Table of Contents

Preface ..... ***v***

Chapter 1 What Survivor Analysis Is About

1.1 The Nature of Survival Data 1
1.2 Exercises 5
1.3 Calendar Time and Study Time 5
1.4 Exercise 6
1.5 Example 6
1.6 Functions That Describe Survival 9
1.7 Exercises 11
1.8 Some Commonly Used Survival Functions 11
1.9 Exercises 12
1.10 Functions That Allow for Cure 13
1.11 Fully Parametric and Nonparametric Methods 15
1.12 Some Common Assumptions 16
1.13 Exercises 16

Chapter 2 Non-Parametric Survival Function Estimation

2.1 The Kaplan-Meier Estimate of the Survival Function 17
2.2 Exercise 20
2.3 The Actuarial Life Table 20
2.4 The Variance of the Kaplan-Meier Estimator 23
2.5 Hypothesis Tests 24
2.6 Confidence Intervals 25
2.7 Some Problems with the Kaplan-Meier Estimator of S(t) 25
2.8 Using PROC LIFETEST 27
2.9 Two Macros as Alternatives to PROC LIFETEST 32
2.10 Planning a Study to Control the Standard Error 37
2.11 Example 39
2.12 The KMPLAN Macro 39
2.13 Exercise 42
2.14 Interval-Censored Data 42
2.15 Macros 48

Chapter 3 Non-Parametric Comparison of Survival Distributions

3.1 Notation 53
3.2 The Log Rank Statistic 54
3.3 More Than Two Groups 56
3.4 Other Linear Rank Tests 57
3.5 Using PROC LIFETEST 59
3.6 Exercises 64
3.7 A Test for Trend 64
3.8 Stratified Analyses 65
3.9 The Macro LINRANK 66
3.10 Permutation Tests and Randomization Tests 73
3.11 The Mantel-Byar Method 79
3.12 Power Analysis 84
3.13 Early Stopping Based on Conditional Power 92
3.14 Listings of Macros 95

Chapter 4 Proportional Hazards Regression

4.1 Some Thoughts about Model-Based Estimation and Inference 111
4.2 The Cox (Proportional Hazards) Regression Method....112
4.3 The Hazard Ratio and Survival....113
4.4 Multiple Covariates 114
4.5 Defining Covariates....114
4.6 Scaling the Covariates 115
4.7 Survival Probabilities 116
4.8 Maximum Likelihood Estimation of the Coefficients....116
4.9 Using PROC PHREG 117
4.10 Model-Building Considerations....131
4.11 Time-Dependent Covariates 134
4.12 More Complex Models....136
4.13 Checking the Proportional Hazards Assumption 136
4.14 Exercise 138
4.15 Survival Probabilities 138
4.16 Residuals....143
4.17 Power and Sample Size 145
4.18 Imputing Missing Values....148
4.19 Listings of Macros 150

Chapter 5 Parametric Methods

5.1 Introduction 153
5.2 The Accelerated Failure Time Model....155
5.3 PROC LIFEREG 156
5.4 Example Using of PROC LIFEREG....156
5.5 Comparison of Models 159
5.6 Estimates of Quantiles and Survival Probabilities 160
5.7 The PROC LIFEREG Parameters and the "Standard" Parameters 163
5.8 The Macro PARAMEST 163
5.9 Example Using the Macro PARAMEST 166
5.10 An Example with a Positive Cure Rate....169
5.11 Comparison of Groups....173
5.12 One-Sample Tests of Parameters....176
5.13 The Effects of Covariates on Parameters....176
5.14 Complex Expressions for the Survival and Hazard Functions....179
5.15 Graphical Checks for Certain Survival Distributions....179
5.16 A Macro for Fitting Parametric Models to Survival Data....180
5.17 Other Estimates of Interest 183
5.18 Listings of Macros 183

Appendix A....187
Appendix B....193
Appendix C....209
References....219
Index....221