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## **Introductory Time Series with R**

Paul S. P. Cowpertwait and Andrew V. Metcalfe  
Springer-Verlag, New York, NY, 2009.  
ISBN 978-0-387-88697-8. 253 pp. EUR 49.95.  
<http://www.massey.ac.nz/~pscowper/ts/>

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The book “Introductory Time Series with R” gives a very broad and practical overview of the most common models for time series analysis in the time domain and in the frequency domain, with emphasis on how to implement them with base R and existing R packages such as **Rnlme**, **MASS**, **tseries**, **fracdiff**, **mvtnorm**, **vars**, and **sspir**. The authors explain the models by first giving a basic theoretical introduction followed by simulation of data from a particular model and fitting the latter to the simulated data to recover the parameters. After that, they fit the class of models to either environmental, finance, economics, or physics data. There are many applications to climate change and oceanography. The R programs for the simulations are given even if there are R functions that would do the simulation. All examples given can be reproduced by the reader using the code provided by the authors in all the chapters. Exercises at the end of each chapter are interesting, involving simulation, estimation, description, graphical analysis, and some theory. Data sets used throughout the book are available in a web site or come with base R or the R packages used. The book is a great guide to those wishing to get a basic introduction to modern time series modeling in practice, and in a short amount of time. It only assumes that the reader has taken a calculus-based introductory statistics course with regression, and it is easy to follow.

The time domain models covered are: Time series regression, i.e., deterministic trend and seasonal models with residuals that form a time series (Chapter 5); ARMA or stationary moving average and autoregressive models (Chapter 6); ARIMA, SARIMA, ARCH, and GARCH for nonstationary time series (Chapter 7); FARIMA for long memory processes (Chapter 8); VAR for multivariate time series and cointegrated time series with common stochastic trend (Chapter 11); state space with applications for which we require parameters to change over time (Chapter 12). Chapters 9–10 are dedicated to frequency domain analysis. Chapters 1–4 are introductions to time series data and the main issues to consider when analyzing this data. They are obligatory reading to be done before getting into the more sophisticated model identification and model fitting of Chapters 5–12. Chapter 1 introduces too many ideas at once. The authors show how to summarize, plot, and find correlations between time series, and they provide the basic code to define and work with time series objects in R.

Then they introduce time series decomposition, estimation of seasonal effects and moving average smoothers. Chapter 2 is more self-contained, talking about covariance, correlation, autocovariance, autocorrelation and the correlogram (ACF) plots. Chapter 3 introduces the cross-correlation function, the Bass model, and exponential smoothers to illustrate forecasting and model fitting with time moving parameters. Chapter 4 talks about lags, backward shift and difference operators, random walks, and autoregressive models. This chapter motivates better than other books I have read why we need the partial autocorrelation function (PACF) to identify models. As we can see in the above description of the chapters, the book does not follow the classical organization of other time series books.

Four things make this book unique among all introductory textbooks. First, the authors encourage the reader to write his/her own code to understand better the simulation of the models and the process of model selection with Akaike's information criterion (the only criterion used all long the book for model selection). The book gives templates to do so. But if there are inbuilt R functions that do the task, the authors point them out and reproduce the same example using that function. Sections 7.2.4 and 7.3.2 are good examples of this tactic. Second, the authors do not create yet another package to do their own version of the ACF or the PACF and such things, like other time series books in the market do; rather, the authors just use what R has to offer already and the reader can see which packages are being used. This makes it very convenient and useful for the reader, because while learning about time series s/he learns about base R and existing R packages, that could be used in other areas. Third, lots of practical tips to carry out analysis and interpretations of the latter appear throughout the book, e.g.: What may happen if you difference a deterministic linear trend using differencing (p. 138)? What is a misleading interpretation of the ACF of a GARCH process (p. 147, Section 7.4.7)? What is the interpretation of a differencing estimate of 0 in a FARIMA model (Section 8.4.3)? These tips rarely appear in other time series books, but are often the questions that the practitioner encounters when doing time series analysis. Fourth, the exercises at the end of the chapter are very related to what is learned in the body of the chapter. While challenging in some cases, the reader is given plenty of examples to build from and lots of code and practical tips to start and finish the problems.

As we have seen in the above review, "Introductory Time Series with R" is a book with ambitious scope. The topics are not conventionally organized or conventionally presented in Chapters 1–4. If used as a complement to a textbook, the teacher and any other reader will have a little hard time matching page numbers in our book with the conventional order of other textbooks. Perhaps the best thing is to use "Introductory Time Series with R" as the main textbook and complement it with pages in other, more conventional textbooks. Certainly, to learn practical time series with R the book is highly recommended. There is no better book in the market yet with such scope and insights for the practitioner.

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