ST909-15 Applications of Stochastic Calculus in Finance

21/22

Department
Statistics
Level
Taught Postgraduate Level
Module leader
Gechun Liang
Credit value
15
Module duration
9 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module is available for students on a course where it is a listed option (subject to restrictions*) and as an Unusual Option to students who have completed the prerequisite modules.

Pre-requisites:
ST401 Stochastic Methods in Finance or ST403 Brownian Motion or ST908 Probability and Stochastic Processes (non Statistics students)

*Students who are not enrolled on the MSc in Mathematical Finance may take at most two of;
ST909 Application of Stochastic Calculus in Finance,
ST958 Advanced Trading Strategies,
ST420 Statistical Learning and Big Data.

Module web page

Module aims

To give a thorough understanding of how stochastic calculus is used in continuous time finance.
To develop an in-depth understanding of models used for various asset classes.

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.

Option Pricing and Hedging in Continuous Time

- Pricing Europeans via equivalent martingale measures, numeraire, fundamental valuation formula, arbitrage and admissible strategies
- Pricing Europeans via PDEs (brief review)
- Completeness for the Black Scholes economy
- Implied volatility, market implied distributions, Dupire
- Stochastic volatility and incomplete markets
- Pricing a vanilla swaption, Black's formula for a PVBP-digital swaption
- Multicurrency Economy
- Black-Scholes economy with dividends
- Economy with possibility of default CVA, DVA of a vanilla swap
  Applications across Asset classes
  Interest Rates: Term Structure Models
- Short rate models. Introduction to main examples, implementation of Hull-White
- Market Models (Brace, Gaterek and Musiela approach), specification in terminal and spot measure
- Pricing callable interest rate derivatives with market models, drift approximation and separability, implementation via Longstaff-Schartz
- Greeks via Monte Carlo for market models, pathwise method, likelihood ratio method.
- Markov-functional models
- Practical issues in choice of model for various exotics, Bermudan swaptions
- Calibration: global versus local
- Stochastic volatility models, SABR
  Credit
- Description of main credit derivative products: CDS, First-to-default swaps, CDOs
- Extension of integration by parts, Ito's formula, Doleans exponential to cover jumps
- Martingale characterization of single jump processes, Girsanov's Theorem
- State variable, default and enlarged filtrations
- Filtration switching formula
- Intensity-correlation versus default-events correlation
- Conditional Jump Diffusion approach to modelling of default correlation
  FX
- Stochastic local volatility models, calibration,
- Gyongy's Theorem
- Barrier options
  Time permitting
  Equity
- Dividends
- Volatility as an asset class, variance swaps, volatility derivatives
- Heston model

Learning outcomes

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

- Demonstrate an advanced theoretical knowledge of the main models currently used across asset classes in the market, an appreciation of calibration and implementation issues concerning these models and a sufficient grounding in the tools of stochastic calculus to be able to keep abreast of new advances.
- Appreciate the practical issues in the implementation of models in the commercial setting and sufficient familiarity with the main models to enable implementation to be carried out.
- Critically assess the suitability of a particular model for a given product.
- Research new advances in modelling which is an important skill in the fast changing market setting.
- Carry out relevant calculations using knowledge of stochastic calculus when faced with implementing an unfamiliar model.

Indicative reading list

- Bergomi L (2016) Stochastic volatility modelling, Chapman and Hall
- Buehler H (2009) Volatility Markets: Consistent Modeling, Hedging and Practical Implementation of Variance Swap Market Models VDM Verlag Dr. Muller
- Elouerkhaoui, Y (2017), Credit Correlation: Theory and Practice, Macmillan.
- Hunt PJ and Kennedy JE, (2004), Financial Derivatives in Theory and Practice, second edition, Wiley.
- Homescu, C, Local Stochastic Volatility Models: Calibration and Pricing (2014)
- Available at SSRN: https:fissrn.com/abstract=2448098 or htto://dx.doi.org/10.2139/ssrn.2448098
- Pelsser A, (2000), Efficient Methods for Valuing Interest Rate Derivatives, Springer.
- Glasserman P, (2004), Monte Carlo Methods in Financial Engineering, Springer.
- Gatheral J, (2006) The Volatility Surface: A Practitioners Guide, Wiley

Subject specific skills

-Demonstrate an advanced theoretical knowledge of the main models currently used across asset classes in the market, an appreciation of calibration and implementation issues concerning these models and a sufficient grounding in the tools of stochastic calculus to be able to keep abreast of new advances.
-Appreciate the practical issues in the implementation of models in the commercial setting and sufficient familiarity with the main models to enable implementation to be carried out.
-Critically assess the suitability of a particular model for a given product.
Research new advances in modelling which is an important skill in the fast changing market setting.
-Carry out relevant calculations using knowledge of stochastic calculus when faced with implementing an unfamiliar model.

Transferable skills

TBC

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Tutorials	10 sessions of 1 hour (7%)
Private study	110 hours (73%)
Total	150 hours

Private study description

Weekly revision of lecture notes and materials, wider reading, practice exercises and preparing for examination.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group D3

	Weighting	Study time
Class Test 1	10%	

This class test will take place during a lecture in week 8 of term 2.

Class Test 2	10%	

This class test will take place during a lecture in week 10 of term 2.

Locally Timetabled Examination	80%	

The examination paper will contain four questions, of which the best marks of THREE questions will be used to calculate your grade.

Assessment group R1

	Weighting	Study time
Locally Timetabled Examination - Resit	100%	

Feedback on assessment

Feedback on class tests will be returned after 4 weeks, following each test.

Solutions and cohort level feedback will be returned for the examinations.

Examination scripts are retained for the external examiners and will not be returned to you.

Past exam papers for ST909

Availability

Courses

This module is Core for:

- Year 1 of TIBS-N3G1 Postgraduate Taught Financial Mathematics

This module is Optional for:

- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
  - Year 3 of G300 Mathematics, Operational Research, Statistics and Economics
  - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics

This module is Option list A for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 5 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)

This module is Option list B for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated

This module is Option list D for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational

Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated

This module is Option list E for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated