

# Quantitative Finance Investment Advanced Exam

Fall 2018/Spring 2019

## Important Exam Information:

<a href="#">Exam Registration</a>	Candidates may register online or with an application.
<a href="#">Order Study Notes</a>	Study notes are part of the required syllabus and are not available electronically but may be purchased through the online store.
<a href="#">Introductory Study Note</a>	The Introductory Study Note has a complete listing of all study notes as well as errata and other important information.
Case Study	There is no case study for this examination.
<a href="#">Past Exams</a>	Past Exams from 2000-present are available on SOA website.
<a href="#">Updates</a>	Candidates should be sure to check the Updates page on the exam home page periodically for additional corrections or notices.
Formula Package	A Formula Package will be provided with the exam. Please see the Introductory Study Note for more information.
<a href="#">Table</a>	A Cumulative normal distribution table will be provided with the exam.

*Recognized by the Canadian Institute of Actuaries*

## 1. Topic: Advanced Option Pricing

### Learning Objectives

The candidate will understand:

- A) Approaches to volatility modeling.
- B) The standard yield curve models, including:
  - One and two-factor short rate models.
  - LIBOR market models.

### Learning Outcomes

The Candidate will be able to:

- a) Identify and differentiate the features of the classic short rate models including the Vasicek and the Cox-Ingersoll-Ross (CIR) models
- b) Understand and explain the terms Time Homogeneous Models, Affine Term Structure Models and Affine Coefficient models and explain their significance in the context of short rate interest models
- c) Explain the dynamics of and motivation for the Hull-White extension of the Vasicek model
- d) Explain the features of the Black-Karasinski model
- e) Understand and explain the relationship between market-quoted caplet volatilities and model volatilities
- f) Explain how deterministic shifts can be used to fit any given interest rate term structure
- g) Demonstrate an understanding of the CIR++ model
- h) Understand and explain the features of the G2++ model, including: The motivation for more than one factor, calibration approaches, the pricing of bonds and options, and the model's relationship to the two-factor Hull-White model
- i) Explain the set up and motivation of the lognormal Forward LIBOR Model (LFM)
- j) Describe the calibration of the LFM to Cap and Floor prices
- k) Explain the LFM drift terms and their dependence on the calibration and choice of numeraire
- l) Define and explain the concept of volatility smile and some arguments for its existence
- m) Calculate the hedge ratio for a call option given the dependency of the Black-Scholes volatility on the underlying
- n) Compare and contrast "floating" and "sticky" smiles
- o) Calculate the risk-neutral density given call option prices
- p) Identify several stylized empirical facts about smiles in a variety of options markets
- q) Describe and contrast several approaches for modeling smiles, including: Stochastic Volatility, local-volatility, jump-diffusions, variance-gamma and mixture models
- r) Describe and explain various issues and approaches for fitting a volatility surface

**Resources**

- *Interest Rate Models - Theory and Practice: With Smile, Inflation and Credit*, Brigo, Damiano and Mercurio, Fabio, 2<sup>nd</sup> Edition, 2007
  - Ch. 1-2 (background only)
  - Ch.3 (sections 3.1-3.3, 3.5-3.6, 3.8-3.9)
  - Ch. 4 (sections 4.1-4.2, excluding Appendices)
  - Ch. 5 (sections 5.1-5.2, background only)
  - Ch. 6 (sections 6.1-6.4)
- *Volatility Correlation – The Perfect Hedger and the Fox*, Rebonato, Riccardo, 2<sup>nd</sup> Edition, 2004
  - Ch. 6
  - Ch. 7
  - Ch. 8 (sections 8.1-8.5)
  - Ch. 9 (sections 9.1-9.9)
- QFIA-121-16: Companion Note to Brigo & Mercurio: *Interest Rate Models - Theory and Practice: With Smile, Inflation and Credit*

## 2. Topic: Credit Risk

### Learning Objectives

The candidate will understand and be able to apply a variety of credit risk theories and models.

### Learning Outcomes

The Candidate will be able to:

- a) Demonstrate an understanding of events and causes of the 2008 global credit crisis
- b) Demonstrate an understanding of the basic concepts of credit risk modeling such as probability of default, loss given default, exposure at default, and expected loss
- c) Demonstrate an understanding of credit valuation models
- d) Demonstrate an understanding of Merton asset value models in the context of credit risk
- e) Demonstrate an understanding of the term structure of default probability
- f) Demonstrate an understanding of modeling approaches for correlated defaults
- g) Demonstrate an understanding of, and be able to apply the concept of Duration Times Spread (DTS)
- h) Demonstrate an understanding of credit default swaps (CDS) and the bond-CDS basis, including the use of CDS in portfolio and trading contexts
- i) Demonstrate an understanding of CDS valuations
- j) Demonstrate an understanding of mortgage default models in the valuation of MBS
- k) Demonstrate an understanding of measuring and marking-to-market counterparty credit risk in credit derivatives
- l) Understand and apply various approaches for managing credit risk in a portfolio setting
- m) Demonstrate an understanding of the rationale, markets and risks of structured finance

### Resources

- *Handbook of Fixed Income Securities*, Fabozzi, Frank J., 8<sup>th</sup> Edition, 2012
  - Ch. 66 and 67
- *Introduction To Credit Risk Modeling*, Bluhm, Christian, 2<sup>nd</sup> Edition, 2010
  - Ch. 1
  - Ch. 2 (sections 2.1-2.7)
  - Ch. 3
  - Ch.6
- *Quantitative Credit Portfolio Management*, Ben-Dor, et. al.
  - Ch. 1-4
- QFIA-100-13: Modeling of Mortgage Defaults, Jan 22, 2008 (pp. 5- 38; 13-25 background only)

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- QFIA-101-13: *Managing Credit Risk: The Great Challenge for Global Financial Markets*, Caouette, John B., et. al., 2<sup>nd</sup> Edition, 2008, Ch. 20 and 24
- QFIA-103-13: Bond-CDS Basis Handbook, pp. 3-48
- QFIA-104-13: *Asset/Liability Management of Financial Institutions*, Tilman, Leo M., 2003, Ch.9
- QFIA-122-16: Recent Advances in Credit Risk Modeling

### 3. Topic: Liquidity Risk

#### Learning Objectives

The candidate will understand the nature, measurement and management of liquidity risk in financial institutions.

#### Learning Outcomes

The Candidate will be able to:

- a) Demonstrate an understanding of the concept of liquidity risk and the threat it represents to financial intermediaries and markets
- b) Measure and monitor liquidity risk, using various liquidity measurement tools and ratios
- c) Demonstrate an understanding of the levels of liquidity available with various asset types and the impact on a company's overall liquidity risk
- d) Demonstrate an understanding of liability termination provisions such as book-value surrender and the impact on a company's overall liquidity risk
- e) Apply liquidity risk models, including modeling cash flow of various types of assets (e.g. indeterminate maturity assets) and liabilities
- f) Apply liquidity scenario analysis with various time horizons
- g) Understand and apply techniques to manage stress liquidity risk
- h) Create liquidity risk management plans and procedures, including addressing appropriate product design, investment guidelines, and reporting given a desired liquidity risk level

#### Resources

- *Quantitative Credit Portfolio Management*, Ben-Dor, et. al., 2012
  - Ch. 5 and 6
- QFIA-105-13: Report of the Life Liquidity Work Group of the American Academy of Actuaries to the Life Liquidity Risk Working Group of the NAIC (final)
- QFIA-106-13: *Liquidity Risk: Measurement and Management - A Practitioner's Guide to Global Best Practices*, Matz, Leonard & Neu, Peter, 2006, Ch. 3
- QFIA-117-13: Reflections on Northern Rock: The Bank Run that Heralded the Global Financial Crisis
- QFIA-123-16: Liquidity Risk Management

#### 4. Topic: Additional Quantitative Techniques

##### Learning Objectives

The candidate will understand important quantitative techniques relating to financial time series, performance measurement, performance attribution and stochastic modeling.

##### Learning Outcomes

The Candidate will be able to:

- a) Demonstrate an understanding of the concept of a factor model in the context of financial time series
- b) Apply various techniques for analyzing factor models including Principal Component Analysis (PCA) and Statistical Factor Analysis
- c) Describe and assess performance measurement methodologies for assets portfolios
- d) Describe and assess techniques that can be used to select or build a benchmark for a given asset, portfolio
- e) Recommend a benchmark for a given asset or portfolio
- f) Calculate and interpret performance attribution metrics for a given asset, portfolio
- g) Explain the limitations of attribution techniques
- h) Understand and apply various techniques of adjusting auto-correlated returns for certain asset classes
- i) Demonstrate an understanding of the general uses and techniques of stochastic modeling

##### Resources

- *Handbook of Fixed Income Securities*, Fabozzi, F.J., 8<sup>th</sup> Edition, 2012
  - Ch. 69 and 70
- QFIA-110-13: *CAIA Level II, Advanced Core Topics in Alternative Investment*, 2<sup>nd</sup> Edition, 2012, Ch. 16
- QFIA-119-14: *Analysis of Financial Time Series*, Tsay, 3<sup>rd</sup> edition, Ch. 9
- QFIA-124-16: *IAA, Stochastic Modeling, Theory and Reality from and Actuarial Perspective*, sections I-1 to I-29 and II-1 to II-24
- QFIA-125-16: *Market Models: A Guide for Financial Data Analysis*, Ch. 6, Principal Component Analysis

<b>5. Topic: Behavioral Finance</b>
<b>Learning Objectives</b>
The candidate will understand the behavior characteristics of individuals and firms, and be able to identify and apply concepts of behavioral finance.
<b>Learning Outcomes</b>
The Candidate will be able to: <ul style="list-style-type: none"><li>a) Explain how behavioral characteristics of individuals or firms affect the investment or capital management process</li><li>b) Describe how behavioral finance explains the existence of some market anomalies.</li><li>c) Identify and apply the concepts of behavioral finance with respect to individual investors, institutional investors, portfolio managers, fiduciaries and corporate managers</li></ul>
<b>Resources</b>
<ul style="list-style-type: none"><li>• QFIA-108-13: Behavioral Finance and Investment Committee Decision Making</li><li>• QFIA-109-13: A Survey of Behavioral Finance</li></ul>



## 6. Topic: Alternative Assets

### Learning Objectives

The candidate will:

- A) Understand and be able to describe the variety and assess the role of alternative assets in investment portfolios.
- B) Demonstrate an understanding of the distinguishing investment characteristics and potential contributions to investment portfolios of the following major alternative asset groups:
  - Real Estate
  - Private Equity
  - Commodities
  - Hedge Funds
  - Managed Futures
  - Distressed Securities
  - Infrastructure

### Learning Outcomes

The Candidate will be able to:

- a) Demonstrate an understanding of the types of investments available in each market and their most important differences for an investor
- b) Demonstrate an understanding of the benchmarks available to evaluate the performance of alternative investment managers and the limitations of the benchmarks
- c) Demonstrate an understanding of the investment strategies and portfolio roles that are characteristic of each alternative investment
- d) Demonstrate an understanding of the due diligence process for alternative investments
- e) Demonstrate an understanding of infrastructure investments

### Resources

- QFIA-111-13: Maginn & Tuttle, *Managing Investment Portfolios*, 3<sup>rd</sup> Ed. 2007, Ch. 8
- QFIA-112-13: *Commercial Real Estate Analysis & Investment*, Ch. 12
- QFIA-113-13: Secular and Cyclic Determinants of Capitalization Rates: The Role of Property Fundamentals, Macroeconomic Factors and “Structural Changes”
- QFIA-126-16: Infrastructure as an Asset Class

## 7. Topic: Liability Manufacturing/Management

### Learning Objectives

The candidate will understand various investment related considerations with regard to liability manufacturing and management.

### Learning Outcomes

The Candidate will be able to:

- a) Identify and evaluate the impact of embedded options in liabilities, specifically indexed annuity and variable annuity guarantee riders (GMAB, GMDB, GMWB and GMIB)
- b) Demonstrate an understanding of risks associated with guarantee riders including: market, insurance, policyholder behavior, basis, credit, regulatory and accounting
- c) Demonstrate an understanding risk management and dynamic hedging for existing GMxB and its embedded options – including:
  - i. Hedgeable components include equity, interest rate, volatility and cross Greeks
  - ii. Partially hedgeable or unhedgeable components include policyholder behavior, mortality and lapse, basis risk, counterparty exposure, foreign bonds and equities, correlation and operation failures
  - iii. Static vs. dynamic hedging
- d) Demonstrate an understanding of target volatility funds and their impact on option costs
- e) Demonstrate an understanding of how differences between models of markets and actual market and policyholder behaviors affect the risks associated with equity linked guarantees
- f) Demonstrate an understanding of projection methods of Greeks (for embedded options in variable annuities) based on:
  - i. Fully nested stochastic simulation
  - ii. Fitted proxy functions based on the Least Square Monte Carlo method
- g) Demonstrate an understanding of liability driven investing (LDI) for pension plans

### Resources

- QFIA-115-13: IAA, *Stochastic Modeling, Theory and Reality from and Actuarial Perspective* IV.A.1-8
- QFIA-116-13: The Impact of Stochastic Volatility on Pricing, Hedging and Hedge Efficiency of Withdrawal Benefit Guarantees in Variable Annuities
- QFIA-120-15: Guarantees and Target Volatility Funds
- QFIA-127-16: Proxy functions for the projection of Variable Annuity Greeks
- QFIA-128-18: The Evolution of LDI & Role of a Completion Manager
- QFI-129-18: Equity Indexed Annuities - Downside Protection, But at What Cost?
- [On the Importance of Hedging Dynamic Lapses in Variable Annuities](#), Risk and Rewards, 2015 issue 66 (pp. 12-16)