

READINGS IN UNOBSERVED COMPONENTS MODELS

Edited by
ANDREW C. HARVEY
and
TOMMASO PROIETTI

OXFORD
UNIVERSITY PRESS

Contents

Part One Signal Extraction and Likelihood Inference for Linear UC Models	1
Introduction	3
1 The Linear State Space Form	3
2 Alternative State Space Representations and Extensions	3
3 The Kalman Filter	4
4 Prediction	5
5 Initialisation and Likelihood Inference	7
6 Smoothing Algorithms	9
6.1 Cross-validatory and auxiliary residuals	10
6.2 Smoothing splines and non parametric regression	10
Prediction Theory for Autoregressive-Moving Average Processes <i>Peter Burridge and Kenneth F. Wallis</i>	14
1 Introduction	14
2 Two Leading Examples	16
2.1 Forecasting the ARMA(1,1) process	16
2.2 Extracting an AR(1) signal masked by white noise	20
3 State-Space Methods and Convergence Conditions	23
3.1 The state-space form and the Kalman filter	23
3.2 Conditions for convergence of the covariance sequence	27
4 Forecasting the ARMA(p, q) Process	29
4.1 Setting up the problem	29
4.2 The invertible moving average case	31
4.3 Moving average with roots on the unit circle	32
4.4 Moving average with roots outside the unit circle	33
5 Signal Extraction in Unobserved-Component ARMA Models	34
5.1 Setting up the problem	34
5.2 The stationary case	37
5.3 The non-stationary detectable case	39
5.4 The non-detectable case	41
6 Discussion	42
Appendix	44
Notes	45
References	46

3. Exact Initial Kalman Filtering and Smoothing for Nonstationary Time Series Models	48
<i>Siem Jan Koopman</i>	
1 Introduction	48
2 The Exact Initial Kalman Filter	51
2.1 The nonsingular and univariate case	53
2.2 Automatic collapse to Kalman filter	53
3 Exact Initial Smoothing	54
4 Log-Likelihood Function and Score Vector	54
5 Some Examples	56
5.1 Local-level component model	56
5.2 Local linear trend component model	56
5.3 Common-level component model	57
6 Miscellaneous Issues	58
6.1 Computational costs	59
6.2 Missing values	60
6.3 Numerical performance	60
7 Conclusions	61
Appendix	63
References	66
4. Smoothing and Interpolation with the State-Space Model	68
<i>Piet De Jong</i>	
1 Introduction	68
2 The State-Space Model, Kalman Filtering, and Smoothing	69
3 A New Smoothing Result	70
3.1 Fixed-interval smoothing	71
3.2 Classic fixed-interval smoothing	71
3.3 Fixed-point smoothing	71
3.4 Fixed-lag smoothing	72
3.5 Covariances between smoothed estimates	72
4 Signal Extraction	72
5 Interpolation	73
6 Diffuse Smoothing	74
Appendix	74
References	75
5. Diagnostic Checking of Unobserved-Components Time Series Models	77
<i>Andrew C. Harvey and Siem Jan Koopman</i>	
1 Properties of Residuals in Large Samples	78
1.1 Local level	79
1.2 Local linear trend	80
1.3 Basic structural model	81

2	Finite Samples	83
2.1	Relationship between auxiliary residuals	84
2.2	Algorithm	85
3	Diagnostics	85
3.1	Tests based on skewness and kurtosis	86
3.2	Monte Carlo experiments	88
4	Miscellaneous Issues	89
4.1	Tests for serial correlation	89
4.2	Residuals from the canonical decomposition	90
4.3	Explanatory variables	91
5	Applications	91
5.1	U.S. exports to Latin America	91
5.2	Car drivers killed and seriously injured in Great Britain	92
5.3	Consumption of spirits in the United Kingdom	93
6	Conclusions	97
	Appendix	97
	References	98
6.	Nonparametric Spline Regression with Autoregressive Moving Average Errors	100
	<i>Robert Kohn, Craig F. Ansley and Chi-Ming Wong</i>	
1	Introduction	100
2	Penalized Least Squares and Signal Extraction	102
3	Parameter Estimation	104
3.1	Maximum likelihood parameter estimation	104
3.2	Parameter estimation by cross-validation	105
4	Unequally Spaced Observations	106
5	Performance of Function Estimators: Simulation Results	107
6	Examples	110
	Appendix	112
	References	113
Part Two	Unobserved Components in Economic Time Series	115
7.	Introduction	117
1	Trends and Cycles in Economic Time Series	117
2	The Hodrick–Prescott Filter	119
3	Canonical Decomposition	121
4	Estimation and Seasonal Adjustment in Panel Surveys	123
5	Seasonality in Weekly Data	124
8.	Univariate Detrending Methods with Stochastic Trends	126
	<i>Mark W. Watson</i>	
1	Introduction	126

2	The Model	128
3	Estimation Issues	130
4	Univariate Examples	134
4.1	GNP	135
4.2	Disposable income	140
4.3	Non-durable consumption	142
5	Regression Examples	144
6	Concluding Remarks	146
	Notes	147
	References	148
9.	Detrending, Stylized Facts and the Business Cycle	151
	<i>A. C. Harvey and A. Jaeger</i>	
1	Introduction	151
2	The Trend Plus Cycle Model	152
3	The Hodrick–Prescott Filter	153
4	Macroeconomic Time Series	155
5	Further Issues	160
5.1	Seasonality	160
5.2	ARIMA methodology and smooth trends	161
5.3	Segmented trends	164
5.4	Spurious cross-correlations between detrended series	164
6	Conclusions	167
	Notes	168
	References	169
10.	Stochastic Linear Trends: Models and Estimators	171
	<i>Agustín Maravall</i>	
1	Introduction: the Concept of a Trend	171
2	The General Statistical Framework	173
3	Some Models for the Trend Component	175
4	A Frequently Encountered Class of Models	178
5	Extensions and Examples	182
6	The MMSE Estimator of the Trend	184
7	Some Implications for Econometric Modeling	191
8	Summary and Conclusions	196
	References	197
11.	Estimation and Seasonal Adjustment of Population Means Using Data from Repeated Surveys	201
	<i>Danny Pfeffermann</i>	
1	State-Space Models and the Kalman Filter	202
2	Basic Structural Models for Repeated Surveys	204

2.1	System equations for the components of the population mean	204
2.2	Observation equations for the survey estimators	206
2.3	A compact model representation	208
2.4	Discussion	209
3	Accounting for Rotation Group Bias	210
4	Estimation and Initialization of the Kalman Filter	211
5	Simulation and Empirical Results	213
5.1	Simulation results	213
5.2	Empirical results using labour force data	218
6	Concluding Remarks	221
	References	222
2.	The Modeling and Seasonal Adjustment of Weekly Observations	225
	<i>Andrew Harvey, Siem Jan Koopman and Marco Riani</i>	
1	The Basic Structural Time Series Model	227
1.1	Trigonometric seasonality	228
1.2	Dummy-variable seasonality	228
1.3	Weekly data	229
2	Periodic Effects	230
2.1	Trigonometric seasonality	230
2.2	Periodic time-varying splines	231
2.3	Intramonthly effects	232
2.4	Leap years	232
3	Moving Festivals: Variable-Dummy Effects	233
4	Statistical Treatment of the Model	233
5	U.K. Money Supply	235
6	Conclusions	242
	Appendix A	243
	Appendix B	248
	References	249
Part Three	Testing in Unobserved Components Models	251
3.	Introduction	253
1	Stationarity and Unit Roots Tests	253
2	Seasonality	256
3	Multivariate Stationarity and Unit Root Tests	257
4	Common Trends and Co-integration	258
5	Structural Breaks	259
	Notes	259

14. Testing for Deterministic Linear Trend in Time Series	260
<i>Jukka Nyblom</i>	
1 Introduction	260
2 Test Statistics	261
3 Eigenvalues of $Z'WZ$	264
4 Asymptotic Distributions and Efficiency	266
5 Asymptotic Moment-Generating Functions	268
6 Conclusions and Extensions	270
References	270
15. Are Seasonal Patterns Constant Over Time? A Test for Seasonal Stability	272
<i>Fabio Canova and Bruce E. Hansen</i>	
1 Regression Models with Stationary Seasonality	275
1.1 Regression equation	275
1.2 Modeling deterministic seasonal patterns	276
1.3 Lagged dependent variables	277
1.4 Estimation and covariance matrices	277
2 Testing for Seasonal Unit Roots	278
2.1 The testing problem	278
2.2 The hypothesis test	279
2.3 Joint test for unit roots at all seasonal frequencies	281
2.4 Tests for unit roots at specific seasonal frequencies	282
3 Testing for Nonconstant Seasonal Patterns	283
3.1 The testing problem	283
3.2 Testing for instability in an individual season	283
3.3 Joint test for instability in the seasonal intercepts	284
4 A Monte Carlo Experiment	286
4.1 First seasonal model	288
4.2 Second seasonal model	292
5 Applications	293
5.1 U.S. post World War II macroeconomic series	293
5.2 European industrial production	297
5.3 Monthly stock returns	298
6 Conclusions	299
References	300
Part Four Non-Linear and Non-Gaussian Models	303
16. Introduction	305
1 Analytic Filters for Non-Gaussian Models	307
2 Stochastic Simulation Methods	308
3 Single Move State Samplers	309

4	Multimove State Samplers	310
5	The Simulation Smoother	311
6	Importance Sampling	313
7	Sequential Monte Carlo Methods	314
	Note	315
17.	Time Series Models for Count or Qualitative Observations	316
	<i>A. C. Harvey and C. Fernandes</i>	
1	Introduction	316
2	Observations from a Poisson Distribution	318
3	Binomial Distribution	321
4	Multinomial Distribution	323
5	Negative Binomial	324
6	Explanatory Variables	326
7	Model Selection and Applications for Count Data	329
	7.1 Goals scored by England against Scotland	330
	7.2 Purse snatching in Chicago	332
	7.3 Effect of the seat-belt law on van drivers in Great Britain	333
	Appendix	334
	References	336
18.	On Gibbs Sampling for State Space Models	338
	<i>C. K. Carter and R. Kohn</i>	
1	Introduction	338
2	The Gibbs Sampler	339
	2.1 General	339
	2.2 Generating the state vector	340
	2.3 Generating the indicator variables	341
3	Examples	342
	3.1 General	342
	3.2 Example 1: Cubic smoothing spline	342
	3.3 Example 2: Trend plus seasonal components time series model	347
	3.4 Normal mixture errors with Markov dependence	348
	3.5 Switching regression model	349
	Appendix 1	350
	Appendix 2	351
	References	352
19.	The Simulation Smoother for Time Series Models	354
	<i>Piet De Jong and Neil Shephard</i>	
1	Introduction	354
2	Single Versus Multi-State Sampling	356
	2.1 Illustration	356
	2.2 Multi-state sampling	358

3	The Simulation Smoother	359
4	Examples	361
5	Regression Effects	363
	Appendix	364
	References	366
20.	Likelihood Analysis of Non-Gaussian Measurement Time Series	368
	<i>Neil Shephard and Michael K. Pitt</i>	
1	Introduction	368
2	Example: Stochastic Volatility	371
2.1	The model	371
2.2	Pseudo-dominating Metropolis sampler	371
2.3	Empirical effectiveness	372
3	Designing Blocks	373
3.1	Background	373
3.2	Proposal density	374
3.3	Stochastic knots	377
3.4	Illustration on stochastic volatility model	377
4	Classical Estimation	380
4.1	An importance sampler	380
4.2	Technical issues	380
5	Conclusions	382
	Appendix	382
	References	383
21.	Time Series Analysis of Non-Gaussian Observations Based on State Space Models from Both Classical and Bayesian Perspectives	386
	<i>J. Durbin and S. J. Koopman</i>	
1	Introduction	386
2	Models	389
2.1	The linear Gaussian model	389
2.2	Non-Gaussian models	389
3	Basic Simulation Formulae	390
3.1	Introduction	390
3.2	Formulae for classical inference	391
3.3	Formulae for Bayesian inference	392
3.4	Bayesian analysis for the linear Gaussian model	394
4	Approximating Linear Gaussian Models	395
4.1	Introduction	395
4.2	Linearization for non-Gaussian observation densities: method 1	396
4.3	Exponential family observations	397

4.4	Linearization for non-Gaussian observation densities: method 2	398
4.5	Linearization when the state errors are non-Gaussian	398
4.6	Discussion	399
5	Computational Methods	400
5.1	Introduction	400
5.2	Simulation smoother and antithetic variables	400
5.3	Estimating means, variances, densities and distribution functions	401
5.4	Maximum likelihood estimation of parameter vector	403
5.5	Bayesian inference	405
6	Real Data Illustrations	407
6.1	Van drivers killed in UK: a Poisson application	407
6.2	Gas consumption in UK: a heavy-tailed application	410
6.3	Pound-dollar daily exchange rates: a volatility application	412
7	Discussion	413
	References	415
	On Sequential Monte Carlo Sampling Methods for Bayesian Filtering	418
	<i>Arnaud Doucet, Simon Godsill and Christophe Andrieu</i>	
1	Introduction	418
2	Filtering via Sequential Importance Sampling	420
2.1	Preliminaries: Filtering for the state space model	420
2.2	Bayesian Sequential Importance Sampling (SIS)	420
2.3	Degeneracy of the algorithm	422
2.4	Selection of the importance function	422
3	Resampling	427
4	Rao-Blackwellisation for Sequential Importance Sampling	429
5	Prediction, smoothing and likelihood	431
5.1	Prediction	431
5.2	Fixed-lag smoothing	432
5.3	Fixed-interval smoothing	433
5.4	Likelihood	434
6	Simulations	435
6.1	Linear Gaussian model	436
6.2	Nonlinear series	437
7	Conclusion	439
	References	439
	References	442
	Author Index	450
	Subject Index	456