Modelling Financial Time Series with S-PLUS

Eric Zivot and Jiahui Wang

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Preface

What is the book and why was it written?

This book is a guide to analyzing and modeling financial time series using `S-PLUS` and `S+FinMetrics`. It is a unique blend of econometric theory, financial models, data analysis, and statistical programming. It serves as a user's guide for Insightful's `S+FinMetrics` module of statistical functions for financial time series analysis and financial econometrics as well as a general reference for models used in applied financial econometrics. The format of the chapters in the book is to give a reasonably complete description of a statistical model and how it works followed by illustrations of how to analyze the model using `S-PLUS` and the functions in `S+FinMetrics`. In this way, the book stands alone as an introduction to financial time series analysis as well as a user's guide for `S+FinMetrics`. It also highlights the general analysis of time series data using the new time series objects in `S-PLUS` 6.

Intended audience

This book is written for a wide audience of individuals who work, do research or study in the areas of empirical finance and financial econometrics. The field of financial econometrics has exploded over the last decade, and this book represents an integration of theory, methods and examples using the `S-PLUS` modeling language to facilitate the practice of financial econometrics. This audience includes researchers and practitioners in the finance industry, academic researchers in economics and finance, and advanced MBA and graduate students in economics and finance. Researchers

and practitioners in the finance industry who already use S-PLUS and desire more functionality for analyzing and modeling financial data will find this text useful. It is also appropriate for financial analysts who may not be familiar with S-PLUS but who desire an integrated and open statistical modeling and programming environment for the analysis of financial data. This guide is useful for academic researchers interested in empirical finance and financial econometrics. Finally, this book may be used as a textbook or a textbook companion for advanced MBA and graduate level courses in empirical finance and financial econometrics.

Audience background

It is assumed that the reader has a basic familiarity with S-PLUS at the level of Krause and Olson (2002) and a background in mathematical statistics at the level of Hogg and Craig (1994), is comfortable with linear algebra and linear regression, and has been exposed to basic time series concepts as presented in Harvey (1993) or Franses (1998). Most importantly, the book assumes that the reader is interested in modeling and analyzing financial time series.

Overview of the book

The chapters in the book cover univariate and multivariate models for analyzing financial time series using S-PLUS and the functions in S+FinMetrics. Chapter one gives a general overview of the use of S-PLUS 6 and highlights certain aspects of the language for statistical modeling. Chapter two introduces the new time series objects in S-PLUS 6 and illustrates the specification, manipulation and visualization of these objects. Chapter three surveys time series concepts used throughout the book. Chapters four through eight cover a variety of topics in the modeling of univariate financial time series, including testing for unit roots, extreme value theory, time series regression models, GARCH models of volatility, and long memory models. Chapter nine introduces rolling analyses of time series models and covers related topics such as technical analysis of financial time series and moving average methods for high frequency data. Chapters ten through fifteen cover models for the analysis of multivariate financial time series. Topics include systems of regression equations, classical and Bayesian vector autoregressive models, cointegration, factor models, multivariate GARCH models, and state space models. Chapter 16 covers aspects of modeling time series arising from fixed income financial assets. Chapter 17, written by Victor Yohai and Jiahui Wang, describes robust REGARIMA models that allow for structural change.

What is S+FinMetrics?

S+FinMetrics is an S-PLUS module for the econometric modeling and prediction of economic and financial time series. With some 600 functions, version 1.0 of S+FinMetrics offers the following functionality:

- Easy-to-use Trellis plots for multivariate time series
- Time series manipulations such as missing value interpolation, disaggregation, differences, distributed lags and polynomial distributed lags
- Rolling sample statistics such as variance, maximum, and minimum
- Moving average operators for both regularly spaced and irregularly spaced time series
- Common technical analysis measures and indicators
- Statistical tests for normality, autocorrelation, heteroskedasticity, multicollinearity, GARCH effects, and long memory
- Extreme value theory models based on generalized extreme value and generalized Pareto distributions as well as copulas
- Autoregressive distributed lag regression models
- White and Newey-West corrections for heteroskedasticity and serial correlation
- Robust estimation of REG-ARIMA models and robust detection of level shifts, trend breaks, and outliers
- Rolling and recursive regression
- Generic rolling models for back-testing
- Long memory fractional ARIMA and SEMIFAR models
- Univariate GARCH models including long memory FIGARCH models
- Multivariate GARCH models
- Linear and nonlinear systems of regression equations
- Classical and Bayesian vector autoregression models
- Tests for unit roots and cointegration
- Vector error correction models
- State space models and efficient estimation, prediction, smoothing, and simulation using the Kalman filter

- Statistical multifactor models for large data sets based on asymptotic principal components
- Term structure interpolation

S+FinMetrics incorporates functions from S+GARCH, the EVIS library of functions for modeling extreme values created by Alexander McNeil, the EVANESCA library of functions for modeling extreme values utilizing copulas created by Rene Carmona, and the *SsfPack* C library of state space modeling functions created by Siem Jan Koopman. S+GARCH was originally developed by Zhuanxin Ding, Hong-Ye Gao, Doug Martin, Jiahui Wang and Yihui Zhan. The S+FinMetrics function arima.rob was written by Ana Bianco, Marta Garcia Ben, Elena Martinez and Victor Yohai. The S+FinMetrics long memory modeling functions FAR, FARIMA, SEMIFAR and fgarch were developed by Jan Beran, Andrew Bruce, Don Percival, Alan Gibbs and Jiahui Wang and supported by NSF grant DMI-9801614 to Insightful Corporation (formerly MathSoft, Inc.). Hu McColloch kindly provided the term structure data included with S+FinMetrics, and James MacKinnon provided data sets for the response surface critical values for the Dickey-Fuller and Phillips-Ouliaris distributions.

Contact information and website

The authors are responsible for all of the material in the book except the material on robust change detection, which was written by Victor Yohai. Eric Zivot is primarily responsible for chapters 2-6, 9-12 and 14-15 and Jiahui Wang is primarily responsible for chapters 1, 7-8, 13, and 16. The authors may be contacted by electronic mail at

```
ezivot@u.washington.edu
jwang@insightful.com
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and welcome feedback and suggestions for improvements to the contents of the book. The website for the book is located on the Insightful Corporation website at

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http://www.insightful.com/support/finmetrics10
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Acknowledgements.

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with help from many people. In particular, Jan Beran wrote many of the long memory functions while acting as a consultant to Insightful. Siem Jan Koopman helped to incorporate the *SsfPack* functions into S-PLUS and to write the chapter on state space models. Alexander McNeil and Rene Carmona graciously provided background material and S-PLUS examples for the material in the chapter on modeling extreme values. A number of people were helpful in proofreading the book and testing the software. Particular thanks go to Andrew Bruce, Chuck Curry, Zhuanxin Ding, Ruud Koning, Steve McKinney, David Weitzel, Quan Wen and Bingcheng Yan.

Topographical conventions

This book obeys the following typographic conventions:

- The *italic* font is used for emphasis, and also for user-supplied variables within UNIX, DOS and S-PLUS commands.
- The `typewriter font` is used for S-PLUS functions, the output of S-PLUS functions and examples of S-PLUS sessions.
- S-PLUS objects of a specified class are expressed in `typewriter font` enclosed in quotations " ". For example, the S-PLUS function `timeSeries` creates objects of class "`timeSeries`".

Displayed S-PLUS commands are shown with the prompt character >. For example

```
> summary(ols.fit)
```

S-PLUS commands that require more than one line of input are displayed with the continuation prompt indicated by + or `Continue string:`. The S-PLUS output and plots in this book were generated from S+FinMetrics Version 1.0 and S-PLUS Version 6.0 release 2 for Windows. The S-PLUS output and "`timeSeries`" objects were generated with the options settings

```
options(width=60)
options(time.zone=''GMT'')
```

In some cases, parts of long output from S-PLUS functions is omitted and these lines are indicated by

```
...
```

Some of the output has been hand edited to avoid line overflow.

References

[1] Franses, P.H. (1998). *Time Series Models for Business and Economic Forecasting*. Cambridge University Press, Cambridge.

[2] Harvey, A.C. (1993). *Time Series Models, Second Edition*. MIT Press, Cambridge.

[3] Hogg, R.V. and A.T. Craig (1994). *Introduction to Mathematical Statistics, Fifth Edition.* Prentice Hall, New York.

[4] Krause, A. and M. Olson (2002). *The Basics of S and S-PLUS, Third Edition*. Springer-Verlag, New York.