ST965-15 Time Series

26/27

Department
Statistics
Level
Taught Postgraduate Level
Module leader
Adam Johansen
Credit value
15
Module duration
10 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Much real data is collected over time reflecting snapshots of the state of an evolving system. This data forms time series. The statistical modelling of time series data is of widespread importance, for example in modelling financial data, traffic flows, biological systems and the motion of celestial bodies to name but a few areas. This module aims to provide the relevant statistical theory and experience in modelling, and performing inference for, time series data. Examples will be drawn from areas including, but not limited to, finance.

Pre-requisites:

- Statistics UG students: ST230 Mathematical Statistics
- MSc in Statistics students: ST961 Statistical Methods and Practice
- MSc in Mathematical Finance students: ST959 Financial Statistics

Module web page

Module aims

The course covers exploratory and descriptive techniques for various features, such as trend, global and local level, seasonality, linear and non-linear dependence, short and long memory dependence, directionality and volatility. Both linear and non-linear models are equally developed.

Linear autoregressive moving average and nonlinear locally non- constant variance models are covered. Their application to volatile financial series of returns, interest and exchange rates will be considered. The flexible state space modelling framework is contrasted with more classical time series models. Ways of fitting these models to time series data, methods of their statistical validation and their use in forecasting, trading systems, fund manager evaluation and simulation are covered.

The course aims to give practical experience in the analysis of time series via examples and exercises. Students attending this course should be able to model and analyse financial time series data, and to extend and develop methodology as required; further, to understand and be able to critically evaluate times series developments and research results.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

1. Time series: stochastic processes with discrete index set. Examples thereof. Exploratory data analysis for time series. Smoothing, e.g. Savitzky-Golay, and the Slutzky-Yule effect.
2. Notions of stationarity: strict and second order. Autocorrelation and partial autocorrelation.
3. Level, trend and seasonality. Price and return data as exemplars (including high-frequency data). Directionality.
4. Linear models of time series. AR, MA, ARMA Models and selected extensions if time permits. Forecasting.
5. Model selection; additional considerations with AIC in time-series contexts.
6. Nonlinear modelling; ARCH and GARCH models. Combining ARMA and GARCH models and the need for still greater flexibility.
7. Hidden Markov models; state space models; switching state space models. The concepts of filtering, smoothing, prediction and forecasting as well as parameter inference and model selection in this context.
8. State-space representations of ARMA models.
9. Extended example of state space modelling: Stochastic volatility. Switching stochastic volatility.

Learning outcomes

By the end of the module, students should be able to:

- Evaluate and apply techniques of time series analysis.
- Initiate an exploratory and then create a descriptive analysis of time series data, with reference to applications including those in finance.
- Derive statistical properties of linear and nonlinear time series models.
- Apply nonlinearity in time series modelling in a variety of situations.
- Create modelling studies of time series involving forecasting and simulation covering model choice, fitting and validation.

Indicative reading list

Reading lists can be found in Talis

Specific reading list for the module

Subject specific skills

- Demonstrate facility with rigorous probabilistic methods.
- Evaluate, select and apply appropriate mathematical and/or probabilist techniques.
- Demonstrate knowledge of and facility with formal probability concepts which are used for probabilistic modelling for example in mathematical finance.
- Create structured and coherent arguments communicating them in written form.
- Construct logical mathematical arguments with clear identification of assumptions and conclusions.
- Reason critically, carefully, and logically and derive (prove) mathematical results.

Transferable skills

- Problem solving: Use rational and logical reasoning to deduce appropriate and well-reasoned conclusions. Retain an open mind, optimistic of finding solutions, thinking laterally and creatively to look beyond the obvious. Know how to learn from failure.
- Self awareness: Reflect on learning, seeking feedback on and evaluating personal practices, strengths and opportunities for personal growth.
- Communication: Present arguments, knowledge and ideas, in a range of formats.
- Professionalism: Prepared to operate autonomously. Aware of how to be efficient and resilient. Manage priorities and time. Self-motivated, setting and achieving goals, prioritising tasks.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Private study	118 hours (79%)
Assessment	2 hours (1%)
Total	150 hours

Private study description

Reviewing lecture notes, working through exercise sheet and preparing for examination.

Other activity description

Revision support equivalent to approximately 2 hours.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B1

Assessment component	Weighting	Study time	Eligible for self-certification
Centrally-timetabled examination (On-campus)	100%	2 hours	No

An examination containing a range of questions covering the module content.
The study time noted refers to the length of the exam in hours.

- Students may use a calculator
- Answerbook Pink (12 page)

Reassessment component is the same

Feedback on assessment

Solutions and cohort level feedback will be provided for the examination.

Past exam papers for ST965

Availability

Courses

This module is Optional for:

- Year 1 of TIBS-N3G2 Postgraduate Taught Mathematical Finance
- TSTA-G4P1 Postgraduate Taught Statistics
    - Year 1 of G4P1 Statistics (Taught)
    - Year 1 of G40B Statistics with Data Science (Taught)
    - Year 1 of G40B Statistics with Data Science (Taught)
    - Year 1 of G40C Statistics with Finance (Taught)
    - Year 1 of G40C Statistics with Finance (Taught)
    - Year 1 of G40A Statistics with Probability (Taught)
    - Year 1 of G40A Statistics with Probability (Taught)
- Year 4 of USTA-G304 Undergraduate Data Science (MSci)
- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
    - Year 4 of G30A Master of Maths, Op.Res, Stats & Economics (Actuarial and Financial Mathematics Stream)
    - Year 4 of G30J Master of Maths, Op.Res, Stats & Economics (Data Analysis Stream)
    - Year 4 of G30B Master of Maths, Op.Res, Stats & Economics (Econometrics and Mathematical Economics Stream)
    - Year 4 of G30C Master of Maths, Op.Res, Stats & Economics (Operational Research and Statistics Stream)
    - Year 4 of G30C Master of Maths, Op.Res, Stats & Economics (Operational Research and Statistics Stream)
    - Year 4 of G30D Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
    - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics
    - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics
    - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)