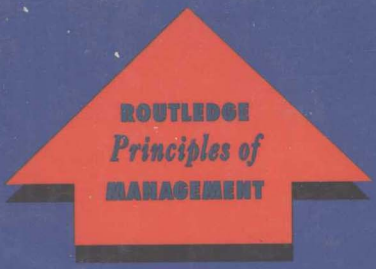

Series editor
Joseph G. Nellis

Principles of APPLIED STATISTICS

Michael C. Fleming and Joseph G. Nellis

Principles of Applied Statistics

Michael C. Fleming
Joseph G. Nellis

London and New York

First published 1994
by Routledge
11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada
by Routledge
29 West 35th Street, New York, NY 10001

© 1994 Michael C. Fleming and Joseph G. Nellis

Typeset in Times by Mathematical Composition Setters Ltd, Salisbury, Wilts.
Printed and bound in Great Britain by
Mackays of Chatham PLC, Chatham, Kent

All rights reserved. No part of this book may be reprinted or reproduced or utilized in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publishers.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data has been applied for

ISBN 0–415–07379–0

Routledge series in the principles of management
Edited by Joseph G. Nellis

The Routledge series in the principles of management offers stimulating approaches to the core topics of management. The books relate the key areas to strategic issues in order to help managers solve problems and take control. By encouraging readers to apply their own experiences, the books are designed to develop the skills of the all-round manager.

Principles of operations management
R. L. Galloway

Principles of information systems of management
John Ward

Principles of law
A. Ruff (ed.)

Principles of personal development and management skills
R. Edwards

Principles of accounting and finance
P. Sneyd

Principles of human resource management
D. Goss

Principles of marketing
Geoffrey Randall

Principles of the business environment
Nigel Healey and Peter Jackson

Principles of Applied Statistics

Statistics and data can be daunting for anyone, but it is vital for managers to know the broad basis of statistical techniques in order to manage information efficiently. More importantly, managers need to interpret the results and draw out implications for effective decision-making. This book guides the reader through the principles of such areas as the presentation of statistical data, probability, statistical significance, regression and correlation analysis, forecasting and time series analysis, smoothing out the intricacies and emphasizing the practical applications. The authors illustrate the techniques with extensive reference to one of the most popular computer-based statistical packages, MINITAB. They show how easy it is to manage information successfully to help develop the organization.

Michael C. Fleming is Professor of Economics at Loughborough University. **Joseph G. Nellis** is Professor of International Management Economics at Cranfield School of Management, Cranfield University. The authors have extensive experience in the application of statistical methods both as lecturers and as consultants to a wide range of public and private sector organizations. They were jointly responsible for the research and development of the UK's most well-known house price analysis systems, employed by the two largest building societies, the Halifax and Nationwide. They have published extensively in professional and academic journals.

此为试读,需要完整PDF请访问: www.ertongbook.com

This book is dedicated to Kathleen Mary Rosamond Nellis who weighed in at 3.49 kg during the preparation of the manuscript, becoming a unique statistic of the UK population and a potential statistics user.

A judicious man looks at Statistics not to get knowledge but to save himself from having ignorance foisted on him.

Thomas Carlyle

Series editor's preface

In recent years there has been a dramatic increase in management development activity in most Western countries, especially in Europe. This activity has extended across a wide spectrum of training initiatives, from continuing studies programmes of varying durations for practising managers to the provision of courses leading to the award of professional and academic qualifications. With regard to the latter the most prominent developments have been in terms of the Master of Business Administration (MBA) and Diploma in Management Studies (DMS) programmes, particularly in the UK where virtually every university now offers some form of post-graduate and/or post-experience management qualification.

However, the explosion of formal management training programmes such as the MBA and DMS has tended to be in advance of suitably tailored management textbooks. Many of the core functional areas of these programmes have had to rely on some of the more specialized and thus more narrowly focused textbooks, which are more appropriate for undergraduate requirements. They have generally not provided a suitable balance between academic rigour and practical, business-related relevance. The Routledge series covering the principles of management has been specifically developed to service the needs of an expanding management audience. The series deals with the full range of core subjects as well as many of the more popular elective courses that one would expect to find in most MBA and DMS programmes. Many of the books will also be attractive to those students taking professional examinations, for example in accountancy, banking, etc., as well as to managers attending a wide range of development courses. Each book in the series is written in a concise format covering the key principles of each topic in a pragmatic style which emphasizes the balance between theory and application. Case studies, exercises and references for further reading are provided where appropriate.

It gives me pleasure to express my thanks to the staff of Routledge for the commitment and energy which they have devoted to the development of this series, and in particular to Francesca Weaver who has skilfully steered each book through the minefield of production from beginning to

Preface

This book provides a general introduction to statistical theory and methods and is aimed at a wide range of potential users. The emphasis throughout is on the applied nature of statistics and, to this end, the use of formal and complex mathematics is avoided to ensure that the book is made as user-friendly as possible. We live in the midst of an information explosion. We are all bombarded virtually every day by the media with information (and mis-information) about virtually every aspect of life, much of it of a statistical nature. At the same time, many people have a direct need as part of their working or private lives to analyse and present statistical information. This explosion in information has gone hand in hand with the development of information technology (IT) in many guises, including the proliferation of small but powerful personal computers (PCs and hand-held calculators) over recent years. This development has brought the possibility of processing and analysing data within the reach of a wide range of people. For all these reasons there is a need to understand and apply basic statistical terminology and principles.

The boom in IT has made the PC into a common piece of equipment at all levels of the education and business worlds and is increasingly bringing it into the home. At the same time there has been an equally explosive growth in the development and availability of special statistical software packages which eliminate the need to understand anything at all about computer programming. In recognition of these developments in both computer hardware and software, we have incorporated a large number of computer-based applications illustrating the principles of each topic wherever possible using a very popular and inexpensive statistical package called MINITAB. However, it is also possible to use this book without reference to MINITAB as each computer application stands alone.

While the book has been written with the needs of a wide range of users in mind, it will be especially attractive to three groups in particular:

- to students taking formal courses in statistics in universities and colleges as part of degree and other programmes;

end. I would also like to express my gratitude to my secretary Christine Williams for maintaining her joviality throughout the development of the 'Principles' series.

Joseph G. Nellis
Cranfield School of Management
Cranfield University

- to those studying for professional and vocational qualifications such as banking and accountancy examinations;
- to people following general post-graduate courses such as the Master of Business Administration (MBA) and Diploma in Management Studies (DMS), as well as practising managers and others following continuing studies programmes.

To serve the needs of different user groups, the book has been broken down into a large number of relatively small chapters so that they can be bundled together to satisfy the requirements of different examining bodies. For many users, for whom the use of statistics is not a regular need, the book will serve as a concise reference and *aide-mémoire*.

As authors, it is always a pleasure to formally record our appreciation for the help and support given by others. This book is certainly no exception. We are most grateful to Su Spencer, Lorraine Whittington, Christine Williams and Denise Simpson for typing and correcting various drafts of the manuscript. Without knowing it, many students have also had a hand in pointing out areas of difficulty and confusion and we are therefore grateful to them. We would also like to express our thanks to our friends M. and Mme Ferrière who, once again, provided moral support and hospitality during a particularly intensive period of writing. As ever, the authors' families deserve the greatest thanks for their support, understanding and forgiveness.

Michael C. Fleming
Loughborough

Joseph G. Nellis
Cranfield

Contents

List of figures in main text ix
List of tables in main text xi
List of worked examples xiii
Series editor's preface xvi
Preface xviii

1 Introduction 1

Part I Descriptive statistics

2 Describing data – tables, charts and graphs 13
3 Describing data – averages 39
4 Describing data – variability 54
5 Exploratory data analysis 65

Part II Probability and probability distributions

6 Probability concepts 73
7 Binomial probability distribution 93
8 Poisson probability distribution 103
9 Normal probability distribution 112

Part III Statistical inference

10 Statistical inference – an overview 135
11 Sampling distributions 138
12 Estimation 152
13 Estimation and the *t* distribution 163
14 Hypothesis testing: single population mean 171
15 Hypothesis testing: two population means 195
16 Estimation and hypothesis testing: proportions 223

此为试读,需要完整PDF请访问: www.ertongbook.com

Part IV Relationships between variables

17 Simple linear regression and correlation 239
18 Multiple linear regression and correlation 273
19 Tests of goodness-of-fit and independence 295

Part V Time series and index numbers

20 Time series analysis 315
21 Index numbers 338

References for further reading 361

Appendix: statistical tables 363

Table A1 Binomial probability distribution 363
Table A2 Poisson probability distribution 369
Table A3 Standard normal distribution 373
Table A4 t distribution 374
Table A5 Critical values of Spearman's rank correlation coefficient 375
Table A6 F distribution 376
Table A7 χ^2 distribution 380

Solutions to self-study exercises 382
MINITAB – Description of program and selected commands 392
Index 396

Figures in main text

1.1	Classifications of numerical data	8
2.1	Line graphs of new house prices	18
2.2	Pie charts of housing tenure	19
2.3	Bar chart of housing tenure	20
2.4	Component bar chart of growth of housing stock and composition	21
2.5	Histogram of equal intervals: distribution of bank loans by size	22
2.6	Histogram of unequal intervals: distribution of bank loans by size	23
2.7	Frequency polygon: distribution of bank loans by size	24
2.8	Comparative frequency polygons: distribution of loans by borrower type	26
2.9	Cumulative frequency curves: distribution of bank loans	28
2.10	Lorenz curves	30
2.11	Rate of change graphs	33
3.1	Mode for grouped data	43
3.2	Relationship between mean, median and mode	44
6.1	Mutually exclusive events	76
6.2	Non-mutually exclusive events	77
6.3	Generalization of addition rules	78
7.1	Tree diagram	95
7.2	Binomial distributions for different values of n and p	98
8.1	Poisson distributions for different values of μ	106
9.1	The normal distribution	113
9.2	Normal distributions: different means and standard deviations	114
9.3	Properties of the normal distribution	115
9.4	Area under the normal distribution curve	116
9.5	Standard normal distribution	117
9.6	Area under the standard normal curve	118
9.7	Area under the standard normal curve for $Z = \pm 1.96$	119

9.8	Normal approximation to the binomial	121
10.1	Sampling, estimation and hypothesis testing: a schematic overview	136
11.1	Sampling distributions of the mean from a population of values: 0, 1, 2, 3, 4	145
11.2	Illustration of the central limit theorem for three populations	146
12.1	Interval estimation of the population mean	154
13.1	Z and t distributions	165
14.1	Acceptance and rejection regions in hypothesis testing for two-tailed and one-tailed tests	174
14.2	Comparison of p values and critical values of Z in a one-tailed test	178
17.1	Scatter diagrams	240
17.2	Equations of straight lines	242
17.3	Deriving the best-fitting regression line	243
17.4	Extrapolation and interpolation	248
17.5	Confidence and prediction limits	249
17.6	Explained and unexplained variations	251
18.1	F distribution	280
19.1	χ^2 distribution for different degrees of freedom	297
19.2	χ^2 distribution for car colour preferences	298
20.1	Illustrations of variation in time series data	318

Tables in main text

1.1	Scales of measurement – a summary	8
1.2	Users and uses of statistics	9
2.1	Raw data: luggage weights	14
2.2	Ordered array of luggage weights	14
2.3	Frequency distribution of luggage weights	15
2.4	Average price of new houses	17
2.5	Distribution of bank loans by size of loan	22
2.6	Distribution of mortgage loans	25
2.7	Cumulative frequency distributions for bank loans	27
2.8	Distribution of income	29
2.9	Cumulative distribution of income	29
2.10	Values of a variable growing by 100 per cent in each time period	32
11.1	Sampling distributions with and without replacement	139
11.2	Sampling distributions of means – sampling with replacement	141
11.3	Variance of sampling distributions – sampling without replacement	142
11.4	Variance of sampling distributions – sampling with replacement	142
12.1	Levels of confidence	156
14.1	Critical values for testing a hypothesized mean μ_0	176
14.2	Errors in hypothesis testing	179
15.1	Summary of hypothesis tests using independent samples	200
15.2	Summary of hypothesis tests using matched samples	204
16.1	Summary of hypothesis tests of a single population proportion	227
16.2	Summary of hypothesis tests of two-population proportions	228
18.1	ANOVA table	279
19.1	Observed and expected frequencies	296
19.2	Contingency table for car colour preferences	300

20.1 Computation of trend using moving-average method when n is an odd number 321
20.2 Computation of trend using moving-average method when n is an even number 322
21.1 Prices, quantities and values of expenditure on selected food items 340
21.2 Simple price indexes 341
21.3 Calculation of weighted average of simple price indexes 342
21.4 Calculation of Laspeyres and Paasche aggregate price indexes 343
21.5 Summary of price index formulae 345
21.6 Calculation of weighted average of simple quantity indexes 347
21.7 Calculation of Laspeyres and Paasche aggregate quantity indexes 348

Worked examples

2.1	Frequency distributions, bar charts and histograms	32
3.1	Describing data – averages: ungrouped data	45
3.2	Describing data – averages: grouped data	46
3.3	Averaging proportions	49
3.4	Geometric mean – averaging growth rates	49
3.5	Compound formula	50
4.1	Describing data – variability: ungrouped data	58
4.2	Describing data – variability: grouped data	60
4.3	Comparing variability of different data sets	62
6.1	Application of addition rule – non-mutually exclusive events	81
6.2	Application of addition rule – mutually exclusive events	82
6.3	Generalization of addition rule – non-mutually exclusive events	83
6.4	Multiplication rule – independent events	84
6.5	Multiplication rule – dependent events	84
6.6	Multiplication rule – sampling without replacement	85
6.7	Bayes' rule	85
6.8	Tree diagrams	86
6.9	Decision trees	87
6.10	Permutations	89
6.11	Combinations	89
7.1	Binomial distribution	97
7.2	Cumulative binomial distribution	99
7.3	Properties of the binomial distribution	100
8.1	Poisson distribution	107
8.2	Cumulative Poisson distribution	108
8.3	Properties of the Poisson distribution	110
9.1	Use of the standard normal (Z) table	122
9.2	The normal distribution	125
9.3	Normal approximation to the binomial	126
11.1	Calculation of the standard error of the mean	147
11.2	Probability of sampling error	147

此为试读,需要完整PDF请访问: www.ertongbook.com