

WILEY FINANCE

Exotic Options and Hybrids

*A Guide to Structuring,
Pricing and Trading*

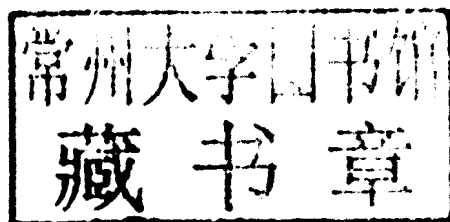
MOHAMED BOUZOUBAA
ADEL OSSEIRAN

www.exotic-options-and-hybrids.com

Exotic Options and Hybrids

A Guide to Structuring, Pricing and Trading

Mohamed Bouzoubaa and Adel Osseiran



A John Wiley and Sons, Ltd., Publication

This edition first published 2010
© 2010 John Wiley & Sons, Ltd

Registered office

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com.

The right of the author to be identified as the author of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

A catalogue record for this book is available from the British Library.

ISBN 978-0-470-68803-8 (H/B)

Typeset in 10/12pt Times by Aptara Inc., New Delhi, India
Printed in Great Britain by CPI Antony Rowe, Chippenham, Wiltshire

Further praise for Exotic Options and Hybrids

“This book brings a practitioner’s prospective into an area that has seen little treatment to date. The challenge of writing a logical, rigorous, accessible and readable account of a vast and diverse field that is structuring of exotic options and hybrids is enthusiastically taken up by the authors, and they succeed brilliantly in covering an impressive range of products.”

Vladimir Piterbarg, Head of Quantitative Research, Barclays

“What is interesting about this excellent work is that the reader can measure clearly that the authors are sharing a concrete experience. Their writing approach and style bring a clear added value to those who want to understand the structuring practices, Exotics pricing as well as the theory behind these.”

Younes Guemouri, Chief Operating Officer, Sophis

“The book provides an excellent and compressive review of exotic options. The purpose of using these derivatives is well exposed, and by opposition to many derivatives’ books, the authors focus on practical applications. It is recommended to every practitioner as well as advanced students looking forward to work in the field of derivatives.”

**Dr Amine Jalal, Vice President, Equity Derivatives Trading,
Goldman Sachs International**

“*Exotic Options and Hybrids* is an exceptionally well written book, distilling essential ingredients of a successful structured products business. Adel and Mohamed have summarized an excellent guide to developing intuition for a trader and structurer in the world of exotic equity derivatives.”

**Anand Batepati, Structured Products Development Manager, HSBC,
Hong Kong**

“A very precise, up-to-date and intuitive handbook for every derivatives user in the market.”

Amine Chkili, Equity Derivatives Trader, HSBC Bank PLC, London

“*Exotic Options and Hybrids* is an excellent book for anyone interested in structured products. It can be read cover to cover or used as a reference. It is a comprehensive guide and would be useful to both beginners and experts. I have read a number of books on the subject and would definitely rate this in the top three.”

Ahmed Seghrouchni, Volatility Trader, Dresdner Kleinwort, London

“A clear and complete book with a practical approach to structured pricing and hedging techniques used by professionals. *Exotic Options and Hybrids* introduces technical concepts in an elegant manner and gives good insights into the building blocks behind structured products.”

Idriss Amor, Rates and FX Structuring, Bank of America, London

“Exotic Options and Hybrids is an accessible and thorough introduction to derivatives pricing, covering all essential topics. The reader of the book will certainly appreciate the alternation between technical explanations and real world examples.”

Khaled Ben-Said, Quantitative Analyst, JP Morgan Chase, London

“A great reference handbook with comprehensive coverage on derivatives, explaining both theory and applications involved in day-to-day practices. The authors’ limpid style of writing makes it a must-read for beginners as well as existing practitioners involved in day-to-day structuring, pricing and trading.”

Anouar Cedrati, Structured Products Sales, HSBC, Dubai

“A good reference and an excellent guide to both academics and experts for its comprehensive coverage on derivatives through real world illustrations and theory concepts.”

Abdessamad Issami, Director of Market Activities, CDG Capital

“Exotic Options and Hybrids offers a hands-on approach to the world of options, giving good insight into both the theoretical and practical side of the business. A good reference for both academics and market professionals as it highlights the relationship between theory and practice.”

**Joseph Nehme, Bachelor of Engineering AUB, ESSEC MBA,
Equity Derivatives Marketer, Merrill Lynch, London**

*“A great guide for experienced professionals or those just starting out in the space. Both the core concepts of structured derivatives as well as the more complex exotic’s pricing and management come across with great lucidity. *Exotic Options and Hybrids* is a great complement to anybody’s financial library.”*

Nabil Achtioui, Volatility Arbitrage Trader, Calyon, Paris

“Exotic Options and Hybrids serves as a good introduction into the world of structured equities and hybrids, and would be useful for both the enthusiastic novice as well as the seasoned professional who wants to recall a few concepts. Highly recommended.”

Rahul Karkun, Rates and Hybrid Structuring, Bank of America, London

List of Symbols and Abbreviations

$\mathbf{1}$	Indicator function
ATM	At the money
ATMF	At the money forward
bp	Basis point, equal to 1% of 1%
EUR	Euro
GBP	Great Britain pound
ITM	In the money
JPY	Japanese yen
K	The strike of a specified option
MTM	Marked-to-market
\mathcal{N}	Normal cumulative distribution function
OTC	Over the counter
OTM	Out of the money
ρ	Correlation
q	Dividend yield of a specified asset
r	Risk-free rate of interest
$S(t)$	Price of asset S at time t
$S_i(t)$	Price of asset S_i at time t (multi-asset case)
σ	The volatility of a specified asset
T	Maturity of an option
USD	United States dollar

Preface

Toxic waste. . . it is a sad day when derivatives are described as toxic waste. Are these financial products really so, particularly those of exotic nature, or is it in fact people's grasp and usage of them that is the source of toxicity? While the use of derivatives increased in recent years at astounding rates, the crash of 2008 has revealed that people's understanding of them has not rivalled their spread. *Exotic Options and Hybrids* covers a broad range of derivative structures and focuses on the three main parts of a derivative's life: the structuring of a product, its pricing and its hedging. By discussing these aspects in a practical, non-mathematical and highly intuitive setting, this book blasts the misunderstandings and the stigma, and stands strong as the only book in its class to make these *exotic* and complex concepts truly accessible.

We base *Exotic Options and Hybrids* on a realistic setting from the heart of the business: inside a derivatives operation. Working from the assumption that one has a range of correctly implemented models, and the ability to trade a set of basic financial instruments, a client's need for a tailored financial product then raises these questions: How does one structure this product, correctly price it for the sale, and then hedge the resulting position until its maturity? Following a risk-centred approach, *Exotic Options and Hybrids* is a well-written, thoroughly researched and consistently organized book that addresses these points in a down-to-earth manner.

The book contains many examples involving time series and scenarios for different assets, and while hypothetical, all are carefully designed so as to highlight interesting and significant aspects of the business. Adoptions of real trades are examined in detail. To further illuminate payoff structures, their introduction is accompanied by payoff diagrams, scenario analyses involving figures and tables of paths, plus lifelike sample term sheets. By first understanding the investor's point of view, readers learn the methodology to structure a new payoff or modify an existing one to give different exposures. The names of various products can sometimes vary from one side of the industry to another, but those attributed to the products discussed in this book are commonly accepted to a great extent. Next, the reader learns how to spot where the risks lie to pave the way for sound valuation and hedging of the products. Models are de-mystified in separately dedicated sections, but their implications are alluded to throughout the book in an intuitive and non-mathematical manner.

Exotic Options and Hybrids is the first book to offer insights into the structuring, pricing and trading of modern exotic and hybrid derivatives, without complicating matters with the use of maths. The applications, the strengths and the limitations of various models are highlighted, in relevance to the products and their risks, rather than the model implementations. Readers can

thus understand how models work when applied to pricing and hedging, without getting lost in the mathematical dwellings that shape related texts. While previous texts are heavily technical, others do not offer enough exposure, if any, to the more advanced and modern structures. The multitude of structures covered in *Exotic Options and Hybrids* is quite comprehensive, and encompasses many of the most up-to-date and promising products, including hybrid derivatives and dynamic strategies.

The book is formed of four parts, each containing related chapters which evolve in increasing degrees of complexity in the structures. Readers will be continuously stimulated by more advanced topics, and because of this breakdown the book can be read from front to back without loss of interest. Alternatively, readers can jump straight to a specific chapter because the book is self-contained and references to earlier chapters and sections within the book are explicitly clear. Furthermore, movement between the various angles of analysis of a specific product or concept is transparent, leaving readers free to focus on one aspect, or to read an entire treatment of a subject.

The first two chapters lay the foundations and explain not only the basic blocks of derivatives but also the setup and people involved in the creation, pricing and hedging of exotic structures. Chapters 3 to 7 define vanilla options, the risks involved in trading them and the different tools one can use to measure them. The second part of the book deals with the concept of dispersion which is of key importance in the world of exotic options. Chapters 10 and 11 focus on barrier options and digitals that are very much used in the conception of structured products. Chapters 13 to 16 constitute the third part of the book and present cliquets and related structures, mountain range options, and volatility derivatives, all of which are considered to be slightly more advanced exotic products.

After completing the discussion of exotic structures based upon equities, we move to hybrid derivatives. These chapters allow us to draw on many of the points made earlier in the book regarding correlation, dispersion and volatility, and provide a transparent insight into the world of hybrid derivatives. The first two of the four chapters on hybrids discuss the key asset classes: interest rates, commodities, foreign exchange, inflation and credit. For each asset class we look at the markets individually and gain insight into the nature of each, the various underlyings, vanilla instruments, skews and smiles and a brief look at some popular exotics in each. These are followed by a chapter that discusses the structuring of hybrid derivatives and explains how to construct meaningful combinations of the various asset classes. The last chapter on hybrids discusses the pricing intricacies of these instruments, starting from each asset class and then modelling combinations thereof. Chapter 21, the final chapter, deals with thematic indices and dynamic strategies. These assets are very different from the traditional structured products presented throughout the book, and constitute the new generation of advanced investment solutions.

We strongly believe that attentive readers of this book will learn many valuable insights in to all facets of the business of structured products. *Exotic Options and Hybrids* appeals to all the parties involved in the creation, pricing and hedging of the simplest to the most complex products. Once the heart of the business and its technical features are deeply assimilated, readers should be well equipped to contribute their own stone to the world of structured products.

Contents

List of Symbols and Abbreviations	xvii
Preface	xix
PART I FOUNDATIONS	1
1 Basic Instruments	3
1.1 Introduction	3
1.2 Interest Rates	3
1.2.1 LIBOR vs Treasury Rates	4
1.2.2 Yield Curves	4
1.2.3 Time Value of Money	5
1.2.4 Bonds	6
1.2.5 Zero Coupon Bonds	7
1.3 Equities and Currencies	8
1.3.1 Stocks	8
1.3.2 Foreign Exchange	10
1.3.3 Indices	10
1.3.4 Exchange-traded Funds	11
1.3.5 Forward Contracts	11
1.3.6 Futures	12
1.4 Swaps	13
1.4.1 Interest Rate Swaps	13
1.4.2 Cross-currency Swaps	14
1.4.3 Total Return Swaps	16
1.4.4 Asset Swaps	16
1.4.5 Dividend Swaps	16
2 The World of Structured Products	19
2.1 The Products	19
2.1.1 The Birth of Structured Products	19
2.1.2 Structured Product Wrappers	20
2.1.3 The Structured Note	20

2.2	The Sell Side	21
2.2.1	Sales and Marketing	21
2.2.2	Traders and Structurers	22
2.3	The Buy Side	23
2.3.1	Retail Investors	23
2.3.2	Institutional Investors	24
2.3.3	Bullish vs Bearish, the Economic Cycle	24
2.3.4	Credit Risk and Collateralized Lines	25
2.4	The Market	26
2.4.1	Issuing a Structured Product	26
2.4.2	Liquidity and a Two-way Market	27
2.5	Example of an Equity Linked Note	28
3	Vanilla Options	31
3.1	General Features of Options	31
3.2	Call and Put Option Payoffs	32
3.3	Put-call Parity and Synthetic Options	34
3.4	Black-Scholes Model Assumptions	35
3.4.1	Risk-neutral Pricing	36
3.5	Pricing a European Call Option	37
3.6	Pricing a European Put Option	38
3.7	The Cost of Hedging	40
3.8	American Options	42
3.9	Asian Options	43
3.10	An Example of the Structuring Process	44
3.10.1	Capital Protection and Equity Participation	44
3.10.2	Capital at Risk and Higher Participation	46
4	Volatility, Skew and Term Structure	49
4.1	Volatility	49
4.1.1	Realized Volatility	49
4.1.2	Implied Volatility	51
4.2	The Volatility Surface	52
4.2.1	The Implied Volatility Skew	52
4.2.2	Term Structure of Volatilities	56
4.3	Volatility Models	57
4.3.1	Model Choice and Model Risk	57
4.3.2	Black-Scholes or Flat Volatility	58
4.3.3	Local Volatility	60
4.3.4	Stochastic Volatility	62
5	Option Sensitivities: Greeks	65
5.1	Delta	66
5.2	Gamma	72
5.3	Vega	74
5.4	Theta	76

5.5	Rho	77
5.6	Relationships between the Greeks	78
5.7	Volga and Vanna	80
5.7.1	Vega–Gamma (Volga)	80
5.7.2	Vanna	81
5.8	Multi-asset Sensitivities	81
5.9	Approximations to Black–Scholes and Greeks	82
6	Strategies Involving Options	87
6.1	Traditional Hedging Strategies	87
6.1.1	Protective Puts	87
6.1.2	Covered Calls	89
6.2	Vertical Spreads	90
6.2.1	Bull Spreads	90
6.2.2	Bear Spreads	93
6.3	Other Spreads	96
6.3.1	Butterfly Spreads	96
6.3.2	Condor Spreads	98
6.3.3	Ratio Spreads	99
6.3.4	Calendar Spreads	99
6.4	Option Combinations	100
6.4.1	Straddles	100
6.4.2	Strangles	101
6.5	Arbitrage Freedom of the Implied Volatility Surface	102
7	Correlation	105
7.1	Multi-asset Options	105
7.2	Correlation: Measurements and Interpretation	106
7.2.1	Realized Correlation	106
7.2.2	Correlation Matrices	109
7.2.3	Portfolio Variance	110
7.2.4	Implied Correlation	111
7.2.5	Correlation Skew	113
7.3	Basket Options	114
7.4	Quantity Adjusting Options: “Quantos”	116
7.4.1	Quanto Payoffs	116
7.4.2	Quanto Correlation and Quanto Option Pricing	116
7.4.3	Hedging Quanto Risk	117
7.5	Trading Correlation	118
7.5.1	Straddles: Index versus Constituents	118
7.5.2	Correlation Swaps	118
PART II	EXOTIC DERIVATIVES AND STRUCTURED PRODUCTS	121
8	Dispersion	123
8.1	Measures of Dispersion and Interpretations	123
8.2	Worst-of Options	125

8.2.1	Worst-of Call	125
8.2.2	Worst-of Put	127
8.2.3	Market Trends in Worst-of Options	128
8.3	Best-of options	129
8.3.1	Best-of Call	129
8.3.2	Best-of Put	131
8.3.3	Market Trends in Best-of Options	132
9	Dispersion Options	135
9.1	Rainbow Options	135
9.1.1	Payoff Mechanism	135
9.1.2	Risk Analysis	136
9.2	Individually Capped Basket Call (ICBC)	137
9.2.1	Payoff Mechanism	137
9.2.2	Risk Analysis	138
9.3	Outperformance Options	141
9.3.1	Payoff Mechanism	141
9.3.2	Risk Analysis	142
9.4	Volatility Models	143
10	Barrier Options	145
10.1	Barrier Option Payoffs	145
10.1.1	Knock-out Options	145
10.1.2	Knock-in Options	148
10.1.3	Summary	150
10.2	Black-Scholes Valuation	151
10.2.1	Parity Relationships	151
10.2.2	Closed Formulas for Continuously Monitored Barriers	151
10.2.3	Adjusting for Discrete Barriers	154
10.3	Hedging Down-and-in Puts	155
10.3.1	Monitoring the Barrier	155
10.3.2	Volatility and Down-and-in Puts	157
10.3.3	Dispersion Effect on Worst-of Down-and-in Puts	158
10.4	Barriers in Structured Products	160
10.4.1	Multi-asset Shark	160
10.4.2	Single Asset Reverse Convertible	163
10.4.3	Worst-of Reverse Convertible	164
11	Digitals	167
11.1	European Digitals	167
11.1.1	Digital Payoffs and Pricing	167
11.1.2	Replicating a European Digital	169
11.1.3	Hedging a Digital	169
11.2	American Digitals	172
11.3	Risk Analysis	174
11.3.1	Single Asset Digitals	174

11.3.2	Digital Options with Dispersion	176
11.3.3	Volatility Models for Digitals	177
11.4	Structured Products Involving European Digitals	178
11.4.1	Strip of Digitals Note	178
11.4.2	Growth and Income	179
11.4.3	Bonus Steps Certificate	181
11.5	Structured Products Involving American Digitals	183
11.5.1	Wedding Cake	183
11.5.2	Range Accrual	184
11.6	Outperformance Digital	185
11.6.1	Payoff Mechanism	185
11.6.2	Correlation Skew and Other Risks	186
12	Autocallable Structures	187
12.1	Single Asset Autocallables	187
12.1.1	General Features	187
12.1.2	Interest Rate/Equity Correlation	190
12.2	Autocallable Participating Note	192
12.3	Autocallables with Down-and-in Puts	194
12.3.1	Adding the Put Feature	194
12.3.2	Twin-Wins	194
12.3.3	Autocallables with Bonus Coupons	196
12.4	Multi-asset Autocallables	198
12.4.1	Worst-of Autocallables	198
12.4.2	Snowball Effect and Worst-of put Feature	200
12.4.3	Outperformance Autocallables	202
PART III	MORE ON EXOTIC STRUCTURES	205
13	The Cliquet Family	207
13.1	Forward Starting Options	207
13.2	Cliquets with Local Floors and Caps	208
13.2.1	Payoff Mechanism	209
13.2.2	Forward Skew and Other Risks	210
13.3	Cliquets with Global Floors and Caps	210
13.3.1	Vega Convexity	213
13.3.2	Levels of These Risks	215
13.4	Reverse Cliquets	217
14	More Cliquets and Related Structures	219
14.1	Other Cliquets	219
14.1.1	Digital Cliquets	219
14.1.2	Bearish Cliquets	220
14.1.3	Variable Cap Cliquets	221
14.1.4	Accumulators/Lock-in Cliquets	222
14.1.5	Replacement Cliquets	222
14.2	Multi-asset Cliquets	224

14.2.1	Multi-asset Cliquet Payoffs	224
14.2.2	Multi-asset Cliquet Risks	225
14.3	Napoleons	226
14.3.1	The Napoleon Structure	226
14.3.2	The Bearish Napoleon	227
14.4	Lookback Options	227
14.4.1	The Various Lookback Payoffs	227
14.4.2	Hedging Lookbacks	228
14.4.3	Sticky Strike and Sticky Delta	229
14.4.4	Skew Risk in Lookbacks	229
15	Mountain Range Options	231
15.1	Altiplano	231
15.2	Himalaya	233
15.3	Everest	235
15.4	Kilimanjaro Select	236
15.5	Atlas	238
15.6	Pricing Mountain Range Products	239
16	Volatility Derivatives	243
16.1	The Need for Volatility Derivatives	243
16.2	Traditional Methods for Trading Volatility	243
16.3	Variance Swaps	244
16.3.1	Payoff Description	245
16.3.2	Variance vs Volatility Swaps	246
16.3.3	Replication and Pricing of Variance Swaps	246
16.3.4	Capped Variance Swaps	248
16.3.5	Forward Starting Variance Swaps	249
16.3.6	Variance Swap Greeks	249
16.4	Variations on Variance Swaps	250
16.4.1	Corridor Variance Swaps	250
16.4.2	Conditional Variance Swaps	251
16.4.3	Gamma Swaps	253
16.5	Options on Realized Variance	254
16.6	The VIX: Volatility Indices	254
16.6.1	Options on the VIX	255
16.6.2	Combining Equity and Volatility Indices	256
16.7	Variance Dispersion	256
PART IV	HYBRID DERIVATIVES AND DYNAMIC STRATEGIES	259
17	Asset Classes (I)	261
17.1	Interest Rates	262
17.1.1	Forward Rate Agreements	262
17.1.2	Constant Maturity Swaps	263
17.1.3	Bonds	264
17.1.4	Yield Curves	265

17.1.5	Zero Coupon, LIBOR and Swap Rates	267
17.1.6	Interest Rate Swaptions	268
17.1.7	Interest Rate Caps and Floors	269
17.1.8	The SABR Model	270
17.1.9	Exotic Interest Rate Structures	271
17.2	Commodities	272
17.2.1	Forward and Futures Curves, Contango and Backwardation	273
17.2.2	Commodity Vanillas and Skew	276
18	Asset Classes (II)	279
18.1	Foreign Exchange	279
18.1.1	Forward and Futures Curves	279
18.1.2	FX Vanillas and Volatility Smiles	281
18.1.3	FX Implied Correlations	287
18.1.4	FX Exotics	287
18.2	Inflation	288
18.2.1	Inflation and the Need for Inflation Products	289
18.2.2	Inflation Swaps	289
18.2.3	Inflation Bonds	290
18.2.4	Inflation Derivatives	290
18.3	Credit	291
18.3.1	Bonds and Default Risk	292
18.3.2	Credit Default Swaps	293
19	Structuring Hybrid Derivatives	295
19.1	Diversification	295
19.1.1	Multi-asset Class Basket Options	296
19.1.2	Multi-asset Class Himalaya	297
19.2	Yield Enhancement	297
19.2.1	Rainbows	298
19.2.2	In- and Out-barriers	299
19.2.3	Multi-asset Class Digitals	299
19.2.4	Multi-asset Range Accruals	300
19.3	Multi-asset Class Views	301
19.4	Multi-asset Class Risk Hedging	303
20	Pricing Hybrid Derivatives	305
20.1	Additional Asset Class Models	305
20.1.1	Interest Rate Modelling	305
20.1.2	Commodity Modelling	309
20.1.3	FX Modelling	310
20.2	Copulas	312
20.2.1	Some Copula Theory	313
20.2.2	Modelling Dependencies in Copulas	314
20.2.3	Gaussian Copula	315
20.2.4	Pricing with Copulas	318

21	Dynamic Strategies and Thematic Indices	321
21.1	Portfolio Management Concepts	321
21.1.1	Mean–variance Analysis	321
21.1.2	Minimum-variance Frontier and Efficient Portfolios	322
21.1.3	Capital Asset Pricing Model	326
21.1.4	Sharpe Ratio	327
21.1.5	Portfolio Rebalancing	328
21.2	Dynamic Strategies	329
21.2.1	Why Dynamic Strategies?	329
21.2.2	Choosing the Assets	330
21.2.3	Building the Dynamic Strategy	330
21.3	Thematic Products	332
21.3.1	Demand for Thematic Products	333
21.3.2	Structuring a Thematic Index	334
21.3.3	Structured Products on Thematic Indices	335
21.3.4	Pricing Options on Thematic Indices	335
	APPENDICES	339
A	Models	341
A.1	Black–Scholes	341
A.1.1	Black–Scholes SDE	341
A.1.2	Black–Scholes PDE	341
A.2	Local Volatility Models	342
A.3	Stochastic Volatility	343
A.3.1	Heston’s Model	343
A.3.2	The SABR Model	345
A.4	Jump Models	346
A.5	Hull–White Interest Rate Model and Extensions	346
B	Approximations	349
B.1	Approximations for Vanilla Prices and Greeks	349
B.2	Basket Price Approximation	351
B.3	ICBC/CBC Inequality	351
B.4	Digitals: Vega and the Position of the Forward	352
	Postscript	355
	Bibliography	357
	Index	361

Part I

Foundations