Time Series Analysis for the Social Sciences

Time series or longitudinal data are ubiquitous in the social sciences. Unfortunately, analysts often treat the time series properties of their data as a nuisance rather than as a substantively meaningful dynamic process to be modeled and interpreted. *Time Series Analysis for the Social Sciences* provides accessible, up-to-date instruction and examples of the core methods in time series econometrics. Janet M. Box-Steffensmeier, John R. Freeman, Matthew P. Hitt, and Jon C. W. Pevehouse cover a wide range of topics, including ARIMA models, time series regression, unit root diagnosis, vector autoregressive models, error correction models, intervention models, fractional integration, ARCH models, structural breaks, and forecasting. This book is aimed at researchers and graduate students who have taken at least one course in multivariate regression. Examples are drawn from several areas of social science, including political behavior, elections, international conflict, criminology, and comparative political economy.

Janet M. Box-Steffensmeier is the Vernal Riffe Professor of Political Science and Professor of Sociology at The Ohio State University (courtesy), where she is a University Distinguished Scholar and directs the Program in Statistics and Methodology (PRISM). Box-Steffensmeier served as president of the Midwest Political Science Association and the Political Methodology Society and as treasurer of the American Political Science Association. She has twice received the Gosnell Prize for the best work in political methodology, and she received the Emerging Scholar Award from the Elections, Public Opinion, and Voting Behavior Subsection of the American Political Science Association and the Career Achievement Award from the Political Methodology Society. She was an inaugural Fellow of the Society for Political Methodology. The Box-Steffensmeier Graduate Student Award, given annually by the Interuniversity Consortium for Political and Social Research (ICPSR), is named after her in recognition of her contributions to political methodology and her support of women in this field.

John R. Freeman is the John Black Johnston Distinguished Professor in the College of Liberal Arts at the University of Minnesota and a Fellow of the American Academy of Arts and Sciences. Among his honors are the Morse-Alumni, All-University, and College of Liberal Arts Distinguished Teaching awards at the University of Minnesota. Freeman is the author of *Democracy and Markets: The Politics of Mixed Economies*, which won the International Studies Association's Quincy Wright Award, and the coauthor of *Three Way Street: Strategic Reciprocity in World Politics*. Freeman also edited three volumes of *Political Analysis*. He has (co)authored numerous research articles in academic journals. Freeman's research projects have been supported by the National Science Foundation, as well as by the Bank Austria Foundation and the Austrian Ministry of Science.

Matthew P. Hitt is an assistant professor of political science at Louisiana State University. His interests include judicial politics, legislative politics, interest groups, the presidency, and quantitative methodology. His research has been published in the *American Political Science Review* and *Presidential Studies Quarterly*.

Jon C. W. Pevehouse is a professor of political science at the University of Wisconsin. His work examines the relationship between domestic and international politics. Pevehouse is the author of *Democracy from Above* (Cambridge University Press, 2005) and *While Dangers Gather* (2007). He is the coauthor, with Joshua Goldstein, of *International Relations*, the leading textbook on international politics. He is the recipient of the Karl Deutch Award, given by the International Studies Association, and has received numerous teaching awards, including the Chancellor's Distinguished Teaching Award at the University of Wisconsin. Pevehouse is also the editor of the journal *International Organization*.

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All that really belongs to us is time; even he who has nothing else has that.

Balthasar Gracian

This book is dedicated to our families, who make time so valuable.

To Mike, Andrew, Zach, Nate, and Lizzy from Jan

To Tom from John

To Jen, Theodore, Shelley, and Larry from Matt

To Jessica, Claire, Ava, and Carl from Jon

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Preface

Our work has several motivations. We think that longitudinal analysis provides infinitely more insight than does examining any one slice of time. As we show throughout the book, longitudinal analysis is essential for the study of normatively important problems such as democratic accountability and international conflict. Given the importance of dynamic analysis in answering new questions and providing new answers to old questions, we want to get more social scientists thinking in dynamic terms. Time series is one of the most useful tools for dynamic analysis, and our goal is to provide a more accessible treatment for this approach. We are also motivated by the burgeoning supply of new social science time series data. Sometimes this causes the opposite problem of too much data and figuring out how to analyze it, but that is a problem we gladly embrace. The proliferation of new social science data requires techniques that are designed to handle complexity, and time series analysis is one of the most applicable tools. The incorporation of time series analysis into standard statistical packages such as STATA and R, as well as the existence of specialized packages such as RATS and Eviews, provides an additional motivation because it enables more scholars to easily use time series in their work.

We have found over our years of teaching time series that, although many social science students have the brain power to learn time series methods, they often lack the training and motivation to use the most well-known books on the topic. We specifically wanted to write an accessible book for social scientists so that they too could leverage the power of time series analysis from the introductory material to current innovations. That said, we are not able to offer complete coverage. We do not address dynamic panel data analysis, Bayesian time series analysis, spectral analysis, or the event history approach to temporal data. We hope the foundation and discussion of recent advances we do provide result in a useful reference book for scholars.

Chapter 1 provides an intuitive motivation for the study of time series and social dynamics. Important issues such as measurement, fit and scale, and structural change are introduced here. Chapter 2 focuses on univariate models, which are important because we argue that understanding the nature of the data-generating process should be the first step in the data analysis process. Chapter 3 provides a discussion of conventional time series regression methods, in particular the workhorse model in which a single lag of the endogenous variable is included on the right side of a single regression equation. In contrast, Chapter 4 explores the specification, estimation, and interpretation of familiar multiequation regression models with strong restrictions, simultaneous structural equation models, and also weakly restricted multiequation dynamic models – vector autoregressions – that allow uncertainty about the specification. The chapter highlights the differences between the approaches. Chapter 5 introduces the concept of stationarity and discusses its methodological and substantive importance. Chapter 6 discusses cointegration, which is a cornerstone of current time series analysis. Cointegration is especially useful for studying equilibrium relationships. Chapter 7 concludes with discussions of four critical concepts in current time series analysis: fractional integration, heterogeneity, unknown structural break(s), and forecasting. The Appendix covers difference equations. This is a foundational concept needed for understanding the mathematical foundation of common time series approaches, such as vector autoregression. Although readers interested in directly estimating models without mathematical preliminaries may skip the Appendix, we strongly encourage readers interested in working in time series methodology to read it closely.

We have had the privilege of team-teaching time series together for about 15 years. John, an award-winning teacher (we think he has won every teaching award possible), graciously offered to team-teach with Jan; this was made possible by the innovation pioneered by Phil Shively and Pete Nardulli, the cross-campus interactive television (I.T.V.) program. We welcomed Jon to the team shortly after he finished graduate school. Indeed, he had been a student in the first iteration of the course, and later, while still in graduate school, he wrapped up a time series course for Jan when her third child was seriously ill. Team-teaching time series for the three of us is a biennial occurrence that does not come frequently enough for us, but is thoroughly enjoyed each time the occasion arises. Matt Hitt was a student in the course who later became a valuable collaborator who pushed the book to completion.

We have a long list of thank you's to our home departments, the I.T.V. program, and our many students. Brandon Bartels, Quintin Beazer, Patrick Brandt, Harold Clarke, Dave Darmofal, Suzie DeBoef, Charles Franklin, Jeff Gill, Tobin Grant, Agnar Helgason, Mel Hinich, Tana Johnson, Ben Jones, Luke Keele, Paul Kellstedt, Matt Lebo, Tse-Min Lin, Eleonora Mattiacci, Sara Mitchell, Jason Morgan, Dave Ohls, Heather Ondercin, Erica Owen, Dave

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