
CONTENTS

INTRODUCTION	11
1. THE NATURE OF TIME SERIES	15
1.1 DESCRIPTION OF TIME SERIES	16
1.2 WHITE NOISE	17
1.3 STATIONARITY	17
1.4 TRANSFORMATIONS OF TIME SERIES	19
1.5 TREND, SEASONAL, AND IRREGULAR PATTERNS	21
1.6 ARMA MODELS OF TIME SERIES	22
1.7 STYLIZED FACTS ABOUT TIME SERIES	23
2. DIFFERENCE EQUATIONS	27
2.1 LINEAR DIFFERENCE EQUATIONS	27
2.2 LAG OPERATOR	28
2.3 THE SOLUTION OF DIFFERENCE EQUATIONS	29
2.3.1 PARTICULAR SOLUTION AND LAG OPERATORS	30
2.3.2 SOLUTION BY ITERATION	31
2.3.3 HOMOGENOUS SOLUTION	33
2.3.4 PARTICULAR SOLUTION	34
2.4 STABILITY CONDITIONS	35
2.5 STABILITY AND STATIONARITY	36

3.	UNIVARIATE TIME SERIES	41
3.1	ESTIMATION OF AN ARMA MODEL	41
3.1.1	AUTOCORRELATION FUNCTION – ACF	42
3.1.2	PARTIAL AUTOCORRELATION FUNCTION – PACF	45
3.1.3	Q-TESTS	48
3.1.4	DIAGNOSTICS OF RESIDUALS	50
3.1.5	INFORMATION CRITERIA	50
3.1.6	BOX-JENKINS METHODOLOGY	52
3.2	TREND IN TIME SERIES	54
3.2.1	DETERMINISTIC TREND	54
3.2.2	STOCHASTIC TREND	55
3.2.3	STOCHASTIC PLUS DETERMINISTIC TREND	56
3.2.4	ADDITIONAL NOTES ON TRENDS IN TIME SERIES	57
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	62
3.4	UNIT ROOTS	64
3.4.1	DICKEY-FULLER TEST	66
3.4.2	AUGMENTED DICKEY-FULLER TEST	68
3.4.3	PHILLIPS-PERRON TEST	71
3.4.4	SHORTCOMINGS OF THE STANDARD UNIT ROOT TEST	72
3.4.5	KPSS TEST	73
3.5	UNIT ROOTS AND STRUCTURAL CHANGE	76
3.5.1	PERRON'S TEST	77
3.5.2	ZIVOT AND ANDREWS' TEST	81
3.6	DETECTING A STRUCTURAL CHANGE	84
3.6.1	SINGLE STRUCTURAL CHANGE	85
3.6.2	MULTIPLE STRUCTURAL CHANGE	91
3.7	CONDITIONAL HETROSKEDEASTICITY AND NON-LINEAR STRUCTURE	98
3.7.1	CONDITIONAL AND UNCONDITIONAL EXPECTATIONS	100
3.7.2	ARCH MODEL	101
3.7.3	GARCH MODEL	104
3.7.4	DETECTING CONDITIONAL HETROSKEDEASTICITY	107
3.7.5	THE BDS TEST	110
3.7.6	AN ALTERNATIVE TO THE BDS TEST: INTEGRATION ACROSS THE CORRELATION INTEGRAL	114
3.7.7	IDENTIFICATION AND ESTIMATION OF A GARCH MODEL	118
3.7.8	EXTENSIONS OF ARCH -TYPE MODELS	122

3.7.9 MULTIVARIATE (G)ARCH MODELS	129
3.7.10 STRUCTURAL BREAKS IN VOLATILITY	135
4. MULTIPLE TIME SERIES	141
4.1 VAR MODELS	143
4.1.1 STRUCTURAL FORM, REDUCED FORM, AND IDENTIFICATION	144
4.1.2 STABILITY AND STATIONARITY OF VAR MODELS	145
4.1.3 ESTIMATION OF A VAR MODEL	148
4.2 GRANGER CAUSALITY	150
4.3 COINTEGRATION AND ERROR CORRECTION MODELS	154
4.3.1 DEFINITION OF COINTEGRATION	157
4.3.2 THE ENGLE-GRANGER METHODOLOGY	162
4.3.3 EXTENSIONS TO THE ENGLE-GRANGER METHODOLOGY	168
4.3.4 THE JOHANSEN METHODOLOGY	170
5. PANEL DATA AND UNIT ROOT TESTS	177
5.1 LEVIN, LIN, AND CHU PANEL UNIT-ROOT TEST WITH A NULL OF UNIT ROOT AND LIMITED COEFFICIENTS HETEROGENEITY	178
5.2 IM, PESARAN, AND SHIN UNIT-ROOT TEST WITH A NULL OF UNIT ROOT AND HETEROGENEOUS COEFFICIENTS	181
5.3 HADRI UNIT-ROOT TESTS WITH A NULL OF STATIONARITY	184
5.4 BREUER, MCNOWN, AND WALLACE TEST FOR CONVERGENCE	186
5.5 VOGELSANG TEST FOR β -CONVERGENCE	187
APPENDIX A: MONTE CARLO SIMULATIONS	193
APPENDIX B: STATISTICAL TABLES	196
REFERENCES	202
INDEX	216