

# ST909-15 Applications of Stochastic Calculus in Finance

**23/24**

**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

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## 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, Gatarek 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://ssrn.com/abstract=2448098> or <http://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

## 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.

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## 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

	<b>Weighting</b>	<b>Study time</b>
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](#)

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## **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:

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

## Economics

- 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 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