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# Swaps

## and other derivatives

Second Edition

RICHARD FLAVELL

# Swaps and Other Derivatives

Second Edition

**Richard Flavell**



 **WILEY**

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## Preface

### **EXTRACT FROM THE PREFACE TO THE FIRST EDITION**

This book is designed for financial professionals to understand how the vast bulk of OTC derivatives are used, structured, priced and hedged, and ultimately how to use such derivatives themselves. A wide range of books already exist that describe in conceptual terms how and why such derivatives are used, and it is not the ambition of this book to supplant them. There are also a number of books which describe the pricing and hedging of derivatives, especially exotic ones, primarily in mathematical terms. Whilst exotics are an important and growing segment of the market, by far the majority of derivatives are still very much first generation, and as such relatively straightforward.

For example, interest rate swaps constitute over half of the \$100 trillion OTC derivative market, and yet there have been few books published in the last decade that describe how they are created and valued in practical detail. So how do many of the professionals gain their knowledge? One popular way is “learning on the job”, reinforced by the odd training course. But swap structures can be quite complex, requiring more than just superficial knowledge, and probably every professional uses a computer-based system, certainly for the booking and regular valuation of trades, and most likely for their initial pricing and risk management. These systems are complex, having to deal with real-world situations, and their practical inner details bear little resemblance to the idealised world of most books. So often, practitioners tend to treat the systems as black boxes, relying on some initial and frequently inadequate range of tests, and hoping their intuition will guide them. The greatest sources of comfort are often the existing customer list of the system (they can’t all be wrong!) and, if the system is replacing an old one, comparative valuations.

The objective of this book is to describe how the pricing, valuation and risk management of generic OTC derivatives may be performed, in sufficient detail and with various alternatives, so that the approaches may be applied in practice. It is based upon some 15 years of varying experience as a financial engineer for ANZ Merchant Bank in London, as a trainer and consultant to banks worldwide, and as Director of Financial Engineering at Lombard Risk Systems responsible for all the mathematics in the various pricing and risk management systems.

The audience for the book is, first, traders, sales people and front-line risk managers. But increasingly such knowledge needs to be more widely spread within financial institutions, such as internal audit, risk control, and IT. Then there are the counterparties such as

organisations using derivatives for risk management, who have frequently identified the need for transparent pricing. This need has been exacerbated in recent years as many developed countries now require that these organisations demonstrate the effectiveness of risk management, and also perform regular (usually annual) mark-to-market. Similarly, organisations using complex funding structures want to understand how the structures are created and priced. Turning to the other side, many fund managers and in particular hedge funds are also using derivatives to manage their risk profile, and then to report using one of the Value-at-Risk techniques. This has been particularly true since the collapse of Long Term Capital Management, despite the fact that most implementations of VaR would not have recognised the risk. Other potential readers are the auditors, consultants, and regulators of the banks and their client organisations.

## PREFACE TO THE SECOND EDITION

Many of the above statements are still true. The swap market has continued to grow six-fold over the intervening years, to a staggering \$328 trillion. Yet, there has been little published to provide guidance and assistance to the professionals in the market. Why was it thought useful to write a second edition? There were two main reasons. First, many readers had suggested changes and developments, which I thought appropriate to include. Second, the exponential growth in credit default swaps and structured securities identified areas which were little discussed in the first edition. This edition attempts to redress that omission.

Institutions offer derivatives with a wide range of maturities, ranging from a few hours (used to provide risk management over the announcement of an economic figure) to perpetuals (i.e. no upfront maturity defined). There is however a golden rule when pricing derivatives, namely always price them off the market that will be used to hedge them. This leads to the first separation in the interest rate swap market between:

- Chapter 2: The short end of the curve, which uses cash, futures and occasionally FRAs to hedge swaps. This chapter first discusses the derivation of discount factors from cash rates, and concentrates on the range of alternative approaches that may be used. It then looks at the derivation of forward interest rates, and how FRAs may be priced using cash and futures. The convexity effect is highlighted for future discussion. Finally an approach is introduced that does not require discounting, but permits the introduction of a funding cost.
- Chapter 3: The medium to long end of the curve. The highly liquid interbank market typically trades plain swaps (usually known as “generic” or “vanilla”), very often between market makers and intermediaries. These are hedged in other financial markets, typically futures for the shorter exposures and bonds for the longer ones. This chapter concentrates initially on the relationship between the bond and swap markets, and how generic swap prices may be implied. It concludes by developing various techniques for the estimation of discount factors from a generic swap curve.
- Chapter 4: The end-user market provides customers with tailored (i.e. non-generic) swaps designed to meet their specific requirements. Such swaps are not traded as such, but created as one-off structures. This chapter describes a



range of simple non-generic swaps, and discusses various techniques for pricing them, including one that requires no discounting. Finally two approaches to the ongoing valuation of an existing (seasoned) swap are demonstrated.

- Chapter 5: Swaps are often used to restructure new or existing securities. This chapter describes some initial structures, par asset packaging and par maturity asset packaging, that are commonly used.
- Chapter 6: Credit derivatives effectively evolved from the asset packaging or securitisation markets. The chapter first discusses total return swaps as being the earliest form of credit derivative, but then moves rapidly on to its successor, single-name credit default swaps. The chapter is in three parts. First, a broad description of the mechanics of the market, especially following the Big and Small Bangs in 2009. Second, an analysis of the relationship between asset packaging and the hedging of CDSs, leading to a discussion around the credit basis. Third, a derivation of implied forward default probabilities from CDS prices using a couple of slightly different approaches. This in turn allows the pricing of non-generic CDSs such as forward starts, amortising and floating rate.
- Chapter 7: This discusses a range of more complex swaps known generally as mismatch swaps. This includes structures such as yield curve (also known as CMSs), in arrears, average rate, and compound. The chapter and its appendix re-introduce the concept of convexity-adjusted pricing more formally.
- Chapter 8: This introduces a range of what are often called cross-market swaps. These involve the normal interbank floating rate (or indeed a fixed rate) on one side, and another reference rate drawn from another market on the other side, such as an overnight rate, or a base rate, or a mortgage rate, or an inflation rate, or an equity return, and so on. The main purpose of these swaps is to permit people with exposures in the other market to gain access to the range of risk management instruments that exists in the interbank market.
- Chapter 9: The earliest swap structures were cross-currency swaps, although this market has been long overtaken by interest rate swaps. Nevertheless they possess some unique characteristics and structures. This chapter starts with the fundamental CCS building block, the cross-currency basis swap, and explores its characteristics, uses, pricing and hedging. This employs a novel approach: worst case simulation. The role of CCBSs in the derivation of cross-currency discount factors is also explored. The main other types of swaps are then discussed: fixed–floating, floating–floating, diff, and quanto–diff. Fixed–fixed swaps occupy a special place because they are a general case of long-term FX forward contracts, so the pricing and hedging of these is considered in some detail. Finally swap valuation is revisited because, in the CCS market, such swaps are frequently valued annually and the principals reset to the current exchange rate.
- Chapter 10: There is an active market in many currencies in medium to long-term options on forward interest rates, usually known as the cap and floor market. Such

structures are intimately linked to swaps for two reasons: first, because combinations of options can create swaps and, second, swaps are generally used to hedge them. In many banks, they are actually traded and risk-managed together. This chapter reviews a range of different option structures and touches albeit briefly on option pricing. Volatility plays a crucial role and various techniques for estimation, including transformation from par to forward as well as volatility smiles and volatility spaces, are described in detail. These options are also frequently embedded in many swap structures, and the breakdown and pricing of a range of structures is discussed. There is also an active market in options on forward swaps (aka swaptions or swop-tions) which, not unnaturally, is closely related to the swap market. The pricing and embedding of swaptions is described. The chapter concludes with two sections on FX options. These options are mainly traded OTC, although there is some activity on a few exchanges such as Philadelphia. The first section concentrates on the pricing of these options, and how it may be varied depending on the method of quoting the underlying currencies. The second section shows how traders would dynamically create a delta-neutral hedge for such an option, together with the hedging errors through time.

- Chapter 11: This chapter concentrates on more complex swaps arising from the need to swap structured securities. It starts by discussing the swapping of range accruals. It goes on to price structures such as callable bonds, Bermudan swaptions and path-dependent products such as target accrual redemption notes and snowballs using both numerical trees and Libor-based simulation.
- Chapter 12: In the early days of the swap market, swap portfolios were risk-managed either using asset–liability methods such as gapping or the more advanced institutions used bond techniques such as duration. By the late 1980s a number of well-publicised losses had forced banks to develop more appropriate techniques such as gridpoint hedging. These (in today’s eyes) traditional approaches stood the banks in good stead for the next decade. This chapter describes the main techniques of both gridpoint and curve hedging, taking into account both first and second-order sensitivities. In passing, mapping cashflows to gridpoints is also discussed. The use of swap futures, as a relatively new hedging instrument, is also considered. The chapter then extends risk management to interest rate options. Most texts discuss the “Greeks” using short-dated options; unfortunately the discussion often does not apply to long-term options, and so their different characteristics, especially as a function of time, are examined. The effectiveness of some optimisation techniques to construct robust hedges are examined as an alternative to the more traditional delta–gamma methods. Finally, the chapter shows how the same techniques can be used to create an inflation hedge for a portfolio of inflation swaps.
- Chapter 13: Risk management however is not a static subject, but has evolved rapidly during the latter half of the 1990s and beyond. Traditional risk management operates quite successfully, but there is a very sensible desire by senior management to be able to assess the riskiness of the entire trading operation

and even wider. The traditional risk measures are not combinable in any fashion and cannot be used. Value-at-Risk was developed as a family of approaches designed very much to address this objective. It is now being developed further to encompass not only market risk but also credit and even operational risks into the same set of measures.<sup>1</sup> This chapter describes the major approaches used to estimate VaR: delta, historic and Monte Carlo simulations, as well as second-order delta–gamma approaches. The advantages and disadvantages of each approach are discussed, along with various extensions such as extreme value theory and sampling strategies. The measurement of spread VaR and equity VaR using either individual stocks or a stock index are also considered. Finally, stress testing or how to make significant moves in the properties of the underlying risk factors (especially correlation) is described.

The book is supported by a full range of detailed spreadsheet models, which underpin all the tables, graphs and figures in the main text. Some of the models have not been described in detail in the text, but hopefully the instructions on the sheets should be adequate. Many of the models are designed so that the reader may implement them in practice without much difficulty.

Many of the ideas, techniques and models described here have been developed over the years with colleagues at both ANZ and Lombard Risk Systems, and through various consulting assignments with a wide range of banks across the world.

## BIOGRAPHY

Richard Flavell has spent over twenty years working as a financial engineer, consultant and trainer, specialising in complex derivatives and risk management. He spent seven years as Director of Financial Engineering at Lombard Risk, where he was responsible for the mathematical development and implementation of models in its varied pricing and risk systems. He is currently Chairman of Lucidate, a company which specialises in the provision of consultancy and training to financial institutions.

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<sup>1</sup> See the proposed Basel Accord (for details see the BIS website: [www.bis.org](http://www.bis.org)) for the regulatory requirements using VaR-style approaches.



# Worksheets

(see the accompanying CD inside the back cover)

*Explanatory note:* The vast majority of spreadsheets refer to a base spreadsheet called “Market Data”. Under current Excel rules, this needs to be opened should the reader wish to save any model.

In most cases, there is one spreadsheet containing all the models for each chapter. The nomenclature is clear: for example, “Ch 2 Short-term Swaps” contains all the models for Chapter 2. There are however some exceptions, where some models are contained in separate spreadsheets. These usually involve models containing either optimisation or Monte Carlo simulation, when it is recommended that these models should be run with all other spreadsheets closed. This refers in particular to Chapters 8 and 11, running LPI and BGM simulations, respectively. The names of the individual spreadsheets are included in the list below:

- 2.1 Market data
- 2.2 Worksheet to calculate a discount factor from a set of cash rates
- 2.3 Worksheet to demonstrate the concepts of discounting
- 2.4 Worksheet to calculate forward rates from a set of cash rates
- 2.5 Worksheet to calculate a forward curve from a set of cash rates—II
- 2.6 Worksheet to use futures to calculate a FRA
- 2.7 Pricing a money market swap using futures and cash
- 2.8 Pricing a money market swap off a futures strip
- 2.9 The construction of a discount curve when futures are not evenly spaced—correcting for the date mismatches in the futures
- 2.10 Pricing a money market swap off a futures strip—version 2
- 2.11 Pricing a money market swap off a futures strip using forward valuing
  
- 3.1 Market data
- 3.2 Worksheet to generate the cashflows of a generic USD swap
- 3.3 Worksheet to demonstrate the discovery of a synthetic par bond
- 3.4 Worksheet to generate the fixed cashflows of a generic USD swap
- 3.5 Worksheet to calculate a discount curve using linear interpolation on the swap curve and different methods on the discount curve
- 3.6 *Details of Hermitian interpolation*
- 3.7 Worksheet to calculate a discount curve using Hermite interpolation on the swap curve and different methods on the discount curve
- 3.8 Worksheet to calculate a discount curve using an optimisation approach
- 3.9 Building a blended curve using optimisation

- 4.1 Market data
- 4.2 Pricing of non-generic swap—1/5 forward starting—using hedging swaps
- 4.3 Pricing of non-generic swap—1/5 forward starting—using NPA
- 4.4 Pricing of non-generic swap—1/5 forward starting—using implied forwards
- 4.5 Pricing of non-generic swap—1/5 forward starting—using a formula
- 4.6 Pricing of non-generic Swap—1/5 forward starting—using the reference rate method and implied forwards
- 4.7 Pricing of non-generic swap—5-year amortising—using hedging swaps
- 4.8 Pricing of non-generic swap—5-year amortising—using NPA
- 4.9 Pricing of non-generic swap—5-year amortising—using implied forwards
- 4.10 Pricing a non-generic swap using hedging swaps
- 4.11 Pricing a non-generic swap using notional principal amounts
- 4.12 Pricing a non-generic swap using implied forwards
- 4.13 Pricing a non-generic swap using implied forwards and forward valuing
- 4.14 New market data for valuations
- 4.15 Valuing a non-generic swap using NPA
- 4.16 Valuing a non-generic swap using implied forwards

- 5.1 Market data
- 5.2 Diagram of the impact of the Accord on capital
- 5.3 Creating a simple par asset swap with a bond trading below par
- 5.4 Creating a simple par maturity asset swap with a bond trading below par
- 5.5 Creating a simple discount asset swap with a bond trading below par
- 5.6 Forward valuing an asset swap

- 6.1 Market data
- 6.2 Creating a simple par maturity asset swap
- 6.3 Estimating the Z-spread for a bond
- 6.4 Hedging a generic CDS
- 6.5 Modelling a CDS on a quarterly basis
- 6.6 Modelling a CDS on a monthly basis
- 6.7 Estimating FDP curve using quarterly time periods
- 6.8 Hermitian interpolation
- 6.9 Estimating FDP curve using monthly time periods
- 6.10 Estimating FDP curve using daily time periods
- 6.11 Estimating forward default probability curve using optimisation on a quarterly basis
- 6.12 Estimating forward default probability curve using optimisation on a monthly basis
- 6.13 Estimating forward default probability curve by fitting a Nelson–Siegel curve
- 6.14 Modelling a 3-year knock-out forward starting CDS
- 6.15 Modelling a 3-year no-knock-out forward starting CDS
- 6.16 Pricing a floating credit default swap
- 6.17 Constant maturity credit default swap pricing with no convexity adjustment
- 6.18 Estimated volatilities and correlations for convexity adjustment
- 6.19 Constant maturity credit default swap pricing with convexity adjustment
- 6.20 Valuing an old CDS

### **Spreadsheet “Ch 6 Credit-adjusted Pricing”**

- 6.21 Market data for credit-adjusted pricing
- 6.22 Modelling the forward IR envelope
- 6.23 Worksheet to summarise modelling swap exposure and to plot potential future exposure

- 6.24 Estimation of PELs for IRS and CCS
- 6.25 Graph of IRS PEL
- 6.26 Graph of CCS PEL
- 6.27 Worksheet to calculate the credit adjustment on the pricing of an IRS
- 6.28 Graph of accumulative default probabilities
- 6.29 Credit adjustment for a range of maturities and for different rating counterparties

### Spreadsheet “Ch 6 Appendix Modelling a Portfolio CDS”

- 6.30 Market data for Appendix to Chapter 6
- 6.31 Base sector correlations and recovery rates
- 6.32 Accumulative default probabilities
- 6.33 Original portfolio—with full details
- 6.34 Constructed asset correlation matrix from sectoral factors
- 6.35 This worksheet runs a single scenario to calculate the PV of payments to be made under the CDS
- 6.36 This worksheet runs a single antithetic scenario to calculate the PV of payments to be made under the CDS
- 6.37 This worksheet will run a range of scenarios (currently 500 normal and 500 antithetic), build a loss distribution and fit a Weibull distribution

- 7.1 Market data
- 7.2 Pricing an in-arrears swap
- 7.3 Creating a customised average rate swap
- 7.4 Creating a compound swap
- 7.5 Pricing a constant maturity swap—using sa reference rate
- 7.6 Pricing a constant maturity swap—using qu reference rate paying sa
- 7.7 Pricing a constant maturity swap—using sa reference rate paying qu
- 7.8 Pricing a participation constant maturity swap—using sa reference rate
- 7.9 Estimating the convexity effect of a generic IRS using forward rates
- 7.10 Pricing a constant maturity swap: how does it change in value for a shift in the forward curve

### Spreadsheet “Ch 7 Appendix Convexity Structures”

- 7.11 Market data: extracted from market data worksheet for Chapter 7 Appendix
- 7.12 Pricing an in-arrears swap with CX adjustments
- 7.13 Pricing an in-arrears swap via simulation to assess CX
- 7.14 Creating a customised average rate swap with CX adjustment
- 7.15 Turbo-swaps—pricing a 4-year qu/qu swap with CX adjustment
- 7.16 Pricing a constant maturity swap with convexity adjustment
- 7.17 Pricing a constant maturity swap with CX adjustment—using Hagan’s model
- 7.18 Pricing a constant maturity swap with convexity adjustment and timing adjustment
- 7.19 Measuring the convexity effect of a constant maturity swap under parallel shifts
- 7.20 Measuring the scale of the convexity effect of a constant maturity swap by simulation

### Spreadsheet “Ch 7 Measuring the Convexity Effect in an IRS Using BGM”

- 7.21 Market data
- 7.22 This worksheet estimates a parametric forward–forward volatility curve
- 7.23 Correlation matrix
- 7.24 This calculates the expression  $\rho_{k,i} = \sigma(i) * \rho(k,i)$

- 7.25 Generation of forward curves
- 7.26 Modelling the change in value of generic spot swaps

### **Spreadsheet “Ch 8 Cross-market and Other Market Swaps”**

- 8.1 Market data
- 8.2 Modelling an EONIA swap
- 8.3 Some basis swap quotes
- 8.4 Modelling CP–Libor swaps
- 8.5 Modelling Muni–Libor swaps
- 8.6 Example of fixed notional equity swap—without randomness
- 8.7 Example of fixed notional equity swap—with randomness
- 8.8 Example of variable notional equity swap—without randomness
- 8.9 Example of variable notional equity swap—with randomness
- 8.10 Example of cross-currency fixed notional equity swap—without randomness
- 8.11 Example of cross-currency fixed notional equity swap—with randomness
- 8.12 Example of cross-currency variable notional equity swap—without randomness
- 8.13 Example of cross-currency variable notional equity swap—with randomness

### **Spreadsheet “Ch 8 Inflation Swap Models”**

- 8.14 Static gilt data
- 8.15 Static index-linked data
- 8.16 Dynamic data input page
- 8.17 Input RPI data
- 8.18 Worksheet to calculate the dirty price of non-linked gilts from the yield
- 8.19 Building a gilt discount curve using a parametric Nelson–Siegel curve
- 8.20 Worksheet for modelling all the non-index-linked gilt cashflows for N–S modelling
- 8.21 Building a gilt discount curve by bootstrapping
- 8.22 Worksheet for modelling all the non-index-linked gilt cashflows for bootstrapping
- 8.23 Worksheet displaying constructed zero-coupon curves from non-index-linked gilts
- 8.24 Building a forward inflation curve using Nelson–Siegel curves
- 8.25 Worksheet for modelling all the index-linked gilt cashflows for use in an N–S model
- 8.26 Building a forward inflation curve by bootstrapping
- 8.27 Worksheet for modelling all the index-linked gilt cashflows for use in a bootstrapping model

### **Spreadsheet “Ch 8 Building an Inflation Curve by Optimisation”**

- 8.28 Static index-linked data
- 8.29 Input RPI data
- 8.30 Worksheet displaying constructed zero-coupon curves from Chapter 8 inflation swap models
- 8.31 Building a forward inflation curve by optimisation
- 8.32 Worksheet for modelling all the index-linked gilt cashflows for use in the optimisation model

### **Spreadsheet “Ch 8 Inflation Swap Models”**

- 8.33 Mid zero-coupon inflation swap curve—taken from market quotes
- 8.34 Example of pricing a payer’s YoY inflation swap with no convexity adjustment
- 8.35 Examples of market-based volatilities (shown in red) for inflation
- 8.36 Example of pricing a payer’s YoY inflation swap with convexity
- 8.37 Sheet for valuing a fixed–floating inflation swap out of spot

**Spreadsheet “Ch 8 LPI Inflation Swap”**

- 8.38 Libor sheet for interpolation
- 8.39 RPI curve
- 8.40 Sheet for simulating a fixed–floating LPI inflation swap

**Spreadsheet “Ch 8 Inflation Swap Models”**

- 8.41 Pricing an inflation-fixed vs. Libor swap
- 8.42 Hedging a portfolio of inflation swaps

**Spreadsheet “Ch 8 Inflation—Seasonality Adjustments”**

- 8.43 Worksheet to estimate non-parametric monthly adjustments for seasonality from historic data
- 8.44 Model to fit a seasonally adjusted polynomial to RPI
- 8.45 Model to fit a seasonally adjusted polynomial to  $\ln(\text{RPI})$

**Spreadsheet “Ch 8 Cross-market and Other Market Swaps”**

- 8.46 Worksheet to demonstrate variance hedging
  - 8.47 Estimating the function  $f(ST)$
  - 8.48 Worksheet to demonstrate variance hedging assuming a flat volatility
  - 8.49 Generating an example smile curve
  - 8.50 Worksheet to demonstrate variance hedging with a smile effect
- 
- 9.1 USD market data
  - 9.2 Yen market data
  - 9.3 Worksheet to estimate JPY–USD forward rates
  - 9.4 Example of pricing a cross-currency basis swap
  - 9.5 Deriving DFs from a generic swap curve plus a CCBS curve
  - 9.6 Creating a synthetic foreign asset: swapping a USD bond into floating JPY
  - 9.7 Swapping a SA bond into USD Libor
  - 9.8 Pricing a 5-year JPY–USD diff swap
  - 9.9 Pricing a 5-year JPY–USD quanto diff swap
  - 9.10 Pricing a USD–JPY LTFX: analysing the USD leg (1)
  - 9.11 Pricing a USD–JPY LTFX: analysing the USD leg (2)
  - 9.12 Pricing a USD–JPY LTFX
  - 9.13 Valuation of a CCBS—simulation removed
  - 9.14 Valuation of a CCBS with simulation
  - 9.15 Correlation matrix—used in the simulation
  - 9.16 Rebalancing the valuation of a CCBS with zero margin off unadjusted curves—simulation removed
  - 9.17 Rebalancing the valuation of a CCBS with zero margin off unadjusted curves—using simulation
  - 9.18 Rebalancing the valuation of a CCBS with margin off unadjusted curves—simulation removed
  - 9.19 Rebalancing the valuation of a CCBS with margin off unadjusted curves—using simulation
  - 9.20 Rebalancing the valuation of a CCBS with margin off adjusted curves—simulation removed
  - 9.21 Rebalancing the valuation of a CCBS with margin off adjusted curves—using simulation
  - 9.22 Swapping a reverse dual currency A\$–¥ bond into floating USD

- 9.23 Swapping a dual currency A\$–¥ bond into floating USD: calculating the breakeven coupon rate
- 9.24 Pricing a 5-year JPY–USD quanto diff swap with convexity—Approach 1
- 9.25 Pricing a 5-year JPY–USD quanto diff swap with convexity—Approach 2
  
- 10.1 Market data
- 10.2 Cap pricing model
- 10.3 Worksheet to calculate 180-day rolling unweighted and weighted volatilities
- 10.4 Par cap smile curve—against 3 mo. USD Libor
- 10.5 Building a moneyness smile surface
- 10.6 This worksheet bootstraps a piecewise constant forward volatility curve from a par curve
- 10.7 This worksheet constructs a smooth forward volatility curve from a par curve
- 10.8 This worksheet constructs a forward volatility curve from a par curve by direct calculation
- 10.9 Forward volatility surface produced by bootstrapping
- 10.10 A smoothed forward volatility surface
- 10.11 Cap and floor pricing—with USD data
- 10.12 Pricing a curve cap
- 10.13 Pricing a mid-curve cap
- 10.14 Collar pricing
- 10.15 Structuring a participation
- 10.16 Digital cap and floor pricing
- 10.17 Worksheet to replicate a standard call by a strip of digitals
- 10.18 Cap and floor pricing for embedded structures—note that this includes the first fixing
- 10.19 Capped loan—1
- 10.20 Capped loan—2
- 10.21a Worksheet to price a capped swap
- 10.21b Worksheet to price a floored swap
- 10.22 Worksheet to price a reverse floating swap with a collar
- 10.23 Swaption pricing—with USD data
- 10.24 Swaption pricing on a 1 yr underlying swap—with USD data
- 10.25 This worksheet contains an ATM swaption volatility surface and extracts from a volatility smile
- 10.26 Worksheet to transform forward interest rate volatility to forward swap volatility
- 10.27 Pricing extendible and retractable swaps
- 10.28 Pricing a simple European callable swap
- 10.29 Worksheet to calculate USD–JPY FX forward contracts—basic market data
- 10.30 Worksheet to calculate some vanilla FX options
- 10.31 Worksheet to demonstrate option replication—based on option to receive foreign, put domestic
- 10.32 Detailed analysis extracted from Worksheet 10.31—with no randomness

### **Spreadsheet “Ch 10 SABR Model”**

- 10.33 Market data—forward USD volatility surface (extracted from Worksheet 10.9)
- 10.34 SABR parameters estimated using Nelder–Mead least-squares algorithm
- 10.35 Modelling the smile using the SABR model

### **Spreadsheet “Ch 11—Summary of Spreadsheets”**

(lists the main spreadsheets for this chapter)



**Spreadsheet “Ch 11 Modelling WB Accrual Note”**

- 11.1 Swapping World Bank accrual note

**Spreadsheet “Ch 11.3 BDT Modelling a Swap”**

- 11.2 Market data
- 11.3 Valuing a swap by different analytic approaches, and building a rate tree
- 11.4 Discounting tree
- 11.5 X-tree
- 11.6 *This worksheet models a swap twice, and demonstrates the same pricing*
- 11.7 Modelling a Bermudan callable swap using the two different representations

**Spreadsheet “Ch 11.10 Pricing and Calibrating a CMS”**

- 11.8 Notes
- 11.9 Market data
- 11.10 Pricing a constant maturity swap with convexity adjustment
- 11.11 Building the rate tree
- 11.12 Discounting trees—both quarterly and annual
- 11.13 X-tree
- 11.14 *This worksheet models a range of forward swaps*
- 11.15 *This sheet estimates the forward CMS swap rates at specific nodes using the notional principal representation*
- 11.16 *This sheet estimates the value of the fixed side of a forward swap, when the fixed rate = 100%  $\Rightarrow$  effectively calculating an annual  $Q$*
- 11.17 *This sheet estimates the forward value of the floating side of a swap using NPA*
- 11.18 *This sheet models a 5 yr swap receiving {10 yr CMS – margin} ANN, paying 3 mo. Libor*
- 11.19 Pricing swaptions
- 11.20 *This worksheet models a callable 5 yr swap receiving {10 yr CMS – margin} ANN, paying 3 mo. Libor*

**Spreadsheet “Ch 11.22 Pricing a Callable Range Accrual”**

- 11.21 Market data
- 11.22 Pricing a range accrual analytically
- 11.23 Building the rate tree
- 11.24 Discounting tree
- 11.25 X-tree
- 11.26 *This worksheet models a range accrual*
- 11.27 *This worksheet models a callable range accrual*

**Spreadsheet “Ch 11.28 Implied Forward–forward Volatilities**

- 11.28 *This worksheet estimates forward–forward volatilities from a current forward volatility curve*
- 11.29 *This demonstrates bootstrapping breaking down*

**Spreadsheet “Ch 11.36 Example of BGM Simulation”**

- 11.30 Market data
- 11.31 *This worksheet estimates a parametric forward–forward volatility curve*

- 11.32 Correlation matrix
- 11.33  $R(i, j)$
- 11.34 Sum  $s(i, j) \cdot R(i, j) \cdot \rho(k, i)$
- 11.35 RV's
- 11.36 BGM sampling

### Spreadsheet “Ch 11.41 Example of Very Long-step BGM Simulation”

- 11.37 Market data
- 11.38 This worksheet estimates a parametric forward–forward volatility curve
- 11.39 Correlation matrix
- 11.40  $\sigma(i) \cdot \rho(k, i)$
- 11.41 Generation of Long-Step Forward curves
- 11.42 Modelling swaptions using long-step BGM simulation

### Spreadsheet “Ch 11.49 Modelling a Sticky Floater”

- 11.43 Market data
- 11.44 This worksheet estimates a parametric forward–forward volatility curve
- 11.45 Correlation matrix
- 11.46  $\sigma(i) \cdot \rho(k, i)$
- 11.47 Very long-step sampling
- 11.48 Modelling a floater with no stickiness
- 11.49 Simulating two floaters—one sticky, and one not

### Spreadsheet “Ch 11.56 Modelling a TARN”

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- 11.51 This worksheet estimates a parametric forward–forward volatility curve
- 11.52 Correlation matrix
- 11.53  $\sigma(i) \cdot \rho(k, i)$
- 11.54 Very long-step sampling
- 11.55 Modelling a spread floater with different maturities
- 11.56 Modelling a TARN

### Spreadsheet “Ch 11.62 Modelling a Callable Snowball”

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- 11.58 This worksheet estimates a parametric forward–forward volatility curve
- 11.59 Correlation matrix
- 11.60  $\sigma(i) \cdot \rho(k, i)$
- 11.61 Very long-step sampling
- 11.62 Modelling a snowball using BGM
- 11.63 Modelling a snowball with embedded calls using BGM

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- 11.64 This worksheet demonstrates the basic principles of incorporating a smile within a numerical tree
- 11.65 Market data

- 11.66 Floorlet with no smile
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- 11.69 Building a Hull and White tree with a time-dependent volatility curve
- 11.70 Pricing a Bermudan caplet with time-dependent volatility curve
- 11.71 Building a H&W tree, and calibrating the tree to known swaption prices
- 11.72 Pricing a  $2 \times 4$  European swaption
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- 11.74 Pricing a  $4 \times 4$  European swaption

### **Spreadsheet “Ch 11.80 BDT Pricing a Caplet and Some Swaptions”**

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  - 11.77 Building the rate tree
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  - 11.79 X-tree
  - 11.80 Pricing a 5-year Bermudan caplet, exercisable at any fixing date
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