MARKET RISK MEASUREMENT AND MANAGEMENT

PART II EXAM WEIGHT | 20% (MR)

This area focuses on market risk measurement and management techniques. The broad knowledge points covered in Market Risk Measurement and Management include the following:

- VaR and other risk measures
  - Parametric and non-parametric methods of estimation
  - VaR mapping
  - Backtesting VaR
  - Expected shortfall (ES) and other coherent risk measures
  - Extreme Value Theory (EVT)
- Modeling dependence: correlations and copulas
- Term structure models of interest rates
- Volatility: smiles and term structures
- Fundamental Review of the Trading Book (FRTB)

The readings that you should focus on for this section and the specific learning objectives to achieve with each reading are:

Kevin Dowd, *Measuring Market Risk, 2nd Edition* (West Sussex, UK: John Wiley & Sons, 2005).
Chapter 3. Estimating Market Risk Measures: An Introduction and Overview [MR–1]

After completing this reading, you should be able to:

- Estimate VaR using a historical simulation approach.
- Estimate VaR using a parametric approach for both normal and lognormal return distributions.
- Estimate the expected shortfall given profit and loss (P&L) or return data.
- Estimate risk measures by estimating quantiles.
- Evaluate estimators of risk measures by estimating their standard errors.
- Interpret quantile-quantile (QQ) plots to identify the characteristics of a distribution.

Chapter 4. Non-parametric Approaches [MR–2]

After completing this reading, you should be able to:

- Apply the bootstrap historical simulation approach to estimate coherent risk measures.
- Describe historical simulation using non-parametric density estimation.
- Compare and contrast the age-weighted, the volatility-weighted, the correlation-weighted, and the filtered historical simulation approaches.
- Identify advantages and disadvantages of non-parametric estimation methods.

Chapter 7. Parametric Approaches (II): Extreme Value [MR–3]

After completing this reading, you should be able to:

- Explain the importance and challenges of extreme values in risk management.
- Describe extreme value theory (EVT) and its use in risk management.
- Describe the peaks-over-threshold (POT) approach.
- Compare and contrast the generalized extreme value (GEV) and POT approaches to estimating extreme risks.
- Discuss the application of the generalized Pareto (GP) distribution in the POT approach.
- Explain the multivariate EVT for risk management.

Philippe Jorion, *Value at Risk: The New Benchmark for Managing Financial Risk, 3rd Edition* (New York, NY: McGraw-Hill, 2007).

Chapter 6. Backtesting VaR [MR–4]

After completing this reading, you should be able to:

- Describe backtesting and exceptions and explain the importance of backtesting VaR models.
- Explain the significant difficulties in backtesting a VaR model.
- Verify a model based on exceptions or failure rates.
- Identify and describe Type I and Type II errors in the context of a backtesting process.
- Explain the need to consider conditional coverage in the backtesting framework.
- Describe the Basel rules for backtesting.

Chapter 11. VaR Mapping [MR–5]

After completing this reading, you should be able to:

- Explain the principles underlying VaR mapping and describe the mapping process.
- Explain and demonstrate how the mapping process captures general and specific risks.
- Differentiate among the three methods for mapping portfolios of fixed-income securities.
- Summarize how to map a fixed-income portfolio into positions of standard instruments.
- Describe how mapping of risk factors can support stress testing.
- Explain how VaR can be computed and used relative to a performance benchmark.
- Describe the method of mapping forwards, forward rate agreements, interest rate swaps, and options.

Messages from the academic literature on risk measurement for the trading book, Basel Committee on Banking Supervision, Working Paper, No. 19, January 2011. [MR–6]

After completing this reading, you should be able to:

- Explain the following lessons on VaR implementation: time horizon over which VaR is estimated, the recognition of time-varying volatility in VaR risk factors, and VaR backtesting.
- Describe exogenous and endogenous liquidity risk and explain how they might be integrated into VaR models.
- Compare VaR, expected shortfall, and other relevant risk measures.
- Compare unified and compartmentalized risk measurement.
- Compare the results of research on top-down and bottom-up risk aggregation methods.
- Describe the relationship between leverage, market value of asset, and VaR within an active balance sheet management framework.

Gunter Meissner, *Correlation Risk Modeling and Management, 2nd Edition* (Risk Books, 2019).

Chapter 1. Correlation Basics: Definitions, Applications, and Terminology [MR–7]

After completing this reading, you should be able to:

- Describe financial correlation risk and the areas in which it appears in finance.
- Explain how correlation contributed to the global financial crisis of 2007-2009.
- Describe how correlation impacts the price of quanto options as well as other multi-asset exotic options.
- Describe the structure, uses, and payoffs of a correlation swap.
- Estimate the impact of different correlations between assets in the trading book on the VaR capital charge.
- Explain the role of correlation risk in market risk and credit risk.
- Relate correlation risk to systemic and concentration risk.

Chapter 2. Empirical Properties of Correlation: How Do Correlations Behave in the Real World? [MR–8]

After completing this reading, you should be able to:

- Describe how equity correlations and correlation volatilities behave throughout various economic states.
- Calculate a mean reversion rate using standard regression and calculate the corresponding autocorrelation.
- Identify the best-fit distribution for equity, bond, and default correlations.

Chapter 5. Financial Correlation Modeling — Bottom-Up Approaches (pages 126-134 only) [MR–9]

After completing this reading, you should be able to:

- Explain the purpose of copula functions and how they are applied in finance.
- Describe the Gaussian copula and explain how to use it to derive the joint probability of default of two assets.
- Summarize the process of finding the default time of an asset correlated to all other assets in a portfolio using the Gaussian copula.

Bruce Tuckman and Angel Serrat, *Fixed Income Securities: Tools for Today's Markets, 3rd Edition* (Hoboken, NJ: John Wiley & Sons, 2011).

Chapter 6. Empirical Approaches to Risk Metrics and Hedging [MR–10]

After completing this reading, you should be able to:

- Explain the drawbacks to using a DV01-neutral hedge for a bond position.
- Describe a regression hedge and explain how it can improve a standard DV01-neutral hedge.
- Calculate the regression hedge adjustment factor, beta.
- Calculate the face value of an offsetting position needed to carry out a regression hedge.
- Calculate the face value of multiple offsetting swap positions needed to carry out a two-variable regression hedge.
- Compare and contrast level and change regressions.
- Describe principal component analysis and explain how it is applied to constructing a hedging portfolio.

Chapter 7. The Science of Term Structure Models [MR–11]

After completing this reading, you should be able to:

- Calculate the expected discounted value of a zero-coupon security using a binomial tree.
- Construct and apply an arbitrage argument to price a call option on a zero-coupon security using replicating portfolios.
- Define risk-neutral pricing and apply it to option pricing.
- Distinguish between true and risk-neutral probabilities and apply this difference to interest rate drift.
- Explain how the principles of arbitrage pricing of derivatives on fixed-income securities can be extended over multiple periods.
- Define option-adjusted spread (OAS) and apply it to security pricing.

- Describe the rationale behind the use of recombining trees in option pricing.
- Calculate the value of a constant-maturity Treasury swap, given an interest rate tree and the risk-neutral probabilities.
- Evaluate the advantages and disadvantages of reducing the size of the time steps on the pricing of derivatives on fixed-income securities.
- Evaluate the appropriateness of the Black-Scholes-Merton model when valuing derivatives on fixed-income securities.

Chapter 8. The Evolution of Short Rates and the Shape of the Term Structure [MR–12]

After completing this reading, you should be able to:

- Explain the role of interest rate expectations in determining the shape of the term structure.
- Apply a risk-neutral interest rate tree to assess the effect of volatility on the shape of the term structure.
- Estimate the convexity effect using Jensen's inequality.
- Evaluate the impact of changes in maturity, yield, and volatility on the convexity of a security.
- Calculate the price and return of a zero-coupon bond incorporating a risk premium.

Chapter 9. The Art of Term Structure Models: Drift [MR–13]

After completing this reading, you should be able to:

- Construct and describe the effectiveness of a short-term interest rate tree assuming normally distributed rates, both with and without drift.
- Calculate the short-term rate change and standard deviation of the rate change using a model with normally distributed rates and no drift.
- Describe methods for addressing the possibility of negative short-term rates in term structure models.
- Construct a short-term rate tree under the Ho-Lee Model with time-dependent drift.
- Describe uses and benefits of the arbitrage-free models and assess the issue of fitting models to market prices.
- Describe the process of constructing a simple and recombining tree for a short-term rate under the Vasicek Model with mean reversion.
- Calculate the Vasicek Model rate change, standard deviation of the rate change, expected rate in T years, and half-life.
- Describe the effectiveness of the Vasicek Model.

Chapter 10. The Art of Term Structure Models: Volatility and Distribution [MR–14]

After completing this reading, you should be able to:

- Describe the short-term rate process under a model with time-dependent volatility.
- Calculate the short-term rate change and determine the behavior of the standard deviation of the rate change using a model with time-dependent volatility.
- Assess the efficacy of time-dependent volatility models.
- Describe the short-term rate process under the Cox-Ingersoll-Ross (CIR) and lognormal models.
- Calculate the short-term rate change and describe the basis point volatility using the CIR and lognormal models.
- Describe lognormal models with deterministic drift and mean reversion.

John C. Hull, *Options, Futures, and Other Derivatives, 10th Edition* (New York, NY: Pearson, 2017).
Chapter 20. Volatility Smiles [MR–15]

After completing this reading, you should be able to:

- Describe a volatility smile and volatility skew.
- Explain the implications of put-call parity on the implied volatility of call and put options.
- Compare the shape of the volatility smile (or skew) to the shape of the implied distribution of the underlying asset price and to the pricing of options on the underlying asset.

- Describe characteristics of foreign exchange rate distributions and their implications on option prices and implied volatility.
- Describe the volatility smile for equity options and foreign currency options and provide possible explanations for its shape.
- Describe alternative ways of characterizing the volatility smile.
- Describe volatility term structures and volatility surfaces and how they may be used to price options.
- Explain the impact of the volatility smile on the calculation of an option's Greek letter risk measures.
- Explain the impact of a single asset price jump on a volatility smile.

John C. Hull, *Risk Management and Financial Institutions 5th Edition* (Hoboken, NJ: John Wiley & Sons, 2018). Chapter 18. Fundamental Review of the Trading Book [MR-16]

After completing this reading, you should be able to:

- Describe the changes to the Basel framework for calculating market risk capital under the Fundamental Review of the Trading Book (FRTB) and the motivations for these changes.
- Compare the various liquidity horizons proposed by the FRTB for different asset classes and explain how a bank can calculate its expected shortfall using the various horizons.
- Explain the FRTB revisions to Basel regulations in the following areas:
  - Classification of positions in the trading book compared to the banking book.
  - Backtesting, profit and loss attribution, credit risk, and securitizations.