Preface

This book is intended to serve several needs. First (and perhaps foremost), it is supposed to be an introduction to mathematical principles for incoming social science graduate students. For this reason, there is a large set of examples (83 of them, at last count) drawn from various literatures including sociology, political science, anthropology, psychology, public policy, communications, and geography. Almost no example is produced from "hypothetical data." This approach is intended not only to motivate specific mathematical principles and practices, but also to introduce the *way* that social science researchers use these tools. With this approach the topics presumably retain needed relevance.

The design of the book is such that this endeavor can be a semester-long adjunct to another topic like data analysis or it can support the prefresher "math-camp" approach that is becoming increasingly popular. Second, this book can also serve as a single reference work where multiple books would ordinarily be needed. To support this function there is extensive indexing and referencing designed to make it easy to find topics. Also in support of this purpose, there are some topics that may not be suitable for course work that are deliberately included for this purpose (i.e., things like calculus on trigonometric functions and advanced linear algebra topics). Third, the format is purposely made con-

ducive to self-study. Many of us missed or have forgotten various mathematical topics and then find we need them later.

The main purpose of the proposed work is to address an educational deficiency in the social and behavioral sciences. The undergraduate curriculum in the social sciences tends to underemphasize mathematical topics that are then required by students at the graduate level. This leads to some discomfort whereby incoming graduate students are often unprepared for and uncomfortable with the necessary mathematical level of research in these fields. As a result, the methodological training of graduate students increasingly often begins with intense "prequel" seminars wherein basic mathematical principles are taught in short (generally week-long) programs just before beginning the regular first-year course work. Usually these courses are taught from the instructor's notes, selected chapters from textbooks, or assembled sets of monographs or books. There is currently no *tailored* book-length work that specifically addresses the mathematical topics of these programs. This work fills this need by providing a comprehensive introduction to the mathematical principles needed by modern research social scientists. The material introduces basic mathematical principles necessary to do analytical work in the social sciences, starting from first principles, but without unnecessary complexity. The core purpose is to present fundamental notions in standard notation and standard language with a clear, unified framework throughout

Although there is an extensive literature on mathematical and statistical methods in the social sciences, there is also a dearth of introduction to the underlying *language* used in these works, exacerbating the fact that many students in social science graduate programs enter with an undergraduate education that contains no regularized exposure to the mathematics they will need to succeed in graduate school.

Actually, the book *is itself* a prerequisite, so for obvious reasons the prerequisites to this prerequisite are minimal. The only required material is knowledge of high school algebra and geometry. Most target students will have had very little

mathematical training beyond this modest level. Furthermore, the first chapter is sufficiently basic that readers who are comfortable with only arithmetic operations on symbolic quantities will be able to work through the material. No prior knowledge of statistics, probability, or nonscalar representations will be required. The intended emphasis is on a conceptual understanding of key principles and in their subsequent application through examples and exercises. No proofs or detailed derivations will be provided.

The book has two general divisions reflecting a core component along with associated topics. The first section comprises six chapters and is focused on basic mathematical tools, matrix algebra, and calculus. The topics are all essential, deterministic, mathematical principles. The primary goal of this section is to establish the mathematical language used in formal theory and mathematical analysis, as practiced in the social sciences. The second section, consisting of three chapters, is designed to give the background required to proceed in standard empirical quantitative analysis courses such as social science statistics and mathematical analysis for formal theory.

Although structure differs somewhat by chapter, there is a general format followed within each. There is motivation given for the material, followed by a detailed exposition of the concepts. The concepts are illustrated with examples that social scientists care about and can relate to. This last point is not trivial. A great many books in these areas center on engineering and biology examples, and the result is often reduced reader interest and perceived applicability in the social sciences. Therefore, every example is taken from the social and behavioral sciences. Finally, each chapter has a set of exercises designed to reinforce the primary concepts.

There are different ways to teach from this book. The obvious way is to cover the first six chapters sequentially, although aspects of the first two chapters may be skipped for a suitably prepared audience. Chapter 2 focuses on trigonometry, and this may not be needed for some programs. The topics in Chapters 7, 8, and 9 essentially constitute a "pre-statistics" course for social science graduate

students. This may or may not be useful for specific purposes. The last chapter on Markov chains addresses a topic that has become increasingly important. This tool is used extensively in both mathematical modeling and Bayesian statistics. In addition, this chapter is a useful way to practice and reinforce the matrix algebra principles covered in Chapters 3 and 4. This book can also be used in a "just in time" way whereby a course on mathematical modeling or statistics proceeds until certain topics in matrix algebra, calculus, or random variables are needed.

As noted, one intended use of this book is through a "math-camp" approach where incoming graduate students are given a pre-semester intensive introduction to the mathematical methods required for their forthcoming study. This is pretty standard in economics and is increasingly done in political science, sociology, and other fields. For this purpose, I recommend one of two possible abbreviated tracks through the material:

Three-Day Program

- Chapter 1: The Basics.
- Chapter 3: Linear Algebra: Vectors, Matrices, and Operations.
- Chapter 5: Elementary Scalar Calculus.

Five-Day Program

- Chapter 1: The Basics.
- Chapter 3: Linear Algebra: Vectors, Matrices, and Operations.
- Chapter 5: Elementary Scalar Calculus.
- Chapter 7: Probability Theory.
- Chapter 8: Random Variables.

The five-day program focuses on a pre-statistics curriculum after the introductory mathematics. If this is not appropriate or desired, then the continuation chapters on linear algebra and calculus (Chapters 4 and 6) can be substituted for

the latter two chapters. Conversely, a lighter pre-statistics approach that does not need to focus on theory involving calculus might look like the following:

Standard Pre-Statistics Program

- Chapter 1: The Basics.
- Chapter 3: Linear Algebra: Vectors, Matrices, and Operations.
- Chapter 7: Probability Theory.
- Chapter 8: Random Variables.

This program omits Chapter 5 from the previous listing but sets students up for such standard regression texts as Hanushek and Jackson (1977), Gujarati (1995), Neter et al. (1996), Fox (1997), or the forthcoming text in this series by Schneider and Jacoby. For an even "lighter" version of this program, parts of Chapter 3 could be omitted.

Each chapter is accompanied by a set of exercises. Some of these are purely mechanical and some are drawn from various social science publications. The latter are designed to provide practice and also to show the relevance of the pertinent material. Instructors will certainly want to tailor assignments rather than require the bulk of these problems. In addition, there is an instructor's manual containing answers to the exercises available from Cambridge University Press.

It is a cliche to say, but this book was not created in a vacuum and numerous people read, perused, commented on, criticized, railed at, and even taught from the manuscript. These include Attic Access, Mike Alvarez, Maggie Bakhos, Ryan Bakker, Neal Beck, Scott Desposato, James Fowler, Jason Gainous, Scott Gartner, Hank Heitowit, Bob Huckfeldt, Bob Jackman, Marion Jagodka, Renee Johnson, Cindy Kam, Paul Kellstedt, Gary King, Jane Li, Michael Martinez, Ryan T. Moore, Will Moore, Elise Oranges, Bill Reed, Marc Rosenblum, Johny Sebastian, Will Terry, Les Thiele, Shawn Treier, Kevin Wagner, Mike Ward, and Guy Whitten. I apologize to anyone inadvertently left off this list. In particular, I thank Ed Parsons for his continued assistance and patience in helping get this project done. I have also enjoyed the continued support of various chairs,

deans, and colleagues at the University of California–Davis, the ICPSR Summer Program at the University of Michigan, and at Harvard University. Any errors that may remain, despite this outstanding support network, are entirely the fault of the author. Please feel free to contact me with comments, complaints, omissions, general errata, or even praise (`jgill@ucdavis.edu`).