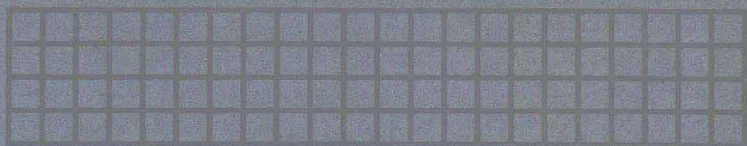
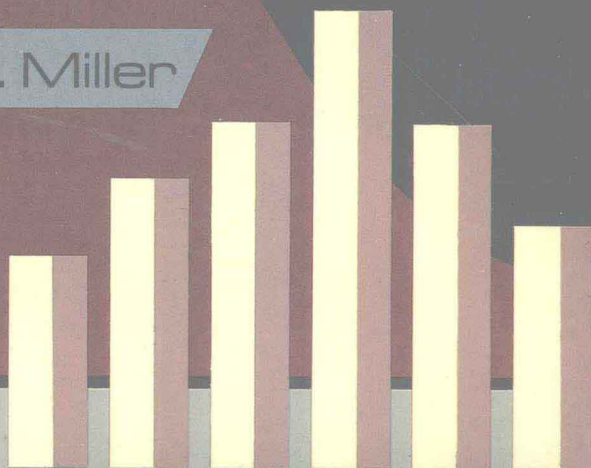


M i n i t a b



Handbook for
Business and
Economics

Robert B. Miller



Revised Printing: Includes Release 6 & 7 Commands

MINITAB HANDBOOK FOR BUSINESS AND ECONOMICS

REVISED PRINTING

Robert B. Miller
University of Wisconsin—Madison



Duxbury Press
An Imprint of Wadsworth Publishing Company
Belmont, California

Duxbury Press

An Imprint of Wadsworth Publishing Company

A division of Wadsworth, Inc.

Copyright © 1988 by PWS-Kent Publishing Company, a division of Wadsworth, Inc.

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transcribed, in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the prior written permission of the publisher, Wadsworth Publishing Company, Belmont, California 94002.

Portions of this book previously appeared in *Minitab Handbook*, Second Edition, by Ryan/Joiner/Ryan, copyright © 1985 by PWS Publishers.

ISBN 0-534-92478-6
(previously ISBN 0-87150-092-2)

Minitab is a registered trademark of Minitab, Inc.

Printed in the United States of America.

3 4 5 6 7 8 9—93

Sponsoring Editor: *Michael Payne*

Production Coordinator: *Elise Kaiser*

Production: *Technical Texts, Inc.*

Composition: *Polyglot Pte. Ltd.*

Cover Printer: *New England Book Components*

Text Printer/Binder: *Halliday Lithograph*

Cover art copyright © 1987 by Julie Gecha.

MINITAB HANDBOOK FOR BUSINESS AND ECONOMICS

PREFACE

This *Handbook* is designed to help you learn how to use Minitab to solve statistical problems in business and economics. Minitab is a general purpose statistical system that can be run in either interactive or batch mode, and on mainframe computers, minicomputers, or microcomputers. Minitab has evolved over the years from a classroom aid to a system that permits an analyst not only to do routine statistical tasks, but also to make creative use of plots, simulations, transformations, as well as exploratory analysis. Many companies, universities, and government agencies around the world make Minitab available to analysts, and even more will do so with the advent of personal computers. Minitab is easy to learn and easy to use. It is an ideal companion for the student or the worker faced with the need to analyze data and to formulate problems involving random variation.

Version 5 of Minitab is used in this book. Version 5 is a substantial revision of earlier versions. Some of the old commands have been dropped, and new ones have been added. If you have an older version of Minitab, you will be able to use this *Handbook*, but you will find some incompatibilities.

This *Handbook* is a close relative of the book *Minitab Handbook*, Second Edition, by Barbara F. Ryan, Brian L. Joiner, and Thomas A. Ryan, Jr. These authors approached me about the possibility of writing a handbook slanted toward business and economics applications. My reaction has been to retain, quite literally, the best features of their book, to try to improve on it where I thought I could, and to add discussion of topics that I thought would make the book appealing to people interested in statistical applications in business and economics. The biggest single addition is the material on time series analysis; the second biggest is an expansion of the material on simulation. Discussions with a number of people who teach statistics in business schools led me to believe that these topics deserved special attention. I was also encouraged to de-emphasize nonparametric statistics, and I have done so.

Another contribution I feel I have made is the inclusion of data sets with a business and economics flavor. Most of these data sets came to me through consulting or executive education experiences. I solicited the RESTAURANT data set in Chapter 4 from my colleague Bill Strang and received his permission to include it in both this book and the one by Ryan,

Joiner, and Ryan. Two or three of the data sets are artificial but are based on true stories. I hope their pedagogical value outweighs any drawbacks due to the artificiality. The fields of business and economics are rich in sources of data. I recommend that users of Minitab, or any other statistical system, not limit themselves to the data sets in this *Handbook* or any other instructional manual. Opportunity for the collection and analysis of primary data is plentiful, and the benefits of working with primary data are immense.

In this *Handbook* you will find two chapters devoted to simulation (Chapters 6 and 7) and two devoted to regression (Chapters 10 and 11). The first of each pair of chapters covers the basics, while the second of each pair covers more advanced topics. I have used this arrangement to try to make the book easy to use in the classroom. Another device with the same purpose is the presentation of elementary time series material in early chapters, where it can be worked into a unit on descriptive statistics. Chapter 12 covers identification, fitting, checking, and forecasting using ARIMA models. It illustrates how to do these things with Minitab, but it is not intended to teach these topics to a novice. The reader should have some training in these topics before tackling Chapter 12.

I would like to acknowledge the help of a number of people. My special thanks must go to Brian Joiner, Barbara Ryan, and Tom Ryan for inviting me to work on this book and for granting me permission to insert many sections of their book into mine. I am grateful to my editor, Michael Payne, for his encouragement, for gentle and gentlemanly prodding, and for not giving up. Those who have reviewed the manuscript have been helpful, particularly in making me aware of what the market is likely to bear. They are Richard Brock, California State University, Sacramento; Jonathan Cryer, University of Iowa; John McKenzie, Babson College; Richard Madsen, University of Missouri; David Pentico, Virginia Commonwealth University; James Scott, Creighton University; Lawrence Sher, University of Kansas; Bert Steece, University of Southern California; William Stewart, College of William and Mary; and Andrew Welki, John Carroll University. I offer a grateful word of thanks to Elise Kaiser and Betty O'Bryant, who have so cheerfully and competently seen to the all-important details of the editing and production.

Finally, my thanks go to my wife and children who helped with the reading of the proofs and proved to be very understanding of the eccentricities of an author.

For further information about the Minitab system contact:

Minitab, Inc.
3081 Enterprise Drive
State College, PA 16801
Telephone: 814/238-3280 #Telex: 881612

MINITAB HANDBOOK FOR BUSINESS AND ECONOMICS

CONTENTS

1 / INTRODUCTION TO MINITAB	1
1.1 A Simple Example	1
1.2 A Brief Overview of Minitab	8
1.3 Some Basic Minitab Capabilities	10
1.4 Another Example: Paid Vacation	15
1.5 More Information on Minitab	19
2 / ONE-VARIABLE DISPLAYS AND SUMMARIES	26
2.1 Three Basic Types of Data	26
2.2 Histograms	28
2.3 Dotplots	31
2.4 Stem-and-Leaf Displays	33
2.5 One-Number Statistics	37
2.6 Summarizing Categorical and Ordinal Data	42
2.7 Boxplots	43
2.8 Transformations to Symmetry	46
3 / PLOTTING DATA	50
3.1 Scatterplots	50
3.2 Plots with Symbols	54
3.3 Plotting Time Series	61
3.4 Lags, Changes, and Percentage Changes	67
4 / TABLES	71
4.1 Tables of Counts and Percents	72
4.2 Tables for Related Variables	76

4.3 Advanced Features of TABLE	79
4.4 Tabling Time Series	83
5 / COMPARING TWO OR MORE SETS OF DATA	88
5.1 Paired Data	88
5.2 Separate Groups	97
5.3 Comparing Several Related Groups	99
6 / BINOMIAL AND NORMAL DISTRIBUTIONS AND ELEMENTARY SIMULATIONS	103
6.1 Bernoulli Trials	103
6.2 The Binomial Distribution	107
6.3 Random Number Generation and the BASE Command	111
6.4 The Normal Distribution	112
6.5 Cumulative Distributions	118
6.6 Inverses of Cumulative Distributions	122
7 / OTHER DISTRIBUTIONS AND MORE ADVANCED SIMULATIONS	125
7.1 How Sample Means Vary and Normal Probability Plots	125
7.2 Summary of Distributions in Minitab	132
7.3 Simulation and Stored Commands	137
7.4 Sampling Finite Populations	140
7.5 Random Walks and the PARSUM Command	141
8 / INFERENCES BASED ON MEANS AND STANDARD DEVIATIONS	147
8.1 Inference for the Mean of One Population	147
8.2 A Note on Randomization and Design of Experiments	151
8.3 Comparing Means of Two Populations	155
9 / ANALYSIS OF VARIANCE	161
9.1 One-Way Analysis of Variance	161
9.2 Randomized Block Designs	167

9.3 Two-Way Analysis of Variance: Testing for Interaction	172
9.4 Residuals and Additive Models	180
10 / FITTING CURVES TO DATA	182
10.1 The Simplest Form of REGRESS	183
10.2 Higher BRIEF Levels and Storage Columns with REGRESS	191
10.3 Fitting a Second-degree Polynomial Using REGRESS	197
10.4 Multiple Regression	200
11 / REGRESSION MODELING: INFERENCE AND PREDICTION	212
11.1 Data for This Chapter	214
11.2 Inferences and Predictions for the Straight Line Model	215
11.3 Inferences and Predictions for Multiple Regression Models	221
11.4 Stepwise Regression	225
11.5 Transformations	227
11.6 Other Subcommands of REGRESS	228
12 / TIME SERIES ANALYSIS	230
12.1 Trend	230
12.2 Stationarity, Autocorrelation, and Partial Autocorrelation	238
12.3 Identifying, Fitting, and Checking Nonseasonal ARIMA Models	243
12.4 Seasonality	253
12.5 Identifying, Fitting, Checking, and Forecasting Seasonal ARIMA Models	257
12.6 Multiple Series and Cross-Correlation	264
12.7 Other Features of ARIMA	267
Appendixes	269
A / DATA SETS USED IN THIS HANDBOOK	270

B / ADDITIONAL FEATURES IN MINITAB	293
C / A LIST OF MINITAB COMMANDS	316
D / CHANGES IN RELEASE 6 AND 7	334
References	337
Index	338

1/INTRODUCTION TO MINITAB

Minitab is an easy-to-use, general-purpose statistical computing system. It is flexible, powerful, and designed especially for people who have no previous experience with computers. In this chapter we discuss how Minitab works; and in the chapters that follow, we will show how Minitab can be used to solve various types of statistical problems. We begin with an example, then follow with an overview of what you need to know to use Minitab.

1.1/ A SIMPLE EXAMPLE

Table 1.1 lists the unemployment rates of Blacks and Whites in the United States for the 12 months of 1984. Our goals are to

1. calculate the ratio of Black to White unemployment rates for each month;
2. find the mean and standard deviation of the ratios for the 12 months;
3. make a histogram of the 12 ratios.

Minitab commands that perform these operations are shown in Exhibit 1.1. Notice that these commands are given in English, just about the same way you would tell someone to do the calculations by hand. Minitab stores the data in a worksheet that it maintains in the computer. The first command

```
READ THE FOLLOWING DATA INTO COLUMNS C1 AND C2
```

tells the computer to take the data from the lines that follow the READ command and put them into columns C1 and C2 of the worksheet. The command

```
END
```

TABLE 1.1 Unemployment Rates for
 U.S. Blacks and Whites,
 1984

<i>Month</i>	<i>Unemployment Rates (seasonally adjusted)</i>	
	<i>Whites</i>	<i>Blacks</i>
January	6.9	16.7
February	6.7	16.2
March	6.7	16.6
April	6.7	16.8
May	6.5	16.0
June	6.3	15.2
July	6.3	16.6
August	6.4	15.8
September	6.3	15.1
October	6.3	15.3
November	6.1	15.1
December	6.2	15.0

Source: U.S. Department of Commerce,
Survey of Current Business, Dec. 1984,
pp. 5–10.

EXHIBIT 1.1 Minitab Program for Unemployment Data

```
READ THE FOLLOWING DATA INTO COLUMNS C1 AND C2
6.9   16.7
6.7   16.2
6.7   16.6
6.7   16.8
6.5   16.0
6.3   15.2
6.3   16.6
6.4   15.8
6.3   15.1
6.3   15.3
6.1   15.1
6.2   15.0
END
LET C3 = C2/C1
PRINT C1, C2, C3
DESCRIBE C3
HISTOGRAM C3
```

signals the end of the data. Exhibit 1.2 shows the worksheet after the data are read.

The next command

```
LET C3 = C2/C1
```

says to divide column C2 of the worksheet by the corresponding entries in column C1 and store the ratios in column C3. Exhibit 1.3 shows the worksheet at this point. Column C3 now contains the ratios of the

EXHIBIT 1.2 Minitab's Worksheet after Reading the Data

<i>C1</i>	<i>C2</i>
6.9	16.7
6.7	16.2
6.7	16.6
6.7	16.8
6.5	16.0
6.3	15.2
6.3	16.6
6.4	15.8
6.3	15.1
6.3	15.3
6.1	15.1
6.2	15.0

EXHIBIT 1.3 Worksheet after LET Command

<i>C1</i>	<i>C2</i>	<i>C3</i>
6.9	16.7	2.42029
6.7	16.2	2.41791
6.7	16.6	2.47761
6.7	16.8	2.50746
6.5	16.0	2.46154
6.3	15.2	2.41270
6.3	16.6	2.63492
6.4	15.8	2.46875
6.3	15.1	2.39683
6.3	15.3	2.42857
6.1	15.1	2.47541
6.2	15.0	2.41935

unemployment rates for each month. The next three commands give printed output.

```
PRINT C1-C3
```

says to print the contents of these three columns.

```
DESCRIBE C3
```

says to calculate and print various descriptive statistics, including the average (or mean), of the numbers in C3.

```
HISTOGRAM C3
```

says to print out a histogram of the numbers in C3. Output from these three commands is shown in Exhibit 1.4.

GETTING STARTED

To use Minitab, you must first learn a little bit about your computer system. Each one is different, so we cannot give you the exact details, but we can give you some general guidance.

Most people use Minitab on a computer terminal that consists of a screen and a keyboard. The screen is often called a CRT (for cathode-ray tube). Some people use typewriterlike terminals. These use paper in place of a screen. In both cases, you give the computer directions by typing them on the keyboard. Always check each line you've typed before you push the carriage return key. On most computers, you can correct errors by simply backspacing and retyping. Once the carriage return is pushed, however, it is usually more difficult to make corrections.

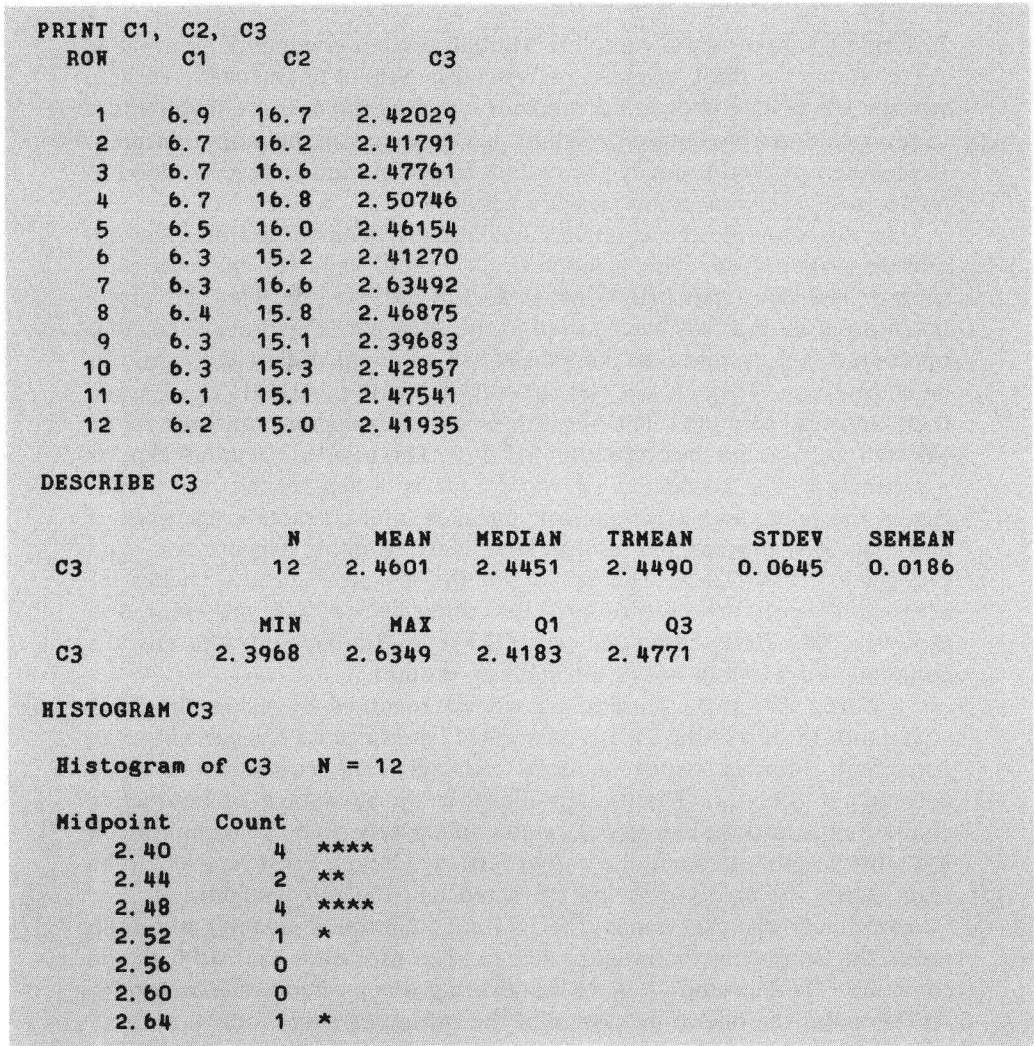
There is a third way to use a computer: with a keypunch machine and computer cards. This used to be the only way to use computers. Now most keypunches have been replaced by terminals, which are both friendlier and cheaper to use. If you are using Minitab with a keypunch, see your local computer experts for help.

Finally, you can use Minitab on a microcomputer. If you do, you may have to learn about floppy disks (they look like flexible records) and disk drives. However, you will still have a keyboard and a screen.

Thus, the first step is to learn about the equipment you will use: where it is located, how to turn it on, how the keyboard works, and so forth. You may have to connect the terminal to the computer with a telephone and a device called a modem. Then you must learn the correct telephone number. These are all minor details that are fairly easy to learn, although they can cause a lot of frustration at times.

There are two basic ways to use Minitab: in interactive mode and batch mode. Most people use interactive mode, which we will discuss in this chapter. If you are using Minitab in batch mode, see your local computer experts for help. Almost all Minitab commands work the same way in both modes.

EXHIBIT 1.4 Output from the Commands PRINT, DESCRIBE, and HISTOGRAM



The second step is to get on (often called logon or login) to your computer. You may need an account number, an identification number, and a password. You will have to learn exactly what to type, and you may have to type everything very carefully and in what seems to be a strange form. Once you have logged-on, you are in what's usually called the computer's operating system.

The third step is to ask to use Minitab. This may involve nothing more than typing the word Minitab. In any case, it should be very simple. At this point, you are in Minitab. You can now type the commands in this book.

USING MINITAB YOURSELF

In Exhibit 1.5 you see a complete Minitab session conducted on an IBM AT computer at the University of Wisconsin School of Business. To help you see what is going on, all commands typed by the user are highlighted. In the actual run the output in Exhibit 1.5 appeared on the monitor screen. It was then printed to make the exhibit and step numbers were added to make the discussion below easier to follow.

In this example the computer has already been turned on. The operating system issues the prompt `C: \>` and waits for the user's response. The user types MINITAB (step 1 in Exhibit 1.5). This activates a batch program that has been stored in the computer's memory. The steps numbered 2, 3, 4, and 5 in the exhibit are automatically issued from this batch program. They change the directory to `\MINITAB MYDATA` and then activate Minitab. This results in an introductory message from Minitab, step 6, and then a prompt `MTB >`. This says that Minitab expects a command. The command `READ C1 C2` is issued by the user. After typing the command, checking for mistakes, and correcting mistakes, if any, the user pushes the return key. Now Minitab expects data and prompts with `DATA>`. The user types the first line of data, checks for errors, and pushes the return key. Two other lines of data are entered in this way. The `END` command (step 11) tells Minitab that data entry is complete, so Minitab issues an `MTB >` prompt.

In step 12, two columns are added together by using the `LET` command. In step 13 the `LET` is misspelled, and since `LTT` is not a Minitab command, Minitab issues an error message. The command is typed correctly in step 14. These steps illustrate an advantage of interactive computing: a mistake can be corrected immediately. In batch computing, a job must be submitted and the output retrieved before error reports can be read. Then the errors must be corrected and the job resubmitted.

In step 15 the user issues a `PRINT` command, and in step 16 Minitab prints the output on the monitor screen. The user ends the run with the command `STOP` in step 17, and Minitab sends a sign-off message in step 18. At this point the operating system of the computer takes control.

At times you will want output on paper. Just type the word `PAPER`. Output from all the commands that you type after the `PAPER` command will be put into a computer file to be printed later. You can stop this process at any time by typing the word `NOPAPER`, and you can restart it by typing `PAPER` again. At the end of your session, after you type `STOP`, everything that you put into your file will be printed on paper, provided that your computer is connected with a printer.

An alternative that is often more convenient when using a micro-computer is the `OUTFILE` command. Suppose you want to send output