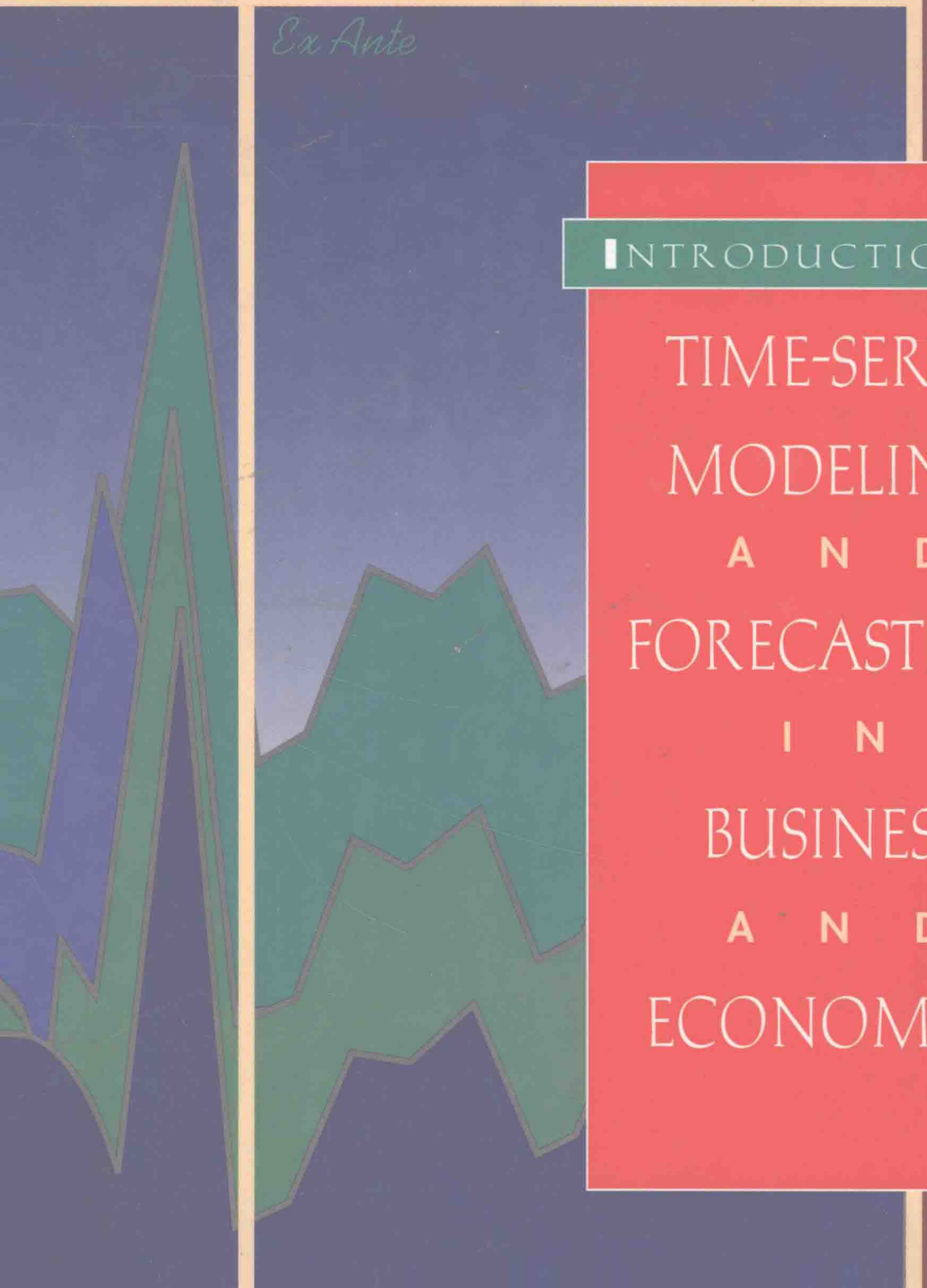
PATRICIA E. GAYNOR ▲ RICKEY C. KIRKPATRICK



INTRODUCTION TO TIME-SERIES MODELING AND FORECASTING IN BUSINESS AND ECONOMICS

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Patricia E. Gaynor
Rickey C. Kirkpatrick
Appalachian State University

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ABOUT THE AUTHORS

Patricia E. Gaynor is a Professor of Statistics in the Economics Department at Appalachian State University. She received her MA and Ph.D. from the University of Miami, where she was elected to Pi Mu Epsilon (National Honorary Mathematics Fraternity) and Phi Kappa Phi (Scholastic Honor Society). In addition to teaching, Professor Gaynor served, for seven years, as Assistant Director of the Computer Center and Manager of Academic and Institutional Research. In 1979–1981 she served as a Statistician/Computer Specialist for a HUD Section 8 Evaluation Research Project. She has authored and co-authored many publications in journals and proceedings. Professor Gaynor is a member of the American Statistical Association and CSWEP (Committee on the Status of Women in the Economic Profession).

Rickey C. Kirkpatrick is a graduate of Tulane University with a Ph.D. degree in economics. Currently, he is Associate Professor of Economics and Director of Special International Programs for the Broyhill Institute for Business Development in the John A. Walker College of Business at Appalachian State University. In his position as Director of the Institute, he has implemented business training programs throughout Russia and has served as a consultant to a newly established business school in Poland. He is the recipient of a National Urban League Summer Fellowship and a National Science Foundation Grant in regional science and has published in the *Review of Economics and Statistics*, *the Journal of Regional Science*, and *Public Finance Quarterly*.

PREFACE

Introduction to Time-Series Modeling and Forecasting in Business and Economics is designed to give a thorough, applied, and simple to comprehend presentation of most of the procedures useful in modeling and forecasting time series data. It is written so that a reader with only a background in basic statistics and high school algebra will have no difficulty in understanding the material. We have attempted in each chapter to present easy to read discussions of the methods with numerous graphs and worked out examples. Each modeling technique is illustrated in an example that applies the procedure to a data set. In each case, an appropriate model is employed to find the "best fit" to the data and then is used to forecast future (short term) values of the time series. We have also incorporated an ongoing case study, demonstrating the procedures discussed in each chapter. In the presentation of the case study, we also include an explanation of why or why not a certain technique can or cannot be used. Certain key words along with their definitions are highlighted in the body of the text.

As mentioned above, the book is written for a student with a limited knowledge of mathematics and statistics. Thus, it would serve well as an undergraduate textbook for any applied course in time-series modeling and forecasting. In particular, any of the disciplines found in business or the social sciences (such as economics, political science, decision science, management science) would find this text useful in their curriculum. It should also prove to be a valuable reference book for those practitioners who must model and forecast time series data in the "real world." The review of basic statistics we have included in two of the appendices will be helpful for those students/practitioners that want to refresh their memories in some of the elementary statistical procedures needed for the understanding of the present material.

At the end of each chapter, we incorporate a detailed explanation of four commonly used computer programs for modeling time-series data. These are Lotus 1-2-3, MicroTSP, Minitab, and Soritec Sampler. We include all four, not because we expect the reader to use all four, but because the probability of at least one being at his/her institution is quite high. In addition, since not all programs will accomplish all things, we hope that we will be presenting some options. Since Lotus is almost universal and Sampler is free for the asking, no

student should be without computer program availability. Furthermore, the use of Lotus as a computer program for the first six chapters is a great pedagogical tool, and we highly recommend it! The accompanying table identifies the computer applications available to the student in each of the chapters.

This book is organized into five parts; each part contains several chapters. It is designed to be covered in a one semester course; however, chapters or even a complete part may be skipped without loss of continuity.

Part I introduces the concepts of time-series analysis and demonstrates some of the most basic procedures in modeling. Included in Chapter 1 is an examination of forecasting accuracy and how it can be measured. One unique feature of Part I is Chapter 2, which explains the many techniques for describing and transforming data. Students will find this chapter a good reference source for topics and classes other than time-series analysis.

The remainder of the text, Parts II through V, leads the students into modeling and forecasting data from its simplest form (trend, irregular) to its most complex form (trend, seasonal, irregular) using Box-Jenkins and/or econometric models.

Part II contains two chapters on modeling and forecasting data containing trend and irregular components. Chapter 3 discusses the use of simple and multiple regression analysis for the modeling of linear and curvilinear trend. Using time as a predictor variable, the form, assumptions, and tests for regression are discussed. Updating regression-based trend models by using an exponential smoothing approach (simple, double, or triple) is covered in Chapter 4. In both chapters, the formulas for the construction of confidence intervals and point forecasts are presented.

Part III describes the use of decomposition techniques and Winters' exponential smoothing to model and forecast time-series described by trend, seasonal, and irregular components. In this part, we present both the additive and multiple models for fitting seasonal data. Detailed discussions as to the differences in the model, the procedures for obtaining the estimates of the components, and the point and interval forecasts are included both for the decomposition method (Chapter 5) and Winters' exponential smoothing (Chapter 6).

Part IV presents a detailed, nontheoretical discussion of the Box-Jenkins methodology for modeling nonseasonal (Chapter 7) and seasonal (Chapter 8) time-series data. The four-step procedure is explained using graphs and correlograms. The techniques (and rules of thumb) for using the behavior of the correlograms to identify a tentative model are also discussed. The diagnostic tests that are presented include the modified Box-Pierce statistic, the t-ratios for the individual parameters, the conditions of stationarity and invertibility, and the correlation matrix of the parameters. Examples that convert a forecast model back to the original data are examined.

Part V examines the use of econometric models to forecast time-series data. The assumptions, testing, and forecasting methods of a multiple regression model are discussed in Chapter 9. The techniques and tests for choosing the

best model are also presented. Many important time-series techniques, often only presented in econometric books, are presented through the use of practical examples. Chapter 10 brings together the entire process of modeling and forecasting by illustrating the technique of combining forecasting methodologies, averaging forecasts, and summarizing the different forecasting techniques presented in the book.

This textbook and the instructor's data disk are abundant with time-series data. In most cases, data are obtained from published secondary sources, which would be readily available to students in their university library. However, a particularly valuable secondary source is the Federal Reserve Economic Data (FRED) electronic bulletin board maintained by the Federal Reserve Bank of St. Louis. Reference to data obtained from this bulletin board is listed in source lines simply as the Federal Reserve Bank, St. Louis.

Many people have contributed to this book. We would especially like to thank officials of Food Lion, Inc., for providing data, students in the John A. Walker College of Business at Appalachian State University for their inspiration, Robert J. Richardson for his indexing services, and Deborah Culler for her clerical assistance in preparation of the final manuscript.

Finally, we wish to thank the following reviewers for their many helpful comments and suggestions on the manuscript: Benito E. Flores, Texas A & M University; Paul S. Foote, California State University–Fullerton; Hans Levenbach, Delphus; Ved P. Sharma, Mankato State University; and Ebenge E. Usip, Youngstown State University.

Patricia E. Gaynor
Rickey C. Kirkpatrick

Relevant Computer Applications by Chapter

	Lotus 1-2-3	MicroTSP	Minitab	Soritec
Chapter 1	×	×		×
Chapter 2	×	×	× *	× *
Chapter 3	×	×	×	×
Chapter 4	× *	×		× *
Chapter 5	×	×		×
Chapter 6	× *	×		×
Chapter 7	×	×	×	
Chapter 8	×	×	×	
Chapter 9	× *	×	×	×
Chapter 10	×	×		×

× = Complete coverage.
× * = Limited coverage.

COMPUTER SOFTWARE USED IN THIS TEXTBOOK

All output from the computer software programs presented in the appendixes of this text was generated using the latest versions of the following:

Lotus® 1-2-3® is a registered trademark of Lotus Development Corporation. It is available in a student edition.

MicroTSP™ is a registered trademark of

Quantitative Micro Software
4521 Campus Drive, Suite 336
Irvine, CA 92715
(714) 856-3368
FAX (714) 856-2044

It is available in a student edition.

MINITAB® Statistical Software (referred to in the text simply as Minitab) is a registered trademark of

Minitab Inc.
3081 Enterprise Dr.
State College, PA 16801
(814) 238-3280
FAX (814) 238-4383

It is available in a student edition.

SORITEC SAMPLER™ is a registered trademark of

The Sorites Group, Inc.
P. O. Box 2939
Springfield, VA 22152
(703) 569-1400
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The authors gratefully acknowledge their cooperation.

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