INTRODUCTION TO Time Series Analysis and Forecasting

WITH APPLICATIONS OF SAS AND SPSS

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with Monnie McGee

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with Applications of SAS and SPSS

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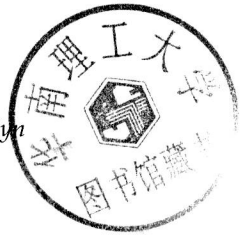

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For
Liz and Mike

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Preface

This book is the product of an intellectual odyssey in search of an understanding of historical truth in culture, society, and politics, and the scenarios likely to unfold from them. The quest for this understanding of reality and its potential is not always easy. Those who fail to understand history will not fully understand the current situation. If they do not understand their current situation, they will be unable to take advantage of its latent opportunities or to sidestep the emergent snares hidden within it. George Santayana appreciated the dangers inherent in this ignorance when he said, "Those who fail to learn from history are doomed to repeat it." Kierkegaard lemented that history is replete with examples of men condemned to live life forward while only understanding it backward. Even if, as Nobel laureate Neils Bohr once remarked, "Prediction is difficult, especially of the future," many great pundits and leaders emphasized the real need to understand the past and how to forecast from it. Winston Churchill, with an intuitive understanding of extrapolation, remarked that "the farther back you can look, the farther forward you can see."

Tragic tales abound where vital policies failed because decision makers did not fathom the historical background—with its flow of cultural forces, demographic resources, social forces, economic processes, political processes—of a problem for which they had to make policy. Too often lives were lost or runied for lack of adequate diplomatic, military, political, or economic intelligence and understanding. Obversely, policies succeeded in accomplishing vital objectives because policy makers have understood the likely scenarios of events. After we learned from the past, we needed to study and understand the current situation to appreciate its future possibilities and probabilities. Indeed, the journalistic and scientific quest for "what is" may reveal the outlines of "what can be." The qualitative investigation of "what has been" and "what is" may be the mere beginning of this quest.

The principal objective of this textbook is to introduce the reader to the

fundamental approaches to time series analysis and forecasting. Although the book explores the basic nature of a time series, it presumes that the reader has an understanding of the methodology of measurement and scale construction. In case there are missing data, the book briefly addresses the imputation of missing data. For the most part, the book assumes that there are not significant amounts of missing data in the series and that any missing data have been properly replaced or imputed. Designed for the advanced undergraduate or the beginning graduate student, this text examines the principal approaches to the analysis of time series processes and their forecasting. In simple and clear language, it explains moving average, exponential smoothing, decomposition (Census X-11 plus comments on Census X-12), ARIMA, intervention, transfer function, regression, error correction, and autoregressive error models. These models are generally used for analysis of historical, recent, current, or simulated data with a view toward forecasting. The book also examines evaluation of models, forecasts, and their combinations. Thus, the text attempts to discuss the basic approaches to time series analysis and forecasting.

Another objective of this text is to explain and demonstrate novel theoretical features and their applications. Some of the relatively new features include treatment of Y2K problem circumventions, Census X-12, different transfer function modeling strategies, a scenario analysis, an application of different forecast combination methods, and an analysis of sample size requirements for different models. Although Census X-12 is not yet part of either statistical package, its principal features are discussed because it is being used by governments as the standard method of deseasonalization. In fact, SAS is planning on implementing PROC X12 in a forthcoming version. When dealing with transfer function models, both the conventional Box–Jenkins–Tiao and the linear transfer function approaches are presented. The newer approach, which does not use prewhitening, is more amenable to more complex, multiple input models. In the chapter on event impact or intervention analysis, an approach is taken that compared the impact of an intervention with what would have happened if all things remained the same. A "what if" baseline is posited against which the impact is measured and modeled. The book also briefly addresses cointegration and error correction models, which embed both long-run and short-run changes in the same model. In the penultimate chapter, the evaluation and comparison of models and forecasts are discussed. Attention is paid to the relative advantages and disadvantages of the application of one approach over another under different conditions. This section is especially important in view of the discovery in some of the forecast competitions that the more complex models do not always provide the best forecasts. The methods as well as the relative advantages and disadvantages of combining forecasts

to improve forecast accuracy are also analyzed. Finally, to dispel erroneous conventional wisdom concerning sample size, the final chapter empirically examines the selection of the proper sample size for different types of analysis. In so doing, Monnie McGee makes a scholarly methodological contribution to the study of sample size required for time series tests to attain a power of 0.80, an approach to the subject of power of time series tests that has not received sufficient discussion in the literature until now.

As theory and modeling are explained, the text shows how popular statistical programs, using recent and historical data are prepared to perform the time series analysis and forecasting. The statistical packages used in this book—namely, the Statistical Analysis System (SAS) and the Statistical Package for the Social Sciences (SPSS)—are arguably the most popular general purpose statistical packages among university students in the social or natural sciences today. An understanding of theory is necessary for their proper application under varying circumstances. Therefore, after explaining the statistical theory, along with basic preprocessing commands, I present computer program examples that apply either or both of the SAS Econometric Time Series (SAS/ETS) module or the SPSS Trends module. The programming syntax, instead of the graphic interfaces, of the packages is presented because the use of this syntax tends to remain constant over time while the graphical interfaces of the statistical packages change frequently. In the presentation of data, the real data are first graphed. Because graphical display can be critical to understanding the nature of the series, graphs of the data (especially the SAS Graphs) are elaborately programmed to produce high-resolution graphical output. The data are culled from areas of public opinion research, policy analysis, political science, economics, sociology, and even astronomy and occasionally come from areas of great historical, social, economic, or political importance during the period of time analyzed. The graphs include not only the historical data; after Chapter 7 explains forecasting, they also include forecasts and their profiles. SAS and SPSS computer programs, along with their data, are posted on the Academic Press Web site (http://www.academicpress.com/sbe/authors) to assist instructors in teaching and students in learning this subject matter. Students may run these programs and examine the output for themselves. Through their application of these time series programming techniques, they can enhance their capabilities in the quest for understanding the past, the present, and to a limited extent, *que sera.*

This text is the product of an abiding interest in understanding longitudinal data analysis in general and time series processes in particular. I could not have accomplished this work without the help of many people. Working on three other projects at the time I was writing this book, I asked Professor

Monnie McGee to help me expedite a time consuming analysis of the sample size and statistical power of common time series models. Although Monnie used S plus and I use SAS and SPSS in the rest of the book, researchers and students will find that many of her findings apply to other statistical packages as well. Therefore, a key contributing scholar is Professor Monnie McGee, who contributed an important chapter on a subject that must be a concern to practitioners in the field, sample size and power of times series tests.

There are a number of scholars to whom I owe a great intellectual debt for both inspiration and time series and forecasting education. Although I have quoted them freely, I would like to give special thanks to George E. P. Box, Gwilym Jenkins, Clive W. J. Granger, Robert F. Engle, Paul Newbold, Spyros Makridakis, Steven Wheelwright, Steven McGee, Rob Hyndman, Michelle Hibon, Robert Fildes, Richard McCleary, Richard Hay, Jr., Wayne Fuller, David A. Dickey, T. C. Mills, David F. Hendry, Charles Ostrom, Dan Wood, G. S. Maddala, Jan Kamenta, Robert Pindyck, Daniel Rubenfeld, Walter Labys, George G. Judge, R. Carter Hill, Henri Theil, J. J. Johnston, Frank Diebold, Bill Greene, David Greenberg, Richard Maisel, J. Scott Armstrong, David F. Hendry, Damodir Gujarati, Jeff Siminoff, Cliff Hurvitch, Gary Simon, Donald Rock, and Mark Nicolich.

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