

CONTENTS

Preface	11
Basic symbols	15
1 Universal model	17
1.1 Estimation of the mean value parameter	21
1.2 Estimation of the unit dispersion	32
1.3 Theorems on equivalence	37
1.4 Uniformly best linear unbiased estimators	43
1.5 Confidence region	45
1.5.1 Joint confidence regions	51
1.5.2 Confidence interval for the ratio of two parametric functions	54
1.6 Testing linear hypotheses	55
1.6.1 General formulae for the degrees of freedom	69
1.7 Additional experiment	79
1.8 Additional constraints	84
1.9 Outliers	88
1.10 Residual and error vectors	91
1.11 Overparametrization and underparametrization	93
1.11.1 Regular model	93
1.11.2 Singular model	97
1.12 Inefficient estimator of β and unknown unit dispersion	105
2 Universal models with type-I constraints	115
2.1 Estimation of the mean value parameter	116
2.2 Estimation of the unit dispersion	126
2.3 Uniformly best linear unbiased estimators	130
2.4 Confidence region	132
2.4.1 Joint confidence regions	142
2.5 Testing linear hypotheses	154
2.6 Additional experiment	160
2.7 Additional constraints	166

2.7.1	Regular model	166
2.7.2	Singular model	168
2.8	Outliers	172
2.9	Residual and error vector	174
2.10	Overparametrization and underparametrization	176
2.10.1	Regular model	177
2.10.2	Singular model	185
2.11	Inefficient estimator of β and unknown unit dispersion	188
3	Universal models with type-II constraints	195
3.1	Estimation of the parameter β	197
3.2	Estimation of the unit dispersion	224
3.3	Uniformly best linear unbiased estimator	228
3.4	Confidence regions	230
3.4.1	Joint confidence regions	241
3.5	Testing linear hypotheses	247
3.5.1	Singular model	249
3.6	Additional experiment	256
3.6.1	Singular model	260
3.7	Additional constraints	264
3.8	Outliers	272
3.9	Residual and error vectors	278
3.10	Overparametrization and underparametrization	279
3.10.1	Regular model	280
3.10.2	Singular model	291
3.11	Inefficient estimator of β and unknown unit dispersion	302
4	MINQUE	305
4.1	Mixed ULSM	306
4.2	Mixed ULSMI	314
4.2.1	Regular model	316
4.3	Mixed ULSMII	328
A	Matrix algebra	331
A.1	Overview	331
A.2	Trace of a matrix	332
A.3	Range and null space	332
A.4	Rank of a matrix	333
A.5	Eigenvalues and eigenvectors	334
A.6	Decomposition of matrices	335
A.7	Generalized inverse	336
A.7.1	The minimum seminorm g-inverse	337
A.7.2	The least squares g-inverse	338
A.7.3	The Moore–Penrose g-inverse	339
A.7.4	Generalized inverse of a partitioned matrix	341

A.8	Projection operator	345
A.9	The Kronecker product	347
A.10	The vec operator	348
A.11	The Loevner partial ordering	348
A.12	Miscellaneous results	349
B	Probability	353
B.1	Distribution of quadratic forms	353
B.2	The Beta distribution	356
B.3	Estimation theory	357
B.4	Miscellaneous results	359
	Bibliography	361
	Index	367