMA). Other advanced technical methods discussed and demonstrated through examples include traditional state space models, notably Stochastic Volatility models, Kalman filters and their nonlinear extensions. The final chapter discusses sequential Monte Carlo methods and their applications and some design issues.

While authors place a great emphasis on applications throughout the text, this naturally feels like a technical book requiring (undergraduate-level) background in statistics and

financial econometrics. Despite that, the authors do a great job of making things fall into place smoothly, thanks to their clear delivery style and by the means of numerous worked examples and real-world case studies accompanied by the solutions and implementation code scripts available on the book's website. On another positive note, the objective of the book is clear and consistent along the way: to bridge the gap between theory and practice of nonlinear time series by bringing such methods to the forefront of mainstream quantitative finance. All in all, "Nonlinear Time Series Analysis" succeeds well in its mission and may be regarded an important and timely contribution to the literature.