

FOREIGN EXCHANGE RISK:
MODELS, INSTRUMENTS AND STRATEGIES



**FOREIGN EXCHANGE RISK:
MODELS, INSTRUMENTS AND
STRATEGIES**

Edited by Jürgen Hakala and Uwe Wystup

RISK
B O O K S

Published by Risk Books, a division of the Risk Waters Group.

Haymarket House
28–29 Haymarket
London SW1Y 4RX
Tel: +44 (0)20 7484 9700
Fax: +44 (0)20 7484 9758
E-mail: books@riskwaters.com
Sites: www.riskbooks.com
www.riskwaters.com

Every effort has been made to secure the permission of individual copyright holders for inclusion.

© Risk Waters Group Ltd 2002

ISBN 1899332 375

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Risk Books Commissioning Editor: Conrad Gardner
Desk Editor: Tamsin Kennedy
Typeset by Tech-Set Ltd

Printed and bound in Great Britain by CPI Bookcraft Ltd, (Bath), Somerset.

Conditions of sale

All rights reserved. No part of this publication may be reproduced in any material form whether by photocopying or storing in any medium by electronic means whether or not transiently or incidentally to some other use for this publication without the prior written consent of the copyright owner except in accordance with the provisions of the Copyright, Designs and Patents Act 1988 or under the terms of a licence issued by the Copyright Licensing Agency Limited of 90, Tottenham Court Road, London W1P 0LP.

Warning: the doing of any unauthorised act in relation to this work may result in both civil and criminal liability.

Every effort has been made to ensure the accuracy of the text at the time of publication. However, no responsibility for loss occasioned to any person acting or refraining from acting as a result of the material contained in this publication will be accepted by Risk Waters Group Ltd.

Many of the product names contained in this publication are registered trade marks, and Risk Books has made every effort to print them with the capitalisation and punctuation used by the trademark owner. For reasons of textual clarity, it is not our house style to use symbols such as TM, ®, etc. However, the absence of such symbols should not be taken to indicate absence of trademark protection; anyone wishing to use product names in the public domain should first clear such use with the product owner.

Contents

<i>The Authors</i>	xi
<i>Preface</i>	xv
Part I. Market: Products and Basics	1
1. Vanilla Options	3
1.1 Model and payoff.	3
1.2 Value	3
1.3 Greeks	5
1.4 Identities.	6
1.5 Quotation	9
1.6 Dual Black–Scholes Partial Differential Equation.	10
1.7 Retrieving the arguments.	10
1.8 Greeks in terms of deltas.	11
2. Volatility Management	15
2.1 Market risk of Foreign Exchange options	15
2.2 Historic volatility vs implied volatility.	16
2.3 Market data	17
2.4 Volatility smile.	17
2.5 Risk reversals and butterflies	19
2.6 Shape of the smile	20
2.7 Reasons for the smile	20
2.8 Term structure models and formulae	21
2.9 Wing shifts	22
2.10 Term structure of volatility at-the-money	23
3. Handling Differing Expiry and Delivery Dates	25
4. The Impact of Non-Business Days on the Pricing of Options	27
4.1 Introduction	27
4.2 Model and results.	27
5. Barrier Options – An Overview.	29
5.1 What is a barrier option?	29
5.2 The popularity of barrier options.	29
5.3 Barrier option crisis in 1994–96, questions about exotics in general	30
5.4 Types of barriers	31
5.5 How the barrier is monitored (continuous vs discrete) and how this influences the price.	33

5.6	How breaching the barrier is determined	33
5.7	Hedging methods, coping with high delta and gamma	34
5.8	How large barrier contracts affect the market	35
5.9	Difference between market prices and theoretical Black–Scholes values explained	35
6.	The Pricing of First Generation Exotics	37
6.1	Introduction	37
6.2	Single barrier options	37
6.3	Digital options	42
6.4	One-touch options	45
6.5	Double no-touch options	49
6.6	Corridors	50
6.7	Double barrier options	51
6.8	Fade-in-out options	54
6.9	Slide-in corridor	54
7.	The Pricing of Second Generation Exotics	57
7.1	Introduction	57
7.2	Forward-start options	57
7.3	Ratchet options	60
7.4	Power options	60
7.5	Instalment options	62
7.6	Stairs options	63
7.7	Compound on forward-start strategy	68
7.8	Options on the minimum/maximum	69
7.9	Generalised options on the minimum/maximum	72
8.	Quanto Options	75
8.1	Introduction	75
8.2	Quanto forward	76
8.3	Quanto European plain vanilla	76
8.4	Quanto forward-start plain vanilla	77
8.5	Quanto power option	77
9.	No-Arbitrage Bounds and Static Hedging of Compound Options	79
9.1	Compound options	79
9.2	Put-call parity and no-arbitrage bounds for compound options	80
9.3	Value of compound options in the Black–Scholes model	84
9.4	Hedging of compound options	85
9.5	Static hedging of compound options	86
10.	Taking a Corporate View: Zero-Cost Structures	97
10.1	Products and markets	97
10.2	Pricing	99
10.3	Conclusion	100
11.	Probability Density Functions and Related Tools	103
11.1	Motivation	103
11.2	The Probability Density Function	105
11.3	First exit times	109

12.	A Note on Forward and Backward Partial Differential Equations for Derivative Contracts with Forwards as Underlyings	115
12.1	Introduction	115
12.2	Forward and backward equations	116
12.3	Forward-based derivation of backward and forward Partial Differential Equations.	118
12.4	Summary.	120
Part II. Risk Management		125
13.	Efficient Computation of Option Price Sensitivities Using Homogeneity and Other Tricks.	127
13.1	Introduction	127
13.2	Fundamental properties.	129
13.3	European options in the Black–Scholes model	132
13.4	The one-dimensional case	134
13.5	A European claim in the two-dimensional Black–Scholes model.	137
13.6	Summary.	141
14.	How the Greeks would have Hedged Correlation Risk of Foreign Exchange Options	143
14.1	Introduction	143
14.2	Foreign Exchange market model	143
14.3	The extension beyond triangular markets	144
14.4	Geometric interpretation	145
14.5	Hedging correlation risk	145
Part III. Models and Applications to Exotic Options		147
15.	An Arithmetic Average Model with Applications to Pricing Asian and Basket Options	149
15.1	Introduction	149
15.2	Moment matching for the arithmetic spot	149
15.3	Alternative method of pricing using stochastic Taylor expansion	151
15.4	Asian options.	156
15.5	Basket options	158
15.6	Conclusion	163
16.	Finite Differences	165
16.1	Introduction	165
16.2	Black–Scholes framework	165
16.3	Stochastic volatility models	167
16.4	Path-dependence at discrete points in time.	170
16.5	The Greeks	171
17.	Monte Carlo Simulations and Variance Reduction Techniques	175
17.1	Introduction	175
17.2	The method.	175
17.3	Path-independent derivatives	176

17.4	Variance reduction methods.	177
17.5	Barrier options.	180
17.6	Stochastic volatility.	182
17.7	Calculating the Greeks	183
18.	Quasi-Random Numbers and their Application to Pricing Basket and Lookback Options.	187
18.1	Introduction	187
18.2	Some quasi-random sequences and a qualitative description . . .	188
18.3	The discrepancy, a quantitative description	192
18.4	Independent quasi-random numbers	195
18.5	Examples of Monte Carlo integration with quasi-random numbers	195
18.6	Convergence	198
18.7	Basket options	200
18.8	Lookback options	202
18.9	Conclusion	203
19.	Quasi-Monte Carlo Techniques for the Valuation of Contingent Claims on Several Assets	209
19.1	Introduction	209
19.2	Problem and notation.	210
19.3	The methods	213
19.4	Numerical results	216
19.5	Summary.	221
20.	Binomial Trees in One and Two Dimensions	227
20.1	One-step model	227
20.2	The martingale measure	228
20.3	Implementation	228
20.4	Convergence	229
20.5	Barrier options.	229
20.6	Binomial trees in two dimensions.	229
21.	Fast Fourier Method for the Valuation of Options on Several Correlated Currencies.	235
21.1	The problem and notation.	235
21.2	The method.	236
21.3	Numerical results	240
21.4	Summary.	245
22.	Local Volatility Surfaces – Tackling the Smile.	249
22.1	Introduction	249
22.2	The model.	250
22.3	Introducing the smile into the model	251
22.4	The main steps on our way to price options	252
22.5	From implied volatility to the dispersion coefficient	253
22.6	Interpolation of the implied volatility	256
22.7	Pricing	259

23. Heston's Stochastic Volatility Model Applied to Foreign Exchange	
Options	267
23.1 Introduction	267
23.2 Foreign Exchange setting	267
23.3 Implementation	268
23.4 Partial Differential Equation for a general contingent claim.	270
23.5 Calibration	272
23.6 Pricing one-touch options	279
24. Valuation of Options in Heston's Stochastic Volatility Model Using	
Finite Element Methods	283
24.1 Introduction	283
24.2 Heston's stochastic volatility model	285
24.3 Finite Element Method	286
24.4 Numerical solution	295
24.5 The basic idea of the Finite Element Method.	295
24.6 Selected solutions	299
25. A Jump-Diffusion Model Applied to Foreign Exchange Markets.	305
25.1 Introduction	305
25.2 A jump-diffusion model.	306
25.3 Option pricing formula	307
25.4 Effect of parameters on the shape of the smile.	309
25.5 Calibration to Foreign Exchange markets	311
25.6 Concluding remarks	316
26. A Model for Long-Term Foreign Exchange Options	317
26.1 Introduction	317
26.2 The model.	318
26.3 Vanilla option pricing.	319
26.4 Implementation of the one-factor model	320
26.5 Influence of correlation on the option price.	322
26.6 Extension to multiple factors	323
26.7 Conclusions.	324
27. Dealing with Dangerous Digitals.	327
27.1 Introduction	327
27.2 Reverse up-and-out call.	329
27.3 Model formulation and survey of super-replication under	
leverage constraints.	330
27.4 Analytical solutions	334
27.5 Numerical Solutions	344
27.6 Summary.	346
<i>Index</i>	349