## Contents

Pref	ace nowledgements	xxi
1.	Spatial Models: Basic Issues	
	1.1 Illustrations Involving Spatial Interactions	1
	1.2 Concept of a Neighbor and the Weighting Matrix	3
	1.3 Some Different Ways to Specify Spatial Weighting Matrices	4
	1.4 Typical Weighting Matrices in Computer Studies	8
	Suggested Problems	10
2.	Specification and Estimation	
	2.1 The General Model	12
	2.1.1 Triangular Arrays	14
	2.1.2 Geršgorin's Theorem and Weighting Matrices	15
	2.1.3 Normalization to Ensure a Continuous Parameter Space	18
	2.1.4 An Important Condition in Large Sample Analysis	20
	2.2 Estimation: Various Special Cases	22
	2.2.1 Estimation When $\rho_1 = \rho_2 = 0$	22
	2.2.2 Estimation When $\rho_1 = 0$ and $\rho_2 \neq 0$	27
	2.2.2.1 Maximum Likelihood Estimation: $\rho_1 = 0, \ \rho_2 \neq 0$	28 33
	2.2.3 Assumptions of the General Model	37
	2.2.4 A Generalized Moments Estimator of $\rho_2$ 2.3 IV Estimation of the General Model	43
	2.4 Maximum Likelihood Estimation of the General Model	46
	2.5 An Identification Fallacy	49
	2.6 Time Series Procedures Do Not Always Carry Over	50
	Appendix A2 Proofs for Chapter 2	52
	Suggested Problems	58
3.	Spillover Effects in Spatial Models	
	3.1 Effects Emanating From a Given Unit	61
	3.2 Emanating Effects of a Uniform Worsening of Fundamentals	64

	3.3 Vulnerability of a Given Unit to Spillovers Suggested Problems	66 69
4.		
7.	- Partial Models	
	<ul><li>4.1 Preliminaries on Expectations</li><li>4.2 Information Sets and Predictors of the Dependent Variable</li><li>4.3 Mean Squared Errors of the Predictors</li></ul>	71 75 80
	Suggested Problems	86
5.	Problems in Estimating Weighting Matrices	
	5.1 The Spatial Model	87
	5.2 Shortcomings of Selection Based on $R^2$	88
	<ul><li>5.3 An Extension to Nonlinear Spatial Models</li><li>5.4 R<sup>2</sup> Selection in the Multiple Panel Case</li></ul>	90
	Suggested Problems	91 95
	and the second s	
6.	Additional Endogenous Variables: Possible Nonlinearities	
	6.1 Introductory Comments	97
	6.2 Identification and Estimation: A Linear System	98
	6.3 A Corresponding Nonlinear Model 6.4 Estimation in the Nonlinear Model	100 102
	6.5 Large Sample and Related Issues	102
	6.6 Generalizations and Special Points to Note	108
	6.7 Applications to Spatial Models 6.8 Problems With MLE	113
		120
	Suggested Problems	121
7.	Bayesian Analysis	
	7.1 Introductory Comments	123
	7.2 Fundamentals of the Bayesian Approach	124
	7.3 Learning and Prejudgment Issues 7.4 Comments on Uninformed Priors	125
	7.5 Applications and Limiting Cases	127 129
	7.6 Properties of the Multivariate <i>t</i>	138
	7.7 Useful Sampling Procedures in Bayesian Analysis	140
	7.8 The Spatial Lag Model and Gibbs Sampling	154
	<ul><li>7.9 Bayesian Posterior Odds and Model Selection</li><li>7.10 Problems With the Bayesian Approach</li></ul>	158
	Suggested Problems	160 161
8.	Pretest and Sample Selection Issues in Spatial Analysis	
	8.1 Introductory Comments	163
		105

	8.2 A Preliminary Result	163
	8.3 Illustrations	164
	8.4 Mean Squared Errors	168
	8.5 Pretesting in Spatial Models: Large Sample Issues	169
	8.6 Final Comments on Pretesting	175
	8.7 A Related Issue: Data Selection	177
	8.8 Endogenous Data Selection Issues	178
	8.9 Exogenous Data Selection Issues	180
	Suggested Problems	182
9.	HAC Estimation of VC Matrices	
	9.1 Introductory Comments on Heteroskedasticity	185
	9.2 Spatially Correlated Errors: Illustrations	189
	9.3 Assumptions and HAC Estimation	193
	9.4 Kernel Functions That Satisfy Assumption 9.8	200
	9.5 HAC Estimation With Multiple Distances	205
	9.6 Nonparametric Error Terms and Maximum Likelihood: Serious	
	Problems	206
	Suggested Problems	208
10.	Missing Data and Edge Issues	
	10.1 Introductory Comments	209
	10.2 A Simple Model and Limits of Information	210
	10.3 Incomplete Samples and External Data	218
	10.4 The Spatial Error Model: IV and ML With Missing Data	219
	10.5 A More General Spatial Model	221
	10.6 Spatial Error Models: Be Careful What You Do	230
	Appendix A10 Proofs for Chapter 10	232
	Suggested Problems	235
11.	Tests for Spatial Correlation	
	11.1 Introductory Comments: Occam's Razor	237
	11.2 Some Preliminary Issues on a Quadratic Form	238
	11.3 The Moran I Test: A Basic Model	240
	11.4 An Important Independence Result	245
	11.5 Application: The Moments of the Moran <i>I</i>	246
	11.6 Generalized Moran I Tests: Qualitative Models and Spatially	
	Lagged Dependent Variable Models	247
	11.7 Lagrangian Multiplier Tests	258
	11.8 The Wald Test	266
	11.9 Spatial Correlation Tests: Comments and Caveats	267
	Suggested Problems	270

12	. Nonnested Models and the <i>J</i> -Test	
	12.1 Introductory Comments	271
	12.2 The Null Model: Nonparametric Error Terms	272
	12.3 The Alternative Models	272
	12.4 Two Predictors	273
	12.5 The Augmented Equation and the <i>J</i> -Test	275
	12.6 The <i>J</i> -Test: SAR Error Terms 12.7 <i>J</i> -Test and Nonlinear Alternatives	277
		278
	Suggested Problems	281
13	. Endogenous Weighting Matrices: Specifications and	
	Estimation	
	13.1 Introductory Comments	283
	13.2 The Model	284
	13.3 Issues Concerning Error Term Specification	284
	13.4 Further Specifications	285
	13.5 The Instrument Matrix 13.6 Estimation and Inference	287 289
	Suggested Problems	292
14	. Systems of Spatial Equations	
	14.1 Introductory Comments	293
	14.2 An Illustrative Two-Equations Model	294
	14.3 The Model With Nonparametric Error Terms	294
	14.4 Assumptions of the Model	296
	14.5 Interpretation of the Assumptions	297
	14.6 Estimation and Inference 14.7 The Model With SAR Error Terms	298
	14.8 Estimation and Inference: GS3SLS	300 302
		306
	Suggested Problems	306
15	. Panel Data Models	
	15.1 Introductory Comments	307
	15.2 Some Important Preliminaries	307
	15.3 The Random Effects Model	308
	15.4 A Generalization of the Random Effects Model	316
	15.5 The Fixed Effects Model	321
	15.6 A Generalization of the Fixed Effects Model 15.7 Tests of Panel Models: The <i>J</i> -Test	329 336
	Suggested Problems	341
A.	Introduction to Large Sample Theory	
	A.1 An Intuitive Introduction	343

A	2 Application of the Large Sample Result in (A.1.6)	345
A	3 More Formalism: Convergence in Probability	345
A	4 Khinchine's Theorem	348
A	5 An Important Property of Convergence in Probability	349
A	6 A Matrix Illustration of Consistency	349
A	7 Generalizations of Slutsky-Type Results	350
A	8 A Note on the Least Squares Model	352
A	9 Convergence in Distribution	352
A.1	0 Results on Convergence in Distribution	353
A.1	1 Convergence in Distribution: Slutsky-Type Results	354
A.1	2 Constructing Finite Sample Approximations	355
A.1	3 A Result Relating to Nonlinear Functions of Estimators	357
	4 Orders in Probability	359
A.1	5 Triangular Arrays: A Central Limit Theorem	362
B. 5	patial Models in R	
В	1 Introduction	363
	2 Introductory Tools	364
	3 Reading Data and Creating Weights	372
	4 Estimating Spatial Models	376
Answer	Manual	389
References		
Index		