

CONTENTS

INTRODUCTION	11
1. THE NATURE OF TIME SERIES	13
1.1 Description of Time Series	13
1.2 White Noise	15
1.3 Stationarity	15
1.4 Transformations of Time Series	17
1.5 Trend, Seasonal, and Irregular Patterns	19
1.6 <i>ARMA</i> Models of Time Series	21
1.7 Stylized Facts about Time Series	22
2. DIFFERENCE EQUATIONS	26
2.1 Linear Difference Equations	26
2.2 Lag Operator	27
2.3 The Solution of Difference Equations	28
2.3.1 Particular Solution and Lag Operators	29
2.3.2 Solution by Iteration	30
2.3.3 Homogenous Solution	32
2.3.4 Particular Solution	34
2.4 Stability Conditions	35
2.5 Stability and Stationarity	37
3. UNIVARIATE TIME SERIES	39
3.1 Estimation of an <i>ARMA</i> Model	39
3.1.1 Autocorrelation Function – <i>ACF</i>	40
3.1.2 Partial Autocorrelation Function – <i>PACF</i>	43
3.1.3 <i>Q</i> -Tests	47
3.1.4 Diagnostics of Residuals	49
3.1.5 Information Criteria	49
3.1.6 Box-Jenkins Methodology	51
3.2 Trend in Time Series	53
3.2.1 Deterministic Trend	54
3.2.2 Stochastic Trend	55
3.2.3 Stochastic plus Deterministic Trend	56
3.2.4 Some Notes on Trends in Time Series	56

3.3	Seasonality in Time Series	58
3.3.1	Removing Seasonal Patterns	59
3.3.2	Estimating Seasonal Patterns	60
3.3.3	Detecting Seasonal Patterns	62
3.3.4	Hodrick-Prescott Filter	63
3.4	Unit Roots	65
3.4.1	Dickey-Fuller Test	67
3.4.2	Augmented Dickey-Fuller Test	69
3.4.3	Phillips-Perron test	72
3.4.4	Shortcomings of the Standard Unit Root Tests	74
3.4.5	<i>KPSS</i> test	75
3.5	Unit Roots and Structural Change	78
3.5.1	Perron's Test	79
3.5.2	Zivot and Andrews' Test	84
3.6	Detecting a Structural Change	87
3.6.1	Single Structural Change	88
3.6.2	Multiple Structural Change	95
3.7	Conditional Heteroskedasticity and Non-Linear Structure	104
3.7.1	Conditional and Unconditional Expectations	106
3.7.2	<i>ARCH</i> Model	107
3.7.3	<i>GARCH</i> Model	111
3.7.4	Detecting Conditional Heteroskedasticity	115
3.7.5	The <i>BDS</i> Test	118
3.7.6	An Alternative to the <i>BDS</i> Test: Integration across the Correlation Integral	122
3.7.7	Identification and Estimation of a <i>GARCH</i> Model	127
3.7.8	Extensions of <i>ARCH</i> -Type Models	132
3.7.9	Multivariate (<i>G</i>) <i>ARCH</i> Models	139
3.7.10	Structural Breaks in Volatility	142
4.	MULTIPLE TIME SERIES	147
4.1	<i>VAR</i> Models	148
4.1.1	Structural Form, Reduced Form, and Identification	150
4.1.2	Stability and Stationarity of <i>VAR</i> Models	151
4.1.3	Estimation of a <i>VAR</i> Model	154
4.2	Granger Causality	157
4.3	Cointegration and Error Correction Models	162
4.3.1	Definition of Cointegration	164
4.3.2	The Engle-Granger Methodology	171
4.3.3	Extensions to the Engle-Granger Methodology	178
4.3.4	The Johansen Methodology	179

4.4	Unit Root Tests in Panel Data	182
4.4.1	Levin, Lin, and Chu Panel Unit Root Test with a Null of Unit Root and Limited Coefficients Heterogeneity	183
4.4.2	Im, Pesaran and Shin Unit Root Test with a Null of Unit Root and Heterogeneous Coefficients	187
4.4.3	Hadri Unit Root Tests with a Null of Stationarity	188
4.4.4	Breuer, McNown, and Wallace Test for Convergence	190
4.4.5	Vogelsang Test for β -Convergence	191
	REFERENCES	195
	APPENDIX A: MONTE CARLO SIMULATIONS	209
	APPENDIX B: STATISTICAL TABLES	215
	INDEX	223