Preface

Exponential smoothing methods have been around since the 1950s, and are still the most popular forecasting methods used in business and industry. Initially, a big attraction was the limited requirements for computer storage. More importantly today, the equations in exponential smoothing methods for estimating the parameters and generating the forecasts are very intuitive and easy to understand. As a result, these methods have been widely implemented in business applications.

However, a shortcoming of exponential smoothing has been the lack of a statistical framework that produces both prediction intervals and point forecasts. The innovations state space approach provides this framework while retaining the intuitive nature of exponential smoothing in its measurement and state equations. It provides prediction intervals, maximum likelihood estimation, procedures for model selection, and much more.

As a result of this framework, the area of exponential smoothing has undergone a substantial revolution in the past ten years. The new innovations state space framework for exponential smoothing has been discussed in numerous journal articles, but until now there has been no systematic explanation and development of the ideas. Furthermore, the notation used in the journal articles tends to change from paper to paper. Consequently, researchers and practitioners struggle to use the new models in applications. In writing this book, we have attempted to compile all of the material related to innovations state space models and exponential smoothing into one coherent presentation. In the process, we have also extended results, filled in gaps and developed totally new material. Our goal has been to provide a comprehensive exposition of the innovations state space framework for forecasting time series with exponential smoothing.

Outline of the Book

We have written this book for people wanting to apply exponential smoothing methods in their own area of interest, as well as for researchers wanting to take the ideas in new directions. In attempting to cater for this broad audience, the book has been structured into four parts, providing increasing levels of detail and complexity.

Part I: Introduction (Chaps. 1 and 2)

If you only want a snack, then read Part I. It provides an overview of our approach to forecasting and an introduction to the state space models that underlie exponential smoothing. You will then be able to appreciate how to implement exponential smoothing in the statistical framework of innovations state space models.

Chapter 1 includes some general information on forecasting time series and provides an historical context. In Chap. 2, we establish the linkage between standard exponential smoothing methods and the innovations state space models. Then, we describe all parts of the forecasting process using innovations state space models in the following order: initialization, estimation, forecasting, evaluation of forecasts, model selection, and an automatic procedure for the entire process which includes finding prediction intervals.

Part II: Essentials (Chaps. 3–7)

Readers wanting a more substantial meal should go on to read Chaps. 3–7. They fill out many of the details and provide links to the most important papers in the literature. Anyone finishing the first seven chapters will be ready to begin using the models for themselves in applied work.

We examine linear models more closely in Chap. 3, before adding the complexity of nonlinear and heteroscedastic models in Chap. 4. These two chapters also introduce the concepts of stationarity, stability, and forecastability. Because the linear models are a subset of the general innovations state space model, the material on estimation (Chap. 5), prediction (Chap. 6), and model selection (Chap. 7) relates to the general model, with considerations of linear models and other special subgroups where informative.

Part III: Further Topics (Chaps. 8–17)

If you want the full banquet, then you should go on to read the rest of the book. Chapters 8–17 provide more advanced considerations of the details of the models, their mathematical properties, and extensions of the models. These chapters are intended for people wanting to understand the modeling framework in some depth, including other researchers in the field.

We consider the normalization of seasonal components in Chap. 8, and the addition of regressors to the model in Chap. 9. In Chap. 10, we address the important issue of parameter space specification, along with the concept of the minimal dimension of a model. The relationship with other standard time series models is investigated. In particular, Chap. 11 looks at ARIMA models, and Chap. 13 examines conventional state space models, which have multiple sources of randomness. An information filter for estimating the parameters in a state space model with a random seed vector is detailed in Chap. 12. The advantages of the information filter over the Kalman filter, which was originally developed for stationary data, are explained. The remaining four chapters address special issues and models for specific types of time series as follows: time series with multiple seasonal patterns in Chap. 14, time series with strictly positive values in Chap. 15, count data in Chap. 16, and vectors of time series in Chap. 17.

Part IV: Applications (Chaps. 18–20)
The final part of the book provides the after-dinner cocktails and contains applications to inventory control, economics and finance.

These applications are intended to illustrate the potentially wide reach and usefulness of the innovations state space models. Procedures for addressing the important inventory problems of nonstationary demand and the use of sales data when true demand is unknown are covered in Chap. 18 for a reorder inventory system. In Chap. 19, the natural implementation of conditional heteroscedasticity in the innovations state space models framework (i.e., a GARCH-type model) is shown and applied to examples of financial time series. In Chap. 20, the Beveridge-Nelson decomposition of a univariate time series into transitory and permanent components is presented in the linear innovations state space framework. The advantages of this formulation over other approaches to the Beveridge-Nelson decomposition are explained.

Website

The website `http://www.exponentialsmoothing.net` provides supplementary material for this book, including data sets, computer code, additional exercises, and links to other resources.

Forecasting Software

Time series forecasting is not a spectator sport, and any serious forecaster needs access to adequate computing power. Most of the analyses presented in this book can readily be performed using the **forecast** package for

R (Hyndman 2007), which is available on CRAN (`http://cran.r-project.org/`). All of the data in the book are available in the **expsmooth** package for **R**. In addition, we provide **R** code at `http://www.exponentialsmoothing.net` for producing most of the examples in the book.

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