

Financial Engineering and Arbitrage  
in the Financial Markets

Robert Dubil



A John Wiley & Sons, Ltd., Publication

# Contents

<b>Introduction</b>	<b>xi</b>
<b>1 Purpose and Structure of Financial Markets</b>	<b>1</b>
1.1 Overview of Financial Markets	1
1.2 Risk Sharing	2
1.3 Transactional Structure of Financial Markets	6
1.4 Arbitrage: Pure Versus Relative Value	8
1.5 Financial Institutions: Transforming Intermediaries vs Broker-Dealers	12
1.6 Primary (Issuance) and Secondary (Resale) Markets	13
1.7 Market Players: Hedgers vs Speculators	15
1.8 Preview of the Book	18
<b>PART 1 RELATIVE VALUE BUILDING BLOCKS</b>	
<b>2 Spot Markets</b>	<b>23</b>
2.1 Bonds and Annual Bond Math	23
2.1.1 Zero-Coupon Bond	23
2.1.2 Coupon Bond	25
2.1.3 Amortizing Bond	27
2.1.4 Floating Rate Bond	28
2.2 Intra-Year Compounding and Day-Count	30
2.2.1 Intra-Year Compounding	30
2.2.2 Day-Count	31
2.2.3 Accrued Interest	33
2.3 Term Structure of Interest Rates and the Discount Factor Bootstrap	34
2.3.1 Term Structure	34
2.3.2 Discount Factor Bootstrap	36
2.3.3 Valuation of an Arbitrary Bond	36
2.4 Interest Rate Risk: Duration and Convexity	39
2.4.1 Duration	41
2.4.2 Portfolio Duration	44
2.4.3 Convexity	45
2.4.4 Other Risk Measures	46

2.5	Equity, Commodity, and Currency Math	47
2.5.1	Equities	48
2.5.2	Currencies	49
2.6	Short Selling	51
2.6.1	Buying on Margin	52
2.6.2	Short Selling in a Margin Account	53
2.6.3	Short Selling of Bonds	54
<b>3</b>	<b>Futures Markets</b>	<b>57</b>
3.1	Fundamentals of Futures and Forwards	57
3.2	Futures Mechanics	59
3.2.1	Physical Commodity Futures	59
3.2.2	Interest Rate Futures	62
3.2.3	Stock Index Futures	69
3.2.4	Currency Futures and Forwards	70
3.3	Cash-and-Carry Arbitrage	73
3.3.1	Commodities	74
3.3.2	Stock Indexes	76
3.3.3	Currencies	79
3.4	Futures Not Subject to Cash-and-Carry	81
3.5	Yield Curve Construction with Interest Rate Futures	84
3.5.1	Certainty Equivalence of Eurodollar Futures	85
3.5.2	Forward Rate Agreements	86
3.5.3	Building Spot Zeros	88
3.5.4	Recovering the Forwards	91
3.5.5	Including Repo Rates in the Calculation of the Forwards	93
<b>4</b>	<b>Swap Markets</b>	<b>95</b>
4.1	Fundamentals of Swaps	95
4.1.1	The Dual Nature of Swaps	96
4.1.2	Implication for Pricing and Hedging	96
4.2	Interest Rate Swaps	97
4.2.1	Definition of an Interest Rate Swap	97
4.2.2	Valuation of Interest Rate Swaps	99
4.2.3	Hedging of Interest Rate Swaps	101
4.3	Cross-Currency Swaps	105
4.3.1	Definition of a Fixed-for-Fixed Cross-Currency Swap	105
4.3.2	Valuation and Settlement of Cross-Currency Swaps	107
4.3.3	Cross-Currency Swaps as Packages of Off-Market FX Forwards	109
4.3.4	Multicurrency and Combination Cross-Currency Swaps	110
4.4	Equity, Commodity, and Exotic Swaps	112
4.4.1	Equity Swaps	112
4.4.2	Commodity Swaps	114
4.4.3	Volatility Swaps	115
4.4.4	Index Principal Swaps	116

<b>5</b>	<b>Options on Prices and Hedge-Based Valuation</b>	<b>119</b>
5.1	Call and Put Payoffs at Expiry	120
5.2	Composite Payoffs at Expiry	122
5.2.1	Straddles and Strangles	122
5.2.2	Spreads and Combinations	123
5.3	Option Values Prior to Expiry	126
5.4	Options and Forwards, Risk Sharing and Put–Call Parity	127
5.5	Currency Options	128
5.6	Binomial Option Pricing	129
5.6.1	One-Step Examples	129
5.7	Black–Scholes Model and Extensions	141
5.7.1	Black–Scholes with No Dividends	141
5.7.2	Dividends	142
5.7.3	Options on Currency Rates	143
5.7.4	Black–Scholes Delta, Gamma, and Vega	144
5.8	Residual Risk of Options: Gamma, Vega, and Volatility	145
5.8.1	Implied Volatility	147
5.8.2	Volatility Smiles and Skews	148
5.9	A Real-Life Option Pricing Exercise	150
5.9.1	Consistency Checks: Put–Call Parity, Black–Scholes, and Binomial	150
 <b>6</b>	 <b>Options on Non-Price Variables</b>	 <b>155</b>
6.1	Black Models For Bond Price Options, Caps/Floors, and European Swaptions	156
6.1.1	Options on Bond Prices	156
6.1.2	Cap and Floor Definitions	158
6.1.3	Relationship of Caps and Floors to FRAs and Swaps	159
6.1.4	A Cap Application	160
6.1.5	Pricing of Caps and Floors	163
6.1.6	European Swaption Definitions	164
6.1.7	Options to Cancel Swaps	165
6.1.8	Relationship of Swaptions to Forward Swaps	165
6.1.9	Pricing of European Swaptions	167
6.1.10	Limitations of the Black Model	168
6.2	Convexity-Adjusted Models For Libor Forwards, Quantos, and Constant Maturity Swaps	168
6.2.1	Convexity Adjustment for Eurodollar Futures	169
6.2.2	Convexity Adjustment for CMS Options	170
6.2.3	Quanto Adjustments	171
6.3	Arbitrage-Free Interest Rate Models	172
6.3.1	Short Rate Models	173
6.3.2	Trinomial Trees and Calibration	174
6.3.3	The Heath–Jarrow–Morton Model and the LIBOR Market Model	176
6.3.4	Bermudan Swaptions and Multifactor Models	180
6.4	Exotic Interest Rate Options	181

---

6.4.1	Periodic Caps	181
6.4.2	Digitals and Ranges	181
<b>7</b>	<b>Default Risk and Credit Derivatives</b>	<b>183</b>
7.1	Credit Default Swaps	184
7.1.1	Credit Default Swap	184
7.1.2	No Arbitrage: CDS vs Corporate Bond Spread	185
7.1.3	Bundled Single-Name Credit Derivatives	186
7.2	A Constant Default Probability Model	190
7.3	A Deterministic Credit Migration Model	193
7.4	A Poisson Model of Single Issuer Default	195
7.4.1	Poisson Distribution	195
7.4.2	A Single Issuer Default Model	196
7.4.3	Pricing a Credit Default Swap in a Single Issuer Default Model	198
7.5	The Default Correlation of the Reference Issuer and the Protection Seller	199
<b>PART II CASH FLOW ENGINEERING</b>		
<b>8</b>	<b>Structured Finance</b>	<b>203</b>
8.1	A Simple Classification of Structured Notes	204
8.2	Interest Rate and Yield Curve-Based Structured Products	206
8.2.1	An Inverse Floater	206
8.2.2	A Leveraged Inverse Floater	209
8.2.3	A Capped Floater	211
8.2.4	A Callable	211
8.2.5	A Range Floater	212
8.2.6	An Index Principal Swap	212
8.3	Asset Class-Linked Notes	213
8.3.1	Principal-Protected Equity-Linked Notes	213
8.3.2	A (Rainbow) Multi-Asset-Linked Note	216
8.3.3	Principal-At-Risk Notes and Commodity-Tracking ETNs	216
8.4	Insurance Risk Structured Products	219
<b>9</b>	<b>Mortgage-Backed Securities</b>	<b>223</b>
9.1	Mortgage Financing Basics	224
9.2	Prepayment Risk	226
9.3	Mortgage Pass-Through Securities	227
9.4	Collateralized Mortgage Obligations	232
9.4.1	Sequential-Pay CMO	232
9.4.2	Planned Amortization Class CMO	233
9.4.3	Interest-only (IO) and Principal-only (PO) Classes	237
9.5	Multiclass and Non-Vanilla CMOs	241
9.5.1	A Multiclass PAC Structure with a PAC I/O and a Floater/Inverse Coupon Split	241
9.5.2	Non-Accelerating Senior and Accrual Tranches in Sequential CMOs	242

---

<b>10 Collateralized Debt Obligations and Basket Credit Derivatives</b>	<b>243</b>
10.1 Collateralized Debt Obligations	243
10.1.1 Cash CDO	244
10.1.2 Synthetic CDO	246
10.2 Basket Credit Derivatives	249
10.2.1 First-to-Default Basket	249
10.2.2 <i>N</i> th-to-Default Basket, Arbitrage Conditions, and Hedging	251
10.2.3 Hedging of Basket Derivatives	252
10.3 Copulas and the Modeling of Default Correlation	252
10.3.1 A Gaussian Copula	254
10.3.2 General Copula Models	255
10.4 Synthetic CDO Tranche Pricing and Loss Analysis	256
10.4.1 Synthetic CDO Revisited	256
10.4.2 Synthetic CDO Pricing and Expected Loss	257
10.4.3 Synthetic CDO – Loss Rates, Ratings and the Crisis of 2008	259
10.5 Credit Derivative Indexes	260
<b>PART III THE PLAYERS</b>	
<b>11 Individual Investors: A Survey of Modern Investment Theory</b>	<b>265</b>
11.1 A Brief History of Investment Thought	266
11.2 Free Cash Flow Valuation of Companies	269
11.2.1 Free Cash Flow Definitions	270
11.2.2 Growth and the Discounting of the Cash Flows	273
11.2.3 Terminal Multiple Models of Cash Flow Discounting	274
11.3 The Modern Portfolio Theory and the CAPM	276
11.3.1 Diversification and the Efficient Frontier	276
11.3.2 Two-Fund Separation	278
11.3.3 Systematic Risk and the CAPM	279
11.3.4 Using the CAPM as a Stock Screen to Discover Alpha	280
11.4 Multifactor Index Models	282
11.4.1 The Fama–French Three-Factor Model	283
11.4.2 The Carhart Fourth Factor: the Momentum	283
11.4.3 International Index Factors	284
11.5 Fundamental Indexing	284
11.5.1 A Brief History of Fundamental Indexing	285
11.5.2 Fundamental Indexing and Rebalancing	285
11.5.3 Tactical Asset Allocation	286
11.5.4 Fundamentally Indexed US Funds	286
<b>12 Hedge Funds: Alpha, Beta, and Strategy Indexes</b>	<b>287</b>
12.1 Hedge Fund Strategies	289
12.1.1 Relative Asset Value Funds	289
12.1.2 Relative Corporate/Credit Structure	292
12.1.3 Theoretical Relative Value	294
12.1.4 Statistical Relative Value Arbitrage	296

12.2	Portable Alpha and Market-Neutral Plays	298
12.3	Hedge Fund Replication and Strategy Indexes	299
<b>13</b>	<b>Banks: Asset-Liability Management</b>	<b>303</b>
13.1	Bank Balance Sheets and Income Statements	305
13.2	Interest-Sensitive Gap Management	313
13.3	Duration Gap Management	320
13.4	Value at Risk	322
<b>14</b>	<b>Private Equity, Pension, and Sovereign Funds</b>	<b>329</b>
14.1	Private Equity	329
14.1.1	Investment in Private Equity – Limited Partnership Funds	330
14.1.2	Leverage Buyouts	331
14.1.3	Private Equity Lending – Mezzanine Capital and Distressed Loans	332
14.1.4	Other Forms of Private Equity – PIPEs	333
14.1.5	Venture Capital	333
14.1.6	Exit Strategies – IPOs and Secondary Sales	334
14.2	Risk Allocation for Pension Funds and Sovereign Funds	335
14.2.1	Defined Benefit Pension Funds and Endowments	335
14.2.2	The Risk Budget Allocation Process	336
	Acknowledgment	338
	<b>References</b>	<b>339</b>
	<b>Index</b>	<b>343</b>