
CONTENTS

PREFACE xiii
ACKNOWLEDGMENTS xv

I

STATISTICAL ANALYSIS AND INFERENCE IN SCIENCE

***“the art of reaching conclusions at the interface of theory
and observation”*** 1

1.1 Introduction 1
1.2 A Format for Statistical Inference 3
1.3 Picking Analysis Techniques and Seeking Help 5
1.4 A Few Examples 6
1.5 Data Sets and Data Management 10
1.6 Final Technical Note 10
Exercises 10

2

DATA AND DATA MANAGEMENT

“what we have to go on” or “accumulated records of observations and their expeditious reorganization” 15

- 2.1 Introduction 15
- 2.2 Daily Climatological Data for 15 Stations 16
- 2.3 Ocean Temperature and Salinity Data 18
- 2.4 A 10-Year, Daily Temperature, and Precipitation Data Set and 94 Years of Monthly Mean Values for State College, Pennsylvania 19
- 2.5 Daily MIN/MAX Temperature Time Series for Five Cities 23
- 2.6 Using MINITAB for Data Management 23
- Exercises 30

3

DESCRIPTIVE STATISTICS

“first impressions” or “sketching features of observed systems with data” 33

- 3.1 Introduction 33
- 3.2 Data Plots, Histograms, and Frequency Distributions for a Time Sequence of Observations 37
- 3.3 Summary Statistics 42
- 3.4 Comparisons 44
- 3.5 Correlations 45
- 3.6 Words of Caution in Interpreting Values of Descriptive Statistics 48
- Exercises 50

4

THE FOUNDATIONS OF INFERENCE

“probability models as descriptions of research outcomes” 53

- 4.1 Introduction 53
- 4.2 The Basic Probability Model 54
- 4.3 Continuous Outcome Description Spaces and Event Set Operations 56

4.4 Probability Models for Vector-Valued Outcomes	60
4.5 Generic Events and Probability Rules	64
4.6 Conditional Probability and Independent Events	66
4.7 An Application of Bayes' Theorem	68
Exercises	69

5

STOCHASTIC VARIABLES AND THE IDENTIFICATION OF THEIR DISTRIBUTIONS

“distilling uncertainty” 73

5.1 Introduction	73
5.2 The Binomial Distribution	77
5.3 The Poisson Distribution	84
Exercises	91

6

THE EXPONENTIAL AND UNIFORM DISTRIBUTIONS

“describing uncertainty in time and space” 95

6.1 Introduction	95
6.2 Exponential Distributions of Waiting Times	96
6.3 Uniform Distributions of Waiting Times	101
6.4 Random Location Distributions	104
Exercises	107

7

THE NORMAL DISTRIBUTIONS

“good approximations for many composite variables” 111

7.1 Introduction	111
7.2 The Univariate Normal Distributions	112
7.3 Multivariate Normal Distributions	125
Exercises	136

8

ANALYZING VARIABILITY

“establishing differences between means and between variances” 143

- 8.1 Introduction 143
 - 8.2 The Quadratic Form: Keystone in Analyses of Variability 145
 - 8.3 The Chi Square Distribution and Confidence Intervals for a Variance Parameter 149
 - 8.4 Student’s t Distribution: Inferences about Means and Differences between Means 155
 - 8.5 Fisher’s F Distribution for a Ratio of Variances 161
 - 8.6 The Correlation Estimate and Fisher’s Z 164
- Exercises 167

9

TESTING HYPOTHESES

“dealing with the generic critic while establishing powerful support for new ideas” 173

- 9.1 Introduction 173
 - 9.2 Statement and Testing of Competing Hypotheses 175
 - 9.3 The Playoff between Risks of Wrong Decisions 180
 - 9.4 The Dependence of Power on the Number of Observations 183
 - 9.5 The Connection between Confidence Intervals and Tests of Hypotheses 188
- Exercises 191

10

LINEAR REGRESSION

“analyzing an influence network” 195

- 10.1 Introduction 195
 - 10.2 Two-Variable Linear Regression 197
 - 10.3 Linear Regression with Several Variables 204
 - 10.4 The Backbone of Regression Analysis in Statistical Theory 209
 - 10.5 Testing Regression Hypotheses 216
- Exercises 220

II**BOOTSTRAPPING****“scientific inference when none of the above apply” 225**

11.1 Introduction 225

11.2 Bootstrap Technology 226

11.3 Examples of Bootstrapping in Geophysics 228

11.4 Open Problems in the Development and Use
of Bootstrap Analysis Techniques 231

Exercises 233

REFERENCES 235

INDEX 239