Cases in Managerial Data Analysis

William L. Carlson

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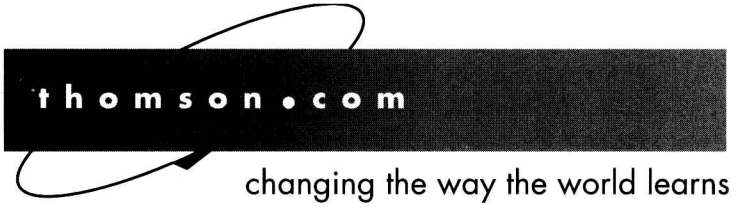

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To

Ruth and Leslie Carlson
for setting the goal!

Charlotte Carlson
for providing the support!

Andrea, Douglas, and Larry
Carlson
for the future!

PREFACE

This book provides the important link between the study of applied statistics and the capability to analyze problems in actual organizations. It offers real business applications, including the data used in those applications. The cases and data files are organized to emphasize problem solving and report preparation by managers and economists, without the overhead of data collection.

My motivation for writing this book is rooted in my teaching experience and in the modern consensus about teaching applied statistics. Good statistical theory and methodology must be combined with experience with real applications if you are to become a competent analyst. Initially I gathered data sets from actual projects that I had conducted. Later I obtained additional data sets from colleagues in business and industry. I developed these data sets into cases with a description of the setting, and students were asked to prepare an analysis and a report. Recently the annual conference on "Making Statistics More Effective in Schools of Business" has emphasized the importance of using applications and data for teaching statistical methodology and practice. Real business and economics applications of the type contained in this book go beyond the extended problems found in most statistics textbooks and provide a sound basis for problem solving.

UNIQUE FEATURES

This book includes the following important components:

- Based on real applications and data, the cases integrate issues from different functional areas, including management, finance, marketing, economics, quality assurance, and accounting.
- The cases contain large data sets and require computer software for analysis.

- Cases are of varying difficulty, permitting student growth through a number of case analyses.
- Guidelines and procedures for project analysis and project report writing are included.
- Teachers are given flexibility to custom-publish individual cases or subgroups of cases at a lower price.
- Extended solution materials are provided for teachers adopting the casebook.

All these components promote effective teaching of applied problem solving.

NATURE OF STATISTICAL STUDIES

Statistical studies generally proceed as follows:

1. Each statistical study begins with a clear statement of the problem situation and the rationale for selecting an appropriate analytical strategy.
2. This is followed by data collection, entry into computer files, and data checking.
3. Next, descriptive and analytical procedures are used to interpret the data and to provide answers to the analysis questions. In this process, efforts are typically devoted to correcting data, finding new insights, and (possibly) revising the initial questions.
4. Final conclusions are developed, based on the initial conclusions and analysis results.
5. Lastly, a written and/or oral report is prepared and presented for the client.

Experience teaches us that problem-solving processes are not linear: analysis results may lead to additional data checking; and writing the report often leads to additional questions and further analysis.

The most time-consuming tasks are data collection and entry, but in this casebook those tasks have been eliminated. This elimination certainly does not detract from the importance of good data collection and the lessons to be learned from actually collecting data. In fact, the task is arguably so important that it should not be presented as a burdensome addition to an already busy course work load. Instead, data collection should be part of an of extended research project that combines business functional areas and statistical analysis.

USING CASES IN STATISTICS COURSES

The Introduction of this book presents an approach to problem analysis and guidelines for preparing project reports. These are based on my experience using the cases in a variety of classroom situations. Initially you can follow the guidelines as presented; but I encourage you to expand and extend the basic framework and develop your own problem-solving methodology. Experience with these cases will provide a suitable environment for doing so.

Faculty who adopt this casebook will receive a data disk that provides easy interactive access to case data files in a format appropriate for most popular statistics packages and spreadsheets. In addition, the teacher's manual provides extended solution notes, all required computational output, and guidelines for assigning cases appropriate for your class and curriculum requirements. Given the wide range of business and economic functional areas included, teachers may decide to use some of these cases for joint projects with other courses in, for example, accounting, finance, marketing, or quality assurance.

Since each case can be completed in a realistic amount of time, the teacher can assign a number of different cases during the course. Typically I assign six or seven cases each semester. Generally the performance on the first case is not outstanding. By providing careful feedback in the grading process, however, I find that students noticeably improve during the semester. Good "statistical practice" is learned best through practice, scrimmage, or rehearsal.

ACKNOWLEDGMENTS

Many people contributed to the success of this project. Well over a thousand St. Olaf students have struggled with various forms of these cases. Their questions, criticisms, and quality project reports were basic to the formulation of the book. I obtained cooperation and assistance from numerous business people who are involved daily with real statistical problems. Their discussions of application situations and their actual data provided the material for the book. Included in this group are Anne Lundstrom, Robert Reul, Phillip Cartwright, Mark Hornung, Mike Giese, John Stull, Cliff Okerlund, Richard Niemic, Alice Miller, Mark Belles, James Donaghy, Keith Casson, Jean Bronk, James Munson, Jim Campbell, Pete Sibal, and Jack Litzau. Several faculty colleagues—Mary Emery, Rick Goedde, and Kathy Chadwick—provided valuable guidance in various business functional areas, and Linda Hunter provided valuable assistance in developing guidelines for the written reports. Douglas Scholz-Carlson prepared a number of TEX layout macros that greatly helped in the writing of this book.

Sincere appreciation is extended to a number of experienced faculty reviewers whose recommendations contributed significantly to this project. These reviewers whose recommendations contributed significantly to this project. These reviewers include Mohammed Askalani, Mankato State University; Michael S. Broida, Miami University; Michael Middleton, University of San Francisco, Paul Paschke, Oregon State University, Paul Randloph, Texas Tech University; Al Schainblatt, San Francisco State University; Paudu R. Tadikamalla, University of Pittsburgh; Stanley Taylor, California State University—Sacramento; Bruce Trumbo, California State University—Hayward; and Cindy Van Es, Cornell University.

Thanks to Scott Isenberg who initially proposed this project and developed the original contract. Editors Millicent Treloar and Curt Hinrichs provided valuable guidance and direction that brought this project to completion.

Finally I must acknowledge the loving support and encouragement of my wife Charlotte. Her willingness to put extra time into family activities during my days of intensive work on this book was a major contribution to the successful completion of it.

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January 1996
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CONTENTS

INTRODUCTION

CASES IN MANAGERIAL DATA ANALYSIS

Preparation of Case Solutions

DEVELOPING STATISTICAL SKILLS

This casebook provides various typical business and government policy problems whose solution involves using statistical analysis. Business is seeking prospective employees who can carry out independent analysis and prepare completed project reports that solve real problems. Thus there is a clear need to move beyond statistics classes that only require solving textbook problems. Textbook problems are clearly important learning tools, but future business analysts need to learn how to examine the problem environment, prepare and implement a solution strategy, and write a clear, concise report. Over many years, participants in the annual conference on "Making Statistics More Effective in Schools of Business" have consistently endorsed this need. In addition to providing examples of real applications, these cases are an important motivator for learning statistical procedures; thus, when taught in the abstract, statistics can be confusing and boring. When used in the context of applied problems, however, it opens many doors and generates excitement as new insights are discovered in diverse areas of business. Applied statistical analysts need to link their statistical understanding to real problems.

The cases in this book reflect typical business applications. Most cases are based on descriptions of actual problems and on data received from a number of different firms and organizations. Descriptions of the organization and specific results have sometimes been disguised, however, to protect important confidential business knowledge. Typically, this involved modifying the original data by a constant or random factor. Such changes do not alter the business and management issues. In some instances, data contain outliers and measurement errors. Thus you must develop mature data-checking skills as you work on these cases. For that reason, the skills and experience gained in performing the analysis and preparing the reports will carry over to your future career.

Cases similar to these have been used for more than fifteen years in college classes. Most students view them as being the outstanding part of the

course. Student evaluations indicate that, although the cases require considerable additional work, they make statistics much more interesting and greatly improve students' understanding of statistical procedures. Finally, students who perform well on the cases typically do well on subsequent exams.

CASE ANALYSIS PROCESS

These cases are designed to create a problem-solving environment that closely matches the environment experienced in an actual business. Case solutions require significant statistical analysis and interpretation of results. The focus is on creating a concise professional report that responds to the original business or public policy question. In contrast, textbook problems often require only a set of statistical analyses and computations. To simulate an actual business setting, you should use a microcomputer to perform the statistical computations and a text editor to prepare a professional-looking report. Working with a graphical interface such as a Macintosh or Microsoft Windows is ideal. These cases are perfect for teams of two students to tackle. Working in teams permits a broader examination of the case questions and fosters useful discussion. In addition, most real-life business problems are solved by teams. Thus students gain practical experience by working with others on a common problem.

Each case ends with a series of questions designed to help guide your analysis. The ultimate goal of your analysis, though, is a formal written report that helps solve the original problem.

Statistical studies follow a general structure, with a number of side diversions resulting from discoveries made along the way. The process usually consists of the following steps:

1. Identifying the analysis questions
2. Converting analysis questions into statistical questions
3. Performing a descriptive analysis of the data
4. Identifying unusual data points
5. Applying formal analysis procedures
6. Developing conclusions and recommendations
7. Identifying unusual outcomes and future analysis

Each of these steps should be accompanied by written descriptions in the final report text file. After all of the analysis and blocks of writing are completed, you may wish to move blocks of text and statistical output around to produce a more coherent report. The final step is then to prepare the Executive Summary, which is the very first section of your report. Each step entails a wide range of options.

1. Identifying the Analysis Questions

Your first task is to read the entire case carefully and make notes concerning key details. From this reading, you can begin to identify the important business questions in the case. In a real business application, this process consists of talking with key managers and other knowledgeable persons. That process usually leads to an analysis proposal, which is then "signed off" by the executive responsible for underwriting the study.

2. Converting Analysis Questions into Statistical Questions

Statistical analysis can answer specific well-structured questions. You have seen many examples of these questions in textbook problems and examples. An important task in any applied study is to convert the case analysis questions into statistical questions. This process requires thorough understanding of the problem requirements and of the available data. In many cases the available data, including the data form and source, limit the kinds of analysis that are possible.

3. Performing a Descriptive Analysis of the Data

Performing a descriptive analysis provides the analyst with a general picture of the data. Means, variances, ranges, and simple correlations are computed for appropriate variables. The analyst may also prepare histograms, box-and-whisker plots, and other graphical displays. If the data have been collected over time, creating time plots will help identify patterns that change over time. From this analysis, you can define the range of applicability for your analysis conclusions.

4. Identifying Unusual Data Points

Data from real business applications frequently contain some unusual observations or outliers. In many cases these result from simple recording or measurement errors. In other cases, however, strange points may indicate important observations of the environment that generated the data. In all cases each unusual data point should be traced to its source, and the error should be corrected or the special condition reported. For symmetrical distributions, about 95 percent of the data set is contained within plus or minus two standard deviations of the mean and very few observations lie outside plus or minus three standard deviations. This rule of thumb can help identify extreme points. Similarly, points that are far from a central linear grouping on a scatter plot should be investigated. Detecting strange data requires knowing how to use the statistical tools in your computer package and being interested in problem solving.

Several statistical procedures can be employed to deal with outliers. Usually they require some assumptions about the data generation process and the underlying probability model. These should be used if you understand their assumptions and if the procedure is appropriate. Analysis quality can be improved by using sophisticated analysis procedures properly. Applied work raises two fundamental questions about outliers: (1) is the data outlier merely a recording error? (2) did the observation actually occur? If the answer to the first question is yes, the error should be corrected. If the answer to the second question is yes, the observation must be included in the analysis and report. But appropriate adjusting procedures can still be used.

5. Applying Formal Analysis Procedures

By this point in the study, you will have developed a good understanding of the problem issues and the basic structure of the data. In addition, if you have been writing intermediate results, you will probably have additional questions. These can be compared against the assumptions required for the various standard statistical procedures. Do you have everything needed for a formal hypothesis test? Do the data satisfy the assumptions required for regression analysis? Which of the available analyses will answer the questions you have formulated?

The analysis should be driven by the questions and not by a desire to demonstrate how clever you can be with various statistical tools. You should be willing to try a variety of procedures to test the stability of the conclusions. For example, means, standard deviations, and other descriptive statistics should show the same results as bar charts and graphs; and regression models of different forms should provide similar conclusions. Analysis of residuals and analysis of outliers in general evince a careful analyst. Study of the distribution patterns for important variables indicates the validity of your analysis. Many strange patterns can occur in data, and you should try the analysis in enough different ways to ensure reliability of the results. Incidentally, the ability to support different analyses is a major advantage of the computer analysis environment.

This is also the time to perform some basic reality checks on your conclusions. Do the results make sense, given what you know about the area being studied? You can also ask other persons with experience in problems of this type to react to your initial conclusions.

Computer-based problem solving can create undeserved support for certain answers, if there were initial errors in the analysis. Older, more tedious non-computer-based analysis procedures were closer to the data and the detailed steps. Thus, errors in computation or analysis approach were more likely to be detected. In our modern computer-based statistical analysis environment, results must be examined for reasonableness and reality.

6. DEVELOPING CONCLUSIONS AND RECOMMENDATIONS

At this point you should review the initial objectives and questions to confirm that all of the required analyses have been completed. If you have been writing after completing each analysis step, you already have the basis for discussion of your major conclusions. Key ideas should be extracted and combined for a smooth-flowing discussion. Some of the more basic details can be moved to an appendix. This is also the time to write the Executive Summary.

Ideally this step involves bringing together your results and then writing a clear discussion that links them. However, real studies do not always proceed linearly (such that the previous step is completed before the next step is begun). Thus you may identify additional questions when you are preparing your conclusions. In that case you must cycle back to perform additional analysis.

7. IDENTIFYING UNUSUAL OUTCOMES AND FUTURE ANALYSIS

Research, analysis, and problem solving are an ongoing process. Answers at one point identify additional questions. Analysis often indicates additional paths that should be followed. However, studies in a business or public policy environment must reach a close. Decision makers require timely answers, and limited resources are allocated to each study. Personnel and financial resources are allocated to a study, and results must be produced within resource limits. As a student, you have only so many hours to devote to each course and/or to special projects. Thus completion of a study is important. Closure typically includes a final written report and/or an oral presentation.

Given the need for closure, you will often be left with unexplored questions in your study. These should be documented and noted as questions for future work. In some cases the questions might be important enough to justify another study. Your task is to document the additional questions objectively and to suggest how they might be answered. Information users must then decide whether additional work should be undertaken.

PREPARING THE WRITTEN REPORT

Since producing a written report is your ultimate objective, you would be wise to begin writing your report after you have identified the analysis questions but simultaneously with performing the statistical calculations. For example, start the case report by preparing the introduction and the project scope, using your text editor. Initial statistical analysis can then be saved in a file and transferred to your emerging report. Next, prepare comments on the