
Contents

Preface	xi
Preface to the First Edition	xiii
Acknowledgments	xv
1 Introduction and Synopsis	1
1.1 Introduction	1
1.2 Synopsis	5
2 Preliminaries	9
2.1 Introduction	9
2.2 Inference in Linear Models	9
2.3 Robustness Concepts	15
2.3.1 Finite-Sample Breakdown and Tail-Performance	20
2.4 Robust and Minimax Estimation of Location	25
2.5 Clippings from Probability and Asymptotic Theory	29
2.5.1 Modes of Convergence of Stochastic Elements	31
2.5.2 Basic Probability Inequalities	34
2.5.3 Some Useful Inequalities and Lemmas	36
2.5.4 Laws of Large Numbers and Related Inequalities	40
2.5.5 Central Limit Theorems	42
2.5.6 Limit Theorems Allied to Central Limit Theorems	48
2.5.7 Central Limit Theorems for Quadratic Forms	50
2.5.8 Contiguity of Probability Measures	51
2.5.9 Hájek–Inagaki–LeCam theorem and the LAN condition	52

2.5.10 Weak Convergence of Probability Measures	53
2.5.11 Some Important Gaussian Functions	57
2.5.12 Weak Invariance Principles	59
2.5.13 Empirical Distributional Processes	60
2.5.14 Weak Invariance Principle: Random Change of Time	64
2.5.15 Embedding Theorems and Strong Invariance Principles	64
2.5.16 Asymptotic Relative Efficiency: Concept and Measures	66
2.6 Problems	67
3 Robust Estimation of Location and Regression	69
3.1 Introduction	69
3.2 M-Estimators	70
3.3 L-Estimators	78
3.4 R-Estimators	91
3.5 Minimum Distance and Pitman Estimators	104
3.5.1 Minimum Distance Estimation	104
3.5.2 Pitman Estimators	106
3.5.3 Pitman-Type Estimators of Location	106
3.5.4 Bayes-Type Estimators of General Parameter	107
3.6 Differentiable Statistical Functions	108
3.7 Problems	112
4 Asymptotic Representations for L-Estimators	117
4.1 Introduction	117
4.2 Bahadur Representations for Sample Quantiles	119
4.3 L-Statistics with Smooth Scores	123
4.4 General L-Estimators	129
4.5 Statistical Functionals	130
4.6 Second-Order Asymptotic Distributional Representations	135
4.7 L-Estimation in Linear Model	142
4.8 Breakdown Point of L- and M-Estimators	152
4.9 Further Developments	155
4.10 Problems	157

5	Asymptotic Representations for M-Estimators	161
5.1	Introduction	161
5.2	M-Estimation of General Parameters	161
5.3	M-Estimation of Location: Fixed Scale	169
5.3.1	Possibly Discontinuous but Monotone ψ	173
5.3.2	Possibly Discontinuous and Nonmonotone ψ	175
5.3.3	Second-Order Distributional Representations	177
5.4	Studentized M-Estimators of Location	182
5.5	M-Estimation in Linear Model	191
5.6	Studentizing Scale Statistics	199
5.7	Hadamard Differentiability in Linear Models	202
5.8	Further Developments	205
5.9	Problems	206
6	Asymptotic Representations for R-Estimators	209
6.1	Introduction	209
6.2	Asymptotic Representations for R-Estimators of Location	210
6.3	Representations for R-Estimators in Linear Model	217
6.4	Regression Rank Scores	224
6.5	Inference Based on Regression Rank Scores	227
6.5.1	RR-Tests	229
6.5.2	RR-Estimators	230
6.5.3	Studentizing Scale Statistics and Regression Rank Scores	231
6.6	Bibliographical Notes	233
6.7	Problems	234
7	Asymptotic Interrelations of Estimators	237
7.1	Introduction	237
7.2	Estimators of location	239
7.3	Estimation in linear model	249
7.4	Approximation by One-Step Versions	252
7.5	Further developments	264
7.6	Problems	265

8	Robust Estimation: Multivariate Perspectives	267
8.1	Introduction	267
8.2	The Notion of Multivariate Symmetry	268
8.3	Multivariate Location Estimation	271
8.4	Multivariate Regression Estimation	276
8.4.1	<i>Normal Multivariate Linear Model</i>	277
8.4.2	<i>General Multivariate Linear Model</i>	277
8.5	Affine-Equivariant Robust Estimation	279
8.5.1	<i>Smooth Affine-Equivariant L-Estimation of θ</i>	281
8.5.2	<i>Affine-Equivariant Regression Estimation</i>	288
8.5.3	<i>Additional Remarks and Comments</i>	290
8.6	Efficiency and Minimum Risk Estimation	291
8.7	Stein-Rule Estimators and Minimum Risk Efficiency	296
8.7.1	<i>Location Model</i>	297
8.7.2	<i>Extension to the Linear Model</i>	301
8.8	Robust Estimation of Multivariate Scatter	306
8.9	Some Complementary and Supplementary Notes	308
8.10	Problems	310
9	Robust Tests and Confidence Sets	315
9.1	Introduction	315
9.2	M-Tests and R-Tests	316
9.2.1	<i>M-Tests of Location</i>	316
9.2.2	<i>M-Tests in Linear Model</i>	319
9.2.3	<i>R-Tests</i>	322
9.2.4	<i>Robustness of Tests</i>	324
9.2.5	<i>Some Remarks on the Wald-Type Tests</i>	327
9.3	Minimax Tests	328
9.4	Robust Confidence Sets	329
9.4.1	<i>Type I Confidence Intervals</i>	330
9.4.2	<i>Type II Confidence Intervals</i>	337
9.5	Multiparameter Confidence Sets	342
9.6	Affine-Equivariant Tests and Confidence Sets	346
9.7	Problems	349

CONTENTS	ix
Appendix	351
Uniform Asymptotic Linearity	351
References	357
Subject index	385
Author index	390