WILEY SERIES IN PROBABILITY AND STATISTICS

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In preparation for the third edition, we sent an electronic mail questionnaire to every statistics department in the United States with a graduate program. We wanted modal opinion on what statistical procedures should be addressed in a statistical methods course in the twenty-first century. Our findings can readily be summarized as a seeming contradiction. The course has changed little since R. A. Fisher published the inaugural text in 1925, but it also has changed greatly since then. The goals, procedures, and statistical inference needed for good research remain unchanged, but the nearly universal availability of personal computers and statistical computing application packages make it possible, almost daily, to do more than ever before. The role of the computer in teaching statistical methods is a problem Fisher never had to face, but today’s instructor must face it, fortunately without having to make an all-or-none choice.

We have always promised to avoid the black-box concept of computer analysis by showing the actual arithmetic performed in each analysis, and we remain true to that promise. However, except for some simple computations, with every example of a statistical procedure in which we demonstrate the arithmetic, we also give the results of a computer analysis of the same data. For easy comparison we often locate them near each other, but in some instances we find it better to have a separate section for computer analysis. Because of greater familiarity with them, we have chosen the SAS® and JMP®, computer applications developed by the SAS Institute.¹ SAS was initially written for use on large main frame computers, but has been adapted for personal computers. JMP was designed for personal computers, and we find it more interactive than SAS. It is also more visually oriented, with graphics presented in the output before any numerical values are given. But because SAS seems to remain the computer application of choice, we present it more frequently than JMP.

Two additions to the text are due to responses to our survey. In the preface to the first edition, we stated our preference for discussing probability only when it is needed to explain some aspect of statistical analysis, but many respondents felt a course in statistical methods needs a formal discussion of probability. We have attempted to “have it both ways” by including a very short presentation of probability in the first chapter, but continuing to discuss it as needed. Another frequent response was the idea that a statistical analysis course now should include some minimal discussion of logistic regression. This caused us almost to surrender to black-box instruction. It is fairly easy to understand the results of a computer analysis of logistic regression, but many of our students have a mathematical background a bit shy of that needed for performing logistic regression analysis. Thus we discuss it, with a worked example, in the last section to make it available for those with the necessary

¹SAS and JMP are registered trademarks of SAS Institute Inc., Cary, NC, USA.
mathematical background, but to avoid alarming other students who might see the mathematics and feel they recognize themselves in Stevie Smith's poem:

Nobody heard him, the dead man,
But still he lay moaning:
I was much further out than you thought
And not waving but drowning.

Consulting with research workers at West Virginia University has caused us to add some topics not found in earlier editions. Many of our examples and exercises reflect actual research problems for which we provided the statistical analysis. That has not changed, but the research areas that seek our help have become more global. In earlier years we assisted agricultural, biological, and behavioral scientists who can design prospective studies, and in our text we tried to meet the needs of their students. After helping researchers in areas such as health science who must depend on retrospective studies, we made additions for the benefit of their students as well. We added examples to show how statistics is applied to health research and now discuss risks, odds and their ratios, as well as repeated-measures analysis. While helping researchers prepare manuscripts for publication, we learned that some journals prefer the more conservative Bonferroni procedures, so we have added them to the discussion of mean separation techniques in Chapter 10. We also have a discussion of ratio and difference estimation. However, that inclusion may be self-serving to avoid yet another explanation of "Why go to the all the trouble of least squares when it is so much easier to use a ratio?" Now we can refer the questioner to the appropriate section in Chapter 9.

There are additions to the exercises as well as the body of the text. We believe our students enjoy hearing about the research efforts of Sir Francis Galton, that delightfully eccentric but remarkably ingenious gentleman scientist of Victorian England. To make them suitable exercises, we have taken a few liberties with some of his research efforts, but only to demonstrate the breadth of ideas of a pioneer who thought everything is measurable and hence tractable to quantitative analysis. In respect for a man who—dare we say?—"thought outside the black box," many of the exercises that relate to Galton will require students to think on their own as he did. We hope that, like Galton himself, those who attempt these exercises will accept the challenge and not be too concerned when they do not succeed.

We are pleased that Daniel M. Chilko, a long-time colleague, has joined us in this endeavor. His talents have made it easier to update sections on computer analysis, and he will serve as webmaster for the web site that will now accompany the text.

We wish to acknowledge the help we received from many people in preparation of this edition. Once again, we thank SAS Institute for permission to discuss their SAS and JMP software.

We want to express our appreciation to the many readers who called to our attention a flaw in the algorithm used to prepare the Poisson confidence intervals in Table A8. Because they alerted us, we made corrections and verified all tables generated by us for this edition.

To all who responded to our survey, we are indeed indebted. We especially thank Dr. Marta D. Remmenga, Professor at New Mexico State University. She provided us with a detailed account of how she uses the text to teach statistics and gave us a number of helpful suggestions for this edition. All responses were helpful, and we do appreciate the time taken by so many to answer our questionnaire.

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Even without this edition, we would be indebted to long-time colleagues in the Department of Statistics at West Virginia University. Over the years, Erdogan Gunel, E. James Harner, and Gerald R. Hobbs have provided the congenial atmosphere and enough help and counsel to make our task easy and joyful.

Shirley M. Dowdy
Stanley Wearden
Daniel M. Chilko
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From its inception, the intent of this text has been to demystify statistical procedures for those who employ them in their research. However, between the first and second editions, the use of statistics in research has been radically affected by the increased availability of computers, especially personal computers which can also serve as terminals for access to even more powerful computers. Consequently, we now feel a new responsibility also to try to demystify the computer output of statistical analyses.

Wherever appropriate, we have tried to include computer output for the statistical procedures which have just been demonstrated. We have chosen the output of the SAS* System* for this purpose. SAS was chosen not only for its relative ubiquity on campus and research centers, but also because the SAS printout shares common features with many other statistical analysis packages. Thus if one becomes familiar with the SAS output explained in this text, it should not be too difficult to interpret that of almost any other analysis system. In the main, we have attempted to make the computer output relatively unobtrusive. Where it was reasonable to do so, we placed it toward the end of each chapter and provided output of the computer analysis of the same data for which hand-calculations had already been discussed. For those who have ready access to computers, we have also provided exercises containing raw data to aid in learning how to do statistics on computers.

In order to meet the new objective of demystifying computer output, we have included the programs necessary to obtain the appropriate output from the SAS System. However, the reader should not be mislead in believing this text can serve as a substitute for the SAS manuals. Before one can use the information provided here, it is necessary to know how to access the particular computer system on which SAS is available, and that is likely to be different from one research location to another. Also, to keep the discussion of computer output from becoming too lengthy, we have not discussed a number of other topics such as data editing, storage, and retrieval. We feel the reader who wants to begin using computer analysis will be better served by learning how to do so with the equipment and software available at his or her own research center.

At the request of many who used the first edition, we now include nonparametric statistics in the text. However, once again with the intent of keeping these procedures from seeming to be too arcane, we have approached each nonparametric test as an analog to a previously discussed parametric test, the difference being in the fact that data were collected on the nominal or ordinal scale of measurement, or else transformed to either of these scales of measurement. The test statistics are presented in such a form that they will appear as similar as possible to their parametric counterparts, and for that reason, we consider only large samples

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