

Managerial Statistics



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Managerial Statistics

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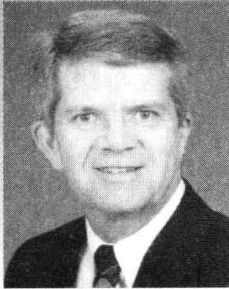


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About the Authors



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Chris Albright got his B.S. degree in Mathematics from Stanford in 1968 and his Ph.D. in Operations Research from Stanford in 1972. Since then he has been teaching in the Operations & Decision Technologies Department in the Kelley School of Business at Indiana University. He has taught courses in management science, computer simulation, and statistics to all levels of business students: undergraduates, MBAs, and doctoral students. In addition, he has recently taught simulation modeling at General Motors and Whirlpool. He has published over 20 articles in leading operations research journals in the area of applied probability, and he has authored the books *Statistics for Business and Economics*, *Student Execustat 3.0 MiniGuide*, and the spreadsheet-based *Practical Management Science* and *Data Analysis and Decision Making*. He is also currently working with the Palisade Corporation on a statistical software package. His current interests are in spreadsheet modeling and the development of VBA applications in Excel and Access.

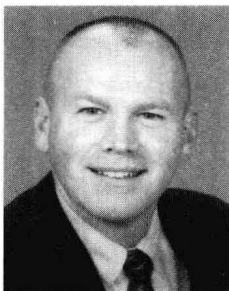
On the personal side, Chris has been married for 28 years to his wonderful wife, Mary, who has somehow endured teaching 7th graders all of that time. They have one son, Sam, who is currently working in New York City in the music business and is playing saxophone with a rock band on the side. Chris has many interests outside the academic area. They include activities with his family (especially traveling with Mary), going to cultural events at Indiana University, playing golf and tennis, running and power walking, and reading. And although he earns his livelihood from statistics and management science, his *real* passion is for playing the piano and listening to classical music.



Wayne Winston

Wayne L. Winston is Professor of Operations & Decision Technologies in the Kelley School of Business at Indiana University, where he has taught since 1975. Wayne received his B.S. degree in mathematics from MIT and his Ph.D. degree in operations research from Yale. He has written the successful textbooks *Operations Research: Applications and Algorithms*, *Mathematical Programming: Applications and Algorithms*, *Simulation Modeling with @RISK*, *Practical Management Science*, and *Financial Models Using Simulation and Optimization*. Wayne has published over 20 articles in leading journals and has won many teaching awards, including the schoolwide MBA award four times. He has taught classes at Microsoft, GM, Ford, Eli Lilly, Bristol-Myers Squibb, Arthur Andersen, Roche, PriceWaterhouseCoopers, and NCR. His current interest is in showing how spreadsheet models can be used to solve business problems in all disciplines, particularly in finance and marketing.

Wayne enjoys swimming and basketball, and his passion for trivia won him an appearance several years ago on the television game show *Jeopardy*, where he won two games. He is married to the lovely and talented Vivian. They have two children, Gregory and Jennifer.



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Chris earned his B.A. in mathematics from DePauw University in 1983 and his M.B.A. and Ph.D. in decision sciences from Indiana University in 1987 and 1988, respectively. Between 1988 and 1993, he performed research and taught various courses in the decision sciences area at the University of Florida in the College of Business Administration. Since 1993, Chris has been serving as an associate professor in the Department of Management at Bucknell University, where he teaches undergraduate courses in business statistics, decision analysis, and computer simulation. Currently, Chris is a visiting faculty member in the Operations and Decision Technologies Department of the Kelley School of Business at Indiana University in Bloomington. He is primarily teaching spreadsheet modeling to students in IU's MBA program. He has published articles in various journals including *Managerial and Decision Economics*, *OMEGA*, *Naval Research Logistics*, and *Interfaces*. His current scholarly interests focus on mathematical programming models of performance appraisal processes and innovative pedagogies in operations research/management science.

Chris has been married to his wonderful wife, Jeannie, for nearly five years now. In addition to playing with his son, Matthew, Chris enjoys traveling with his wife, studying cryptography, reading great books of history, and watching Major League Baseball and college basketball games. Finally, Chris has been serving on the faculty of the Institute for Leadership in Technology and Management at Bucknell University for the past four years.

To my main supporters: *Mary, Sam, Tami, Ruth, and, of course, Charlie. And to Sam Senior, who is up there watching it all.*
S.C.A.

To my wonderful family: *Vivian, Jennifer, Gregory*
W.L.W.

To my wonderful family: *Jeannie and Matthew*
C.J.Z.

Preface

The computer and its associated technologies have forever changed business as we know it. Companies today are able to *collect* tremendous amounts of data with relative ease. Often they have more data than they know what to do with. However, the data are usually meaningless until they are analyzed for trends, patterns, relationships, and other useful *information*. *Managerial Statistics* illustrates in a practical way a variety of statistical methods, from simple to complex, to help you analyze data sets and uncover important information. In many business contexts, data analysis is only the first step in the solution of a problem. Acting on the data analysis and the information it provides to make good decisions is a critical next step. Throughout this book, therefore, we emphasize data analysis in the context of decision making.

We take a very practical approach to teaching this material. We recognize that the vast majority of students in this type of course are *not* majoring in a quantitative area. They are typically *business* majors in finance, marketing, operations management, or some other business or economics discipline who will need to analyze data and make quantitative-based decisions in their jobs. These students are not likely to learn, remember, or use material that is oriented primarily toward theory or formula-based calculations. In contrast, we offer a hands-on, example-based approach (using real examples) that provides value students will appreciate. Our vehicle is spreadsheet software, something with which most students are already familiar and will undoubtedly use in their careers. Our MBA students at Indiana University are so turned on by the required course that is based on the approach in this book that *well over 50%* of them (mostly finance and marketing majors) take our follow-up *elective* course in spreadsheet modeling (a management science course). We believe that students see value in statistical methods for data analysis when the course is taught with a practical and example-based approach.

Rationale for Writing This Book

Managerial Statistics is different from the many fine statistics textbooks on the market. Our rationale for writing this book is based on two fundamental objectives.

- 1 We want the emphasis to be placed on *realistic business examples* and the process by which a manager might analyze a problem—not on abstract theory or computational methods.
- 2 We want to provide students with skills and tools that will enable them to make an *immediate* impact in their chosen careers and will have lasting benefits throughout their careers. To this end, we have adopted Excel and spreadsheet add-ins.

Example-Based

Taking a cue from our *Practical Management Science* and *Data Analysis and Decision Making* books, we wanted this book to be very example-based. We strongly believe that students learn best by working through examples, and they appreciate the material most when the examples are interesting and realistic business examples. Therefore, our approach in this book differs from many traditional statistics textbooks in two important ways. First, there is very little up-front discussion of the “theory” behind the methods. There is some, but just enough to give students an appreciation for the issues raised in the examples. This does not mean that we have thrown fundamental concepts out the window. We certainly have *not*. However, we often introduce important concepts (such as multicollinearity in regression) in

the context of examples, rather than discussing them in the abstract. Our experience is that students gain greater intuition and understanding of the concepts and applications through this approach. It also reinforces their problem-solving and logical skills.

Second, we place virtually no emphasis on hand (or hand calculator) calculations. We believe it is more important for students to understand why they are conducting an analysis and how to interpret statistical output than to grind through the tedious calculations associated with many statistical techniques. Therefore, we illustrate how good software can be used to create graphical and numerical outputs in a matter of seconds, freeing the rest of the time for in-depth interpretation of the output, sensitivity analysis (whenever appropriate), and alternative modeling approaches. Statistics is already a difficult topic for the majority of students, and we see no reason to make it *more* difficult—and less appealing—by making the students memorize complex formulas and perform tedious calculations. In our own courses, we move directly into a discussion of examples, where we focus almost exclusively on interpretation and modeling issues, and we let the computer software perform the number crunching.

Spreadsheet-Based

We are also strongly committed to teaching spreadsheet-based, example-driven courses, regardless of whether the basic area is statistics or management science. We have found tremendous enthusiasm for this approach, from students, faculty, and professionals around the world who have used our books. The students learn (and remember) more, and they *appreciate* the material more. The instructors typically enjoy teaching more, and they usually receive immediate reinforcement through better teaching evaluations.

In writing *Managerial Statistics*, we have had to retool ourselves for the move from non-spreadsheet statistics packages (Minitab, SPSS, JMP, Statgraphics, and so on) to Excel. This was a difficult move, due to the lack of inherent statistical capabilities of Excel. However, as we describe below, we have addressed this problem by including the necessary tools to make the transition fairly easy—and fun.

What We Hope to Accomplish in This Book

Condensing the ideas in the above paragraphs, we hope to:

- Reverse negative student attitudes about statistics by making the subject real, accessible, and interesting;
- Give students lots of hands-on experience with real problems and challenge them to develop their intuition, logic, and problem-solving skills;
- Expose students to real problems in many business disciplines and show them how these problems can be analyzed with statistical methods and interpreted meaningfully;
- Develop spreadsheet skills, including experience with powerful spreadsheet add-ins, that add immediate value in other courses and in the workplace.

Software

This book is based entirely on Microsoft Excel, the spreadsheet package that has become the standard analytical tool in business. Excel is an extremely powerful package, and one of our goals is to convert casual users into *power* users who can take full advantage of its features. If we accomplish no more than this, we will be imparting a valuable skill for the business world. However, Excel has many limitations when it comes to statistics. Therefore, this book includes powerful statistical add-ins that greatly enhance Excel's capabilities.

When we began teaching this course in Excel, it quickly became obvious that Excel's inherent statistical capabilities were limited. There are several functions such as AVERAGE and STDEV that perform simple statistical calculations, and there is an Analysis Tool-Pak that is included with Excel for performing more complex statistical tasks. However, we have found these inherent capabilities of Excel to be lacking in power and convenience. Therefore, we include the Excel add-in, StatPro™, that accompanies this book. We think you will find it to be quite powerful and extremely easy to use. StatPro does not attempt to do what Excel already does well (pivot tables, for example), but it performs most statistical analyses, even those as complex as stepwise regression, logistic regression, and discriminant analysis, in a matter of seconds. (To see a summary of its capabilities, online help is available from the StatPro menu once the add-in has been installed.) If you have been using Excel's built-in Analysis ToolPak, we think you will be very pleasantly surprised with the functionality of StatPro. Our students master it in no time at all.

A subset of StatPro, RandFns, is also included and can be used separately. RandFns is a collection of functions for simulating random numbers from a variety of probability distributions, including the common distributions (normal, binomial, uniform, and so on) and some not so common (multivariate normal and multinomial, for example).

Together with Excel, StatPro and RandFns provide a tremendous amount of power for performing statistical analysis. They are easy to learn, and students will be able to carry their knowledge of these tools directly into the workplace. Excel and its add-ins show no signs of losing their prominent place in business in the foreseeable future.

In addition to these add-ins, we also include a special version of Decision Tools™ Suite by Palisade Corporation. Decision Tools contains several add-ins (@Risk, PrecisionTree, BestFit) to aid in simulation and decision making. These tools will be introduced in Chapter 5 (Probability and Probability Distributions) and Chapter 7 (Decision Making Under Uncertainty).

Finally, we include a Web Connectivity Kit (actually a free download from Microsoft's Web site), which is used in Chapter 4 to develop Web queries for data sets that reside on the Web.

Unique Coverage for Practical Purposes

As stated earlier, we want *Managerial Statistics* to serve as a useful learning resource for students in their future coursework and in their future careers. In teaching our classes and in learning more about the application of statistics in business, we have found the “standard” set of topics incomplete for our students’ needs. For this reason, *Managerial Statistics* contains several unique content features not found in standard Business and Economics Statistics textbooks.

- We discuss pivot tables in Chapters 2 and 3. We have found in our own teaching to industry that pivot tables are considered one of Excel’s most valuable tools for analyzing real data sets. They allow users to “slice and dice” a data set to uncover useful descriptive information.
- Chapter 4 shows how to get the *right* data into Excel, either by cleaning “bad” data or by querying data from various sources: an Excel list, an external

database package such as Access, or even the Web. Although we acknowledge the importance of conducting surveys to obtain *new* data, we believe it is very important to be able to import *existing* data from various external sources into Excel, so that Excel’s powerful tools can be used for analysis. We position this chapter early in the book and believe that many instructors will welcome its addition.

- We integrate simulation in several chapters to make probability and statistics more intuitive. We have found that many students learn much more about these topics through simulation than through theoretical discussions alone.
- To indicate that probability distributions do not just come out of thin air, we introduce the idea of fitting probability distributions to historical data (using BestFit) in Chapter 6.
- Chapter 7 covers decision making under uncertainty. Although we find this topic valuable, there is no “natural” place to put it in a statistics book, and we recognize that some instructors may choose to skip it in the interest of time. We have designed this chapter in a modular fashion so that it can be skipped entirely or can be covered “out of sequence” wherever instructors believe it fits best.
- Chapter 12 provides a practical introduction to ANOVA and experimental design, topics that are becoming increasingly important in business. In particular, this chapter goes beyond the coverage of many introductory textbooks by including a discussion of the multiple comparison problem, two-way ANOVA, the technique of blocking, and the concept behind incomplete factorial designs.
- Chapter 15 introduces discriminant analysis and logistic regression. These are more advanced topics that some instructors might not want to cover (or have time to cover), but we have tried to make them as user-friendly as possible, primarily by adding the software to perform the tedious calculations. We have also attempted, by means of appropriate examples, to show why they are important tools in business. For example, we discuss how a company can discover the characteristics of customers who buy its product versus those who do not buy it.
- Chapter 17 is a short chapter on statistical report writing. In our own classes, we use both written and oral reports as an effective means of bringing the statistical concepts together. Although this chapter lists a number of commonsense ideas for writing good reports (and delivering good oral

presentations), we find that students often violate this commonsense advice. Therefore, we believe this chapter will be useful to build and reinforce good habits in statistical reporting.

Managerial Statistics vs. Data Analysis and Decision Making

Readers who have seen our *Data Analysis and Decision Making* book might wonder what distinguishes that book from *Managerial Statistics*. In terms of level and approach, they are the same. The difference is in the topics covered. The earlier book was written to appeal to the growing number of programs that require a “hybrid” quantitative methods course (including statistics, optimization, decision making under uncertainty, and simulation) in the curriculum. *Managerial Statistics* contains a more conventional Business Statistics organization in that it concentrates entirely on *statistical* methods. More specifically, *Managerial Statistics* does not have chapters on optimization (linear, integer, or nonlinear programming) or simulation (although simulation is used in several chapters in *Managerial Statistics* to illustrate statistical concepts) that appear in *Data Analysis and Decision Making*. In the other direction, *Managerial Statistics* contains four chapters (Getting the Right Data in Excel, ANOVA and Experimental Design, Discriminant Analysis and Logistic Regression, and Statistical Reporting) that are not included in *Data Analysis and Decision Making*.

Possible Sequences of Topics

Although this book can certainly be used for a one-semester course, there is enough material for a two-semester course. We have tried to make the book as modular as possible. However, due to the natural progression of statistical topics, the basic topics in the early chapters should be covered before the more advanced topics (regression, time series analysis, statistical process control, ANOVA, discriminant analysis, and logistic regression) in the later chapters. With this in mind, here are several possible ways to cover the topics.

- *A one-semester required course with no statistics prerequisite* (or where MBA students have forgotten whatever statistics they might have learned years ago).

Here we recommend covering Chapters 2–6 (summarizing data and probability distributions) and Chapters 8–10 (sampling distributions and statistical inference). Depending on the time remaining and the objectives of the course, it is then possible to choose between Chapter 7 (decision making under uncertainty), Chapter 11 (statistical process control), Chapter 12 (ANOVA), Chapters 13 and 14 (regression analysis), Chapter 15 (discriminant analysis and logistic regression), and Chapter 16 (forecasting). Except for the fact that regression should precede Chapters 15 and 16, these topics can be covered in any order.

- *A one-semester required course with a statistics prerequisite.*

Assuming that students know the basic elements of statistics (up through hypothesis testing, say), the material in Chapters 2–6 and 8–10 can be reviewed *quickly*, primarily to illustrate how Excel and add-ins can be used to advantage. (Still, the material in Chapter 4 on cleaning data and querying databases is probably new and, if it is covered at all, it should not be covered too quickly.) Then the instructor can choose between any of the topics in Chapters 7, 11, 12–13, 14, 15, or 16 (in practically any order, as explained in the previous paragraph) to fill up the remainder of the course.

- *A two-semester required sequence.*

Given the luxury of spreading the topics over two semesters, the entire book can be covered. The same comments about the ordering of topics discussed above apply here as well.

Ancillaries

The CD-ROM that accompanies each new copy of the book contains:

- The Excel add-ins from Palisade Corporation, including StatPro and DecisionTools Suite described above
- Excel files (usually data only—not the analyses) for examples in the chapters
- Data files required for the problems and cases

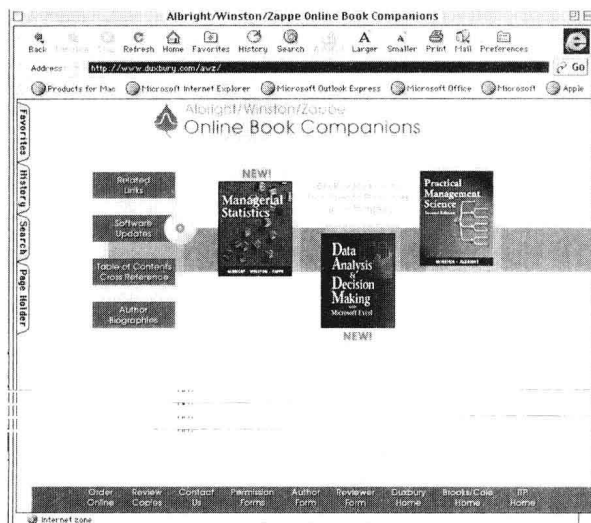
- A file EXCELTUTORIAL.XLS that contains a very useful tutorial in the basic elements of Excel
- A file INSTALL.HTM that contains instructions for installing the add-ins
- A file WEBCNKIT.EXE (a free download from Microsoft's Web site) that contains instructions for creating Web queries

In addition, adopting instructors may obtain the *Instructors Suite for Microsoft Office* CD-ROM that includes:

- Solution files (in Excel format) for all of the problems and cases in the book
- PowerPoint presentation files for all of the examples in the book
- Completed Excel files for all of the examples in the book

Finally, adopting instructors will have access to the following:

- The AWZ (authors' initials) Web Resource Center that includes software updates, errata, additional problems and solutions, and additional resources for both students and faculty (accessible through www.duxbury.com by selecting Online Book Companions)



- A Test Bank and the Thomson Learning Testing
- A Study Guide for students

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There are more people who helped to produce this book than we can list here. However, there are a few special people whom we were happy (and lucky) to have on our team. To make a book with this many details look good on the page and be (relatively) free of errors requires meticulous compositors. We thank Peter Vacek and William Baxter for suffering through occasional corrupted graphics files, last-minute changes, and other headaches to produce a fine-looking product. There may be a few remaining errors, but they are certainly not the fault of our production coordinator, Susan Reiland. Susan is a perfectionist, and her influence clearly shows throughout the book. Not only did she capture the typos, but she also helped us improve our writing styles immeasurably. If you want to learn how to write well, write a book with Susan! The driving force behind this project from day one has been our editor, Curt Hinrichs. There were nights and weekends when we were in no mood to thank Curt, but even when he pushed us to our limits, we knew that he was one hundred percent behind us. No author can ask for more than an editor who knows the market and really cares about a project. We got that consistently from Curt. Any success this book has in the market is due largely to his efforts.

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book a success: Karin Sandberg, Marketing Manager; Janet Hill, Production Editor; Seema Atwal, Assistant Editor; and Sarah Kaminskis, Editorial Assistant.

Finally, we'd like to make one plug. There is a lot of software out there, but seldom does a package deliver exactly what a user needs. An exception is the HyperSnap screen capture shareware package developed by Greg Kochaniak (www.hyperionics.com). We

don't know Greg personally, but we thank him for his excellent program. It helped make our lives *so* much easier!

*S. Christian Albright
Wayne L. Winston
Christopher J. Zappe*

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