Contents

Introduction		ix
1.	Time Series and Their Features	1
	Autocorrelation and Periodic Movements	2
	Seasonality	4
	Stationarity and Nonstationarity	4
	Trends	6
	Volatility	8
	Common Features	9
	Time Series Having Natural Constraints	10
	Endnotes	12
2.	Transforming Time Series	13
	Distributional Transformations	13
	Stationarity Inducing Transformations	20
	Decomposing a Time Series and Smoothing Transformations	23
	Endnotes	30
3.	ARMA Models for Stationary Time Series	31
	Stochastic Processes and Stationarity	31
	Wold's Decomposition and Autocorrelation	33
	First-Order Autoregressive Processes	35
	First-Order Moving Average Processes	36
	General AR and MA Processes	37
	Autoregressive-Moving Average Models	43
	ARMA Model Building and Estimation	46
	Endnotes	55
4.	ARIMA Models for Nonstationary Time Series	57
	Nonstationarity	57
	ARIMA Processes	60
	ARIMA Modeling	65
	Endnotes	68

5.	Unit Roots, Difference and Trend Stationarity, and Fractional Differencing	71
	Determining the Order of Integration of a Time Series	71
	Testing for a Unit Root	73
	Trend Versus Difference Stationarity	77
	Testing for More Than One Unit Root	81
	Other Approaches to Testing for a Unit Root	83
	Estimating Trends Robustly	87
	Fractional Differencing and Long Memory	90
	Testing for Fractional Differencing	93
	Estimating the Fractional Differencing Parameter Endnotes	96 101
6.	Breaking and Nonlinear Trends	103
	Breaking Trend Models	103
	Breaking Trends and Unit Root Tests	105
	Unit Roots Tests When the Break Date Is Unknown	110
	Robust Tests for a Breaking Trend	111
	Confidence Intervals for the Break Date and Multiple Breaks	112
	Nonlinear Trends Endnotes	112 119
7.	An Introduction to Forecasting With Univariate Models	121
	Forecasting With Autoregressive-Integrated-Moving Average	
	(ARIMĂ) Models	121
	Forecasting a Trend Stationary Process	128
	Endnotes	130
8.	Unobserved Component Models, Signal Extraction,	
	and Filters	131
	Unobserved Component Models	131
	Signal Extraction	136
	Filters	139
	Endnotes	144
9.	Seasonality and Exponential Smoothing	145
	Seasonal Patterns in Time Series	145
	Modeling Deterministic Seasonality	145
	Modeling Stochastic Seasonality	147
	Mixed Seasonal Models	152
	Seasonal Adjustment	153
	Exponential Smoothing Endnotes	153 159
		155

10.	Volatility and Generalized Autoregressive Conditional Heteroskedastic Processes	161
	Volatility	161
	Autoregressive Conditional Heteroskedastic Processes	163
	Testing for the Presence of ARCH Errors	165
	Forecasting From an ARMA-GARCH Model	168
	Endnotes	171
11.	Nonlinear Stochastic Processes	173
	Martingales, Random Walks, and Nonlinearity	173
	Nonlinear Stochastic Models	176
	Bilinear Models	177
	Threshold and Smooth Transition Autoregressions	181
	Markov-Switching Models	185
	Neural Networks	188
	Nonlinear Dynamics and Chaos	189
	Testing for Nonlinearity	192
	Forecasting With Nonlinear Models	198
	Endnotes	199
12.	Transfer Functions and Autoregressive Distributed	
	Lag Modeling	201
	Transfer Function-Noise Models	201
	Autoregressive Distributed Lag Models	203
	Endnotes	210
13.	Vector Autoregressions and Granger Causality	211
	Multivariate Dynamic Regression Models	211
	Vector Autoregressions	212
	Granger Causality	213
	Determining the Lag Order of a Vector Autoregression	213
	Variance Decompositions and Innovation Accounting	216
	Structural Vector Autoregressions	222
	Endnotes	230
14.	Error Correction, Spurious Regressions, and	
	Cointegration	233
	The Error Correction Form of an Autoregressive Distributed	
	Lag Model	233
	Spurious Regressions	234
	Error Correction and Cointegration	242
	Testing for Cointegration	247
	Estimating Cointegrating Regressions	250
	enanotes	253

15.	Vector Autoregressions With Integrated Variables,	
	Vector Error Correction Models, and Common Trends	255
	Vector Autoregressions With Integrated Variables	255
	Vector Autoregressions With Cointegrated Variables	257
	Estimation of Vector Error Correction Models and Tests	
	of Cointegrating Rank	260
	Identification of Vector Error Correction Models	264
	Structural Vector Error Correction Models	266
	Causality Testing in Vector Error Correction Models	268
	Impulse Response Asymptotics in Nonstationary VARs	269
	Vector Error Correction Model-X Models	271
	Common Trends and Cycles	274
	Endnotes	279
16.	Compositional and Count Time Series	281
	Constrained Time Series	281
	Modeling Compositional Data	281
	Forecasting Compositional Time Series	283
	Time Series Models for Counts: The IN-AR(1) Benchmark Model	288
	Other Integer-Valued ARMA Processes	289
	Estimation of Integer-Valued ARMA Models	290
	Testing for Serial Dependence in Count Time Series	291
	Forecasting Counts	293
	Intermittent and Nonnegative Time Series	296
	Endnotes	296
17.	State Space Models	299
	•	
	Formulating State Space Models	299
	The Kalman Filter	303
	ML Estimation and the Prediction Error Decomposition	305
	Prediction and Smoothing	307
	Multivariate State Space Models	308
	Endnotes	309
18.	Some Concluding Remarks	311
	Endnotes	313
Refer	rences	315
Inde>	dex	