

CONTENTS

1. INTRODUCTION	1
I. SUBJECT OF TIME SERIES	3
2. RANDOM PROCESSES	5
2.1. Random processes as models for time series	5
2.2. Specific problems of time series analysis	6
2.2.1. Problems of economic and financial data observed in time	7
2.2.2. Methodological problems	9
2.2.3. Problems with construction of predictions	15
2.3. Random processes with discrete states in discrete time	27
2.4. Random processes with discrete states in continuous time	32
2.5. Random processes with continuous states in continuous time	34
2.6. Exercises	36
II. DECOMPOSITION OF ECONOMIC TIME SERIES	37
3. TREND	39
3.1. Trend in time series	40
3.1.1. Subjective methods of elimination of trend	40
3.1.2. Trend modeling by mathematical curves	41
3.2. Method of moving averages	58
3.2.1. Construction of moving averages by local polynomial fitting ..	59
3.2.2. Other types of moving averages	70
3.3. Exponential smoothing	72
3.3.1. Simple exponential smoothing	73
3.3.2. Double exponential smoothing	77
3.3.3. Holt's method	80
3.4. Exercises	82
4. SEASONALITY AND PERIODICITY	85
4.1. Seasonality in time series	85
4.1.1. Simple approaches to seasonality	87
4.1.2. Regression approaches to seasonality	91
4.1.3. Holt-Winters' method	94

4.1.4. Schlicht's method	98
4.2. Tests of periodicity	100
4.3. Transformations of time series	105
4.4. Exercises	109
5. RESIDUAL COMPONENT	111
5.1. Tests of randomness	111
5.2. Exercises	117
III. AUTOCORRELATION METHODS FOR UNIVARATE TIME SERIES ..	119
6. BOX-JENKINS METHODOLOGY	121
6.1. Autocorrelation properties of time series	122
6.2. Basic processes of Box-Jenkins methodology	126
6.3. Construction of models by Box-Jenkins methodology	133
6.3.1. Identification of model	134
6.3.2. Estimation of model	138
6.3.3. Verification of model	141
6.4. Stochastic modeling of trend	146
6.4.1. Tests of unit root	149
6.4.2. Process ARIMA	154
6.5. Stochastic modeling of seasonality	157
6.6. Predictions in Box-Jenkins methodology	161
6.7. Long memory process	166
6.8. Exercises	168
7. AUTOCORRELATION METHODS IN REGRESSION MODELS	169
7.1. Dynamic regression model	169
7.2. Linear regression models with autocorrelated residuals	171
7.3. Distributed lag model	179
7.4. Autoregressive distributed lag models	184
7.5. Exercises	187
IV. FINANCIAL TIME SERIES	189
8. VOLATILITY OF FINANCIAL TIME SERIES	191
8.1. Characteristic features of financial time series	191
8.2. Classification of nonlinear models of financial time series	195
8.3. Volatility modeling	197
8.3.1. Historical volatility and models EWMA	198
8.3.2. Implied volatility	201

8.3.3. Autoregressive models of volatility	201
8.3.4. ARCH models	202
8.3.5. GARCH models	208
8.3.6. Various modifications of GARCH models	212
8.4. Exercises	220
9. OTHER METDODS FOR FINANCIAL TIME SERIES	221
9.1. Models nonlinear in mean value	221
9.2. Further models of financial time series	230
9.3. Tests of linearity	233
9.4. Duration modeling	237
9.5. Exercises	239
10. MODELS OF DEVELOPMENT OF FINANCIAL ASSETS	241
10.1. Financial modeling in continuous time	241
10.1.1. Diffusion process	243
10.1.2. Ito's lemma and stochastic integral	244
10.1.3. Exponential Wiener process	245
10.2. Black-Scholes formula	249
10.3. Modeling of term structure of interest rates	252
10.4. Exercises	256
11. VALUE AT RISK	257
11.1. Financial risk measures	258
11.1.1. <i>VaR</i>	258
11.1.2. Other risk measures	260
11.2. Calculation of <i>VaR</i>	266
11.3. Extreme value theory	277
11.3.1. Block maxima	278
11.3.2. Threshold excesses	285
11.4. Exercises	291
V. MULTIVARIATE TIME SERIES	293
12. METHODS FOR MULTIVARIATE TIME SERIES	295
12.1. Generalization of methods for univariate time series	295
12.2. Vector autoregression VAR	303
12.3. Tests of causality	316
12.4. Impulse response and variance decomposition	319
12.5. Cointegration and EC models	322
12.6. Exercises	335

13. MULTIVARIATE VOLATILITY MODELING	337
13.1. Multivariate models EWMA	338
13.2. Implied mutual volatility	339
13.3. Multivariate GARCH models	339
13.3.1. Models of conditional covariance matrix	341
13.3.2. Models of conditional variances and correlations	344
13.3.3. Factor models	346
13.3.4. Estimation of multivariate GARCH models	347
13.4. Conditional value at risk	351
13.5. Exercises	359
14. STATE SPACE MODELS OF TIME SERIES	361
14.1. Kalman filter	361
14.1.1. Recursive estimation of multivariate GARCH models	368
14.2. State space model approach to exponential smoothing	373
14.3. Exercises	380
REFERENCES	381
INDEX	393