

Preface

In many applications of statistics, a large proportion of the questions of interest are fundamentally questions of causality rather than simply questions of description or association. For example, a medical researcher may wish to find out whether a new drug is effective against a disease. An economist may be interested in uncovering the effects of a job-training program on an individual's employment prospects, or the effects of a new tax or regulation on economic activity. A sociologist may be concerned about the effects of divorce on children's subsequent education. In this text we discuss statistical methods for studying such questions.

The book arose out of a conversation we had in 1992 while we were both on the faculty at Harvard University. We found that although we were both interested in questions of causality, we had difficulty communicating our ideas because, coming from different disciplines, we were used to different terminology and conventions. However, the excitement about the ideas in these different areas motivated us to capitalize on these difficulties, which led to a long collaboration, including research projects, graduate and undergraduate teaching, and thesis advising. The book is a reflection of this collaboration.

The book is based directly on many semester and quarter-length courses we, initially jointly, and later separately, taught for a number of years, starting in 1995 at Harvard University, followed by the University of California at Los Angeles, the University of California at Berkeley, and Stanford University, to audiences of graduate and undergraduate students from statistics, economics, business, and other disciplines using applied statistics. In addition, we have taught shorter versions of such courses in Barcelona, Beijing, Berlin, Bern, Geneva, Maastricht, Mexico City, Miami, Montevideo, Santiago, Stockholm, Uppsala, Wuppertal, Zurich, and at the World Bank as well as other associations and agencies.

There are a number of key features of the approach taken in this book. First of all, the perspective we take is that all causal questions are tied to specific interventions or treatments. Second, causal questions are viewed as comparisons of potential outcomes, with each potential outcome corresponding to a level of the treatment. Each of these potential outcomes could have been observed had the treatment taken on the corresponding level. After the treatment has taken on a specific level, only the potential

outcome corresponding to that level is realized and can actually be observed. Causal effects involve the comparison of the outcome actually observed with other potential outcomes that could have been observed had the treatment taken on a different level, but that are not, in fact, observed. Causal inference is therefore fundamentally a missing data problem and, as in all missing data problems, a key role is played by the mechanism that determines which data values are observed and which are missing. In causal inference, this mechanism is referred to as the assignment mechanism, the mechanism that determines levels of the treatment taken by the units studied.

The book is organized in seven parts. In the first part we set out the basic philosophy underlying our approach to causal inference and describe the potential outcomes framework. The next three parts of the book are distinguished by the assumptions maintained about the assignment mechanism. In Part II we assume that the assignment mechanism corresponds to a classical randomized experiment.

In Part III we assume that the assignment mechanism is “regular” in a well-defined sense, which generalizes randomized experiments. In this part of the book we discuss what we call the “design” phase of an observational study, which we view as extremely important for credible conclusions. In the next part, Part IV, we discuss data analysis for studies with regular assignment mechanisms. Here we consider matching and subclassification procedures, as well as model-based and weighting methods.

In Part V we relax this regularity assumption and discuss more general assignment mechanisms. First we assess the key assumption required for regularity, unconfoundedness. We also explore in this part of the text sensitivity analyses where we relax some of the key features of a regular assignment mechanism.

Next, in Part VI of the text, we consider settings where the assignment mechanism is regular, but compliance with the assignment is imperfect. As a result, the probability of receipt of treatment may depend on both observed and unobserved characteristics and outcomes of the units. To address these complications, we turn to instrumental variables methods. Part VII of the book concludes.

As with all books, ours has limitations. Foremost is our focus on binary treatments. Although many of the results can easily be extended to multi-valued treatments, we focus on the binary treatment case because many critical conceptual issues arise already in that setting. Second, throughout most of the book we make the “stability” assumption that treatments applied to one unit do not affect outcomes for other units and that there are no unrepresented versions of the treatments. There is a growing literature on interactions through networks and peer effects that builds on the notions of causality discussed in this book. Finally, although we designed the book to be theoretically tight and principled, we focus on practical rather than mathematical results, including detailed applications with real data sets, consistent with our target audience of researchers in applied fields.

ACKNOWLEDGMENTS

We are deeply indebted to many collaborators, colleagues, and students from whom we have learned much about the topics discussed in this book over the years. These include Alberto Abadie, Nikola Andric, Joshua Angrist, Susan Athey, Thomas Barrios, David Card, Matias Cattaneo, Gary Chamberlain, Raj Chetty, Rajeev Dehejia, Mike Dickstein,

Peng Ding, David Drukker, Dean Eckles, Valeria Espinosa, Avi Feller, Sergio Firpo, Andrew Gelman, Paul Gift, Paul Goldsmith-Pinkham, Bryan Graham, Roee Gutman, Gary Harvey, Jane Herr, Kei Hirano, Nate Holt, Joe Hotz, Wilbert van der Klaauw, Jacob Klerman, Alan Krueger, Tony Lancaster, Joseph Lee, Victoria Liublinska, Chuck Manski, Eric Maskin, Fabrizia Mealli, Kari Lock Morgan, Eduardo Morales, Julie Mortimer, Eleanor Murray, Whitney Newey, Cassandra Wolos Pattanayak, Jack Porter, Geert Ridder, Paul Rosenbaum, Bruce Sacerdote, Hal Stern, Elizabeth Stuart, Neal Thomas, Sadek Wahba, David Watson, Jeff Wooldridge, Alan Zaslavsky, and Elizabeth Zell.

We are grateful for stimulating discussions over the years with David Freedman, Sander Greenland, James Heckman, Nick Jewell, Mark van der Laan, Judea Pearl, Jamie Robins, Jasjeet Sekhon, Jeffrey Smith, and Edward Vytlačil.

We are also grateful to Joshua Angrist, David Card, Raj Chetty, Rajeev Dehejia, Esther Duflo, Brad Efron, Alan Krueger, Robert Lalonde, June Reinisch, Bruce Sacerdote, Sadek Wahba, and Scott Zeger for making their data available.

Finally, we would like to extend our gratitude to Dean Eckles and Karthik Rajkumar for comments on the first edition, and to Michael Pollman for a remarkably thorough check for errors and typos.

