

Michael Hanke

**Credit Risk, Capital Structure, and
the Pricing of Equity Options**

SpringerWienNewYork

Contents

List of Symbols	xiv
1 Option Pricing with an Exogenous Stock Price Process	1
1.1 A One-Period Pricing Model	1
1.1.1 Model Description	2
1.1.2 Replicating Portfolios	3
1.1.3 Absence of Arbitrage	4
1.1.4 Risk-Neutral Valuation and Equivalent Martingale Measures	5
1.1.5 Numerical Example	7
1.2 The Binomial Model	9
1.2.1 Model Description	9
1.2.2 Replicating Portfolios	9
1.2.3 Absence of Arbitrage	10
1.2.4 Martingale Measure	11
1.2.5 Numerical Example	11
1.3 The Black-Scholes-Merton Model	13
1.3.1 Model Description	13
1.3.2 Replicating Portfolios	15
1.3.3 Absence of Arbitrage and Risk-Neutral Pricing . . .	16
1.3.4 "Measure-Independent" Derivation of Probabilities .	18
1.3.5 Extension: Continuous Dividend Yield	21
2 Option Pricing with an Endogenous Stock Price Process	23
2.1 The Extended One-Period Option Pricing Model with Endogenous Stock Price Process	23
2.1.1 Model Description	23
2.1.2 Risk-Neutral Valuation of Corporate Securities . . .	24
2.1.3 Risk-Neutral Valuation of Options	25
2.1.4 Numerical Examples	25

2.2	The Extended Binomial Option Pricing Model with Endogenous Stock Price Process	26
2.2.1	Model Description	26
2.2.2	Risk-Neutral Valuation of Corporate Securities . . .	27
2.2.3	Risk-Neutral Valuation of Options	28
2.2.4	Numerical Examples	28
2.3	The Extended Black-Scholes Model with Endogenous Stock Price Process	31
2.3.1	Model Description	31
2.3.2	Risk-Neutral Valuation of Corporate Securities . . .	31
2.3.2.1	Equity	32
2.3.2.2	Corporate Bond	33
2.3.3	Risk-Neutral Valuation of Options	33
2.3.4	"Measure-Independent" Derivation of Probabilities .	34
2.3.5	Numerical Examples	35
3	Exotic Options	39
3.1	Non-Barrier Exotic Options	39
3.2	Barrier Options	40
3.2.1	Preliminaries	41
3.2.2	Option Types and Barrier-Dependent Probabilities .	42
3.3	Applications: Barrier Heavisides, Calls and Puts	49
3.3.1	Barrier Heavisides	49
3.3.2	Barrier Calls	50
3.3.3	Barrier Puts	51
3.3.4	Relation to the Standard Approach	52
3.4	Numerical Examples	54
4	A Probabilistic, Firm Value Based Security Pricing Framework	59
4.1	Ericsson and Reneby (1998)	59
4.1.1	Assumptions	60
4.1.2	Valuation of the Building Blocks	61
4.1.3	Results	65
4.2	Ericsson and Reneby (2001)	69
4.3	Additional Building Blocks within the Probabilistic Framework	74

5	A Review of Firm Value Based Security Pricing Models from a Probabilistic Perspective	91
5.1	Finite-Maturity Discount Bonds, No Intermediate Default (Merton 1974)	92
5.2	Finite-Maturity, Continuous-Coupon Bonds, Intermediate Default (Black and Cox 1976)	92
5.3	Finite-Maturity, Discrete-Coupon Bonds, Intermediate Default (Geske 1977)	94
5.4	Finite-Maturity, Convertible Discount Bonds, No Intermediate Default (Ingersoll 1977a)	95
5.4.1	Convertible Discount Bonds	95
5.4.2	Callable Convertible Discount Bonds	96
5.5	Finite-Maturity, Discrete-Coupon Bonds, Intermediate Default, Discrete Dividends, Taxes, Stochastic Interest Rates (Brennan and Schwartz 1977,1978,1980)	98
5.6	Warrants (Galai and Schneller 1978)	99
5.7	Empirical Study of Firm Value Based Pricing of Corporate Bonds (Jones, Mason and Rosenfeld 1984)	101
5.8	Finite-Maturity, Continuous-Coupon Bonds, Intermediate Default, CIR Interest Rates (Kim, Ramaswamy and Sundaresan 1993)	102
5.9	Finite-Maturity, Continuous-Coupon Bonds, Intermediate Default, Vasicek Interest Rates (Longstaff and Schwartz 1995)	103
5.10	Infinite-Maturity, Continuous-Coupon Bonds, Taxes, Intermediate Default, Bankruptcy Costs (Leland 1994)	104
5.11	Finite-Maturity, Continuous-Coupon Bonds, Taxes, Intermediate Default, Bankruptcy Costs (Leland and Toft 1996)	107
5.12	Finite-Average-Maturity, Continuous-Coupon Bonds, Taxes, Intermediate Default, Bankruptcy Costs, Costly Debt Issuance (Leland 1998)	110
5.13	“Model A”: Finite-Maturity, Continuous-Coupon Bonds, Exponentially Increasing Debt, Intermediate Default, Bankruptcy Costs, Taxes, Deviations from Absolute Priority (Extended Leland and Toft)	111

6	Extension of the Probabilistic Security Pricing Framework to Derivative Securities	115
6.1	Ericsson and Reneby (1996)	115
6.1.1	Assumptions and Results	115
6.1.2	Correcting the Ericsson–Reneby (1996) Results . . .	118
6.2	Reneby (1998)	121
6.3	Extending the Ericsson–Reneby (1996) Results	122
6.3.1	Lifting Assumptions	122
6.3.2	Down-and-Out Underlyings Other than Calls or Heavisides	123
6.3.3	Put Options on Down-and-Out Underlyings	133
6.3.4	Underlyings of the Up-Barrier Type	134
7	Review of Firm Value Based Pricing Models for Equity Derivatives from a Probabilistic Perspective	139
7.1	Option Pricing Extension of Merton (1974): Geske (1979) .	139
7.2	Option Pricing Extension of Leland (1994): Toft and Prucyk (1997)	141
7.3	Option Pricing Extension of Galai and Schneller (1978): Hanke and Pötzelberger (2002)	143
8	Option Pricing Extensions for Several Classical Capital Structure Models	147
8.1	Model 1: Option Pricing Extension of Black and Cox (1976)	147
8.2	Option Pricing Extensions of Ingersoll (1977a)	149
8.2.1	Model 2: Convertible Discount Bonds	149
8.2.2	Model 3: Callable Convertible Discount Bonds . . .	150
8.3	Model 4: Option Pricing Extension of Leland and Toft (1996)	150
8.4	Model 5: Option Pricing Extension of (a Restricted Version of) Leland (1998)	151
8.5	Model 6: Option Pricing Extension of Ericsson and Reneby (2001)	152
8.6	Model 7: Option Pricing Extension of Model A	153
9	Capital Structure Effects in Option Prices – The Static Case	155
9.1	Pricing Biases of the Black–Scholes Model – “Stylized Facts”	156

9.1.1	The Volatility Smile	156
9.1.2	The Term Structure of Volatilities	157
9.1.3	The Debt-Maturity Term Structure of Volatilities . .	158
9.2	Pure Debt-Equity Capital Structures	158
9.2.1	Merton (1974)/Geske (1979)	158
9.2.1.1	Volatility Smile	159
9.2.1.2	Term Structure of Volatilities	162
9.2.1.3	Debt-Maturity Term Structure of Volatilities	164
9.2.2	Black and Cox (1976)/Model 1	164
9.2.2.1	Positive Asset Payouts, No Barrier	165
9.2.2.2	Positive and Exponentially Increasing Barrier, No Asset Payouts	169
9.2.3	Leland (1994) / Toft and Prucyk (1997)	172
9.2.4	(Restricted) Leland (1998) / Model 5	173
9.2.5	Leland and Toft (1996) / Model 4	177
9.2.6	Ericsson and Reneby (2001) / Model 6	180
9.2.7	Model A / Model 7	182
9.2.8	Conclusions	186
9.3	Capital Structure Models with Convertibles	186
9.3.1	Ingersoll (1977a): Convertible Discount Bonds / Model 2	187
9.3.2	Ingersoll (1977a): Callable Convertible Discount Bonds / Model 3	187
10	Option Pricing Effects of Changes in a Firm's Capital Structure	191
10.1	Changes within Model 7	192
10.1.1	Changes in the Level of Debt	192
10.1.2	Changes in the Growth Rate of Debt	194
10.1.3	Changes in Debt Maturity	195
10.1.4	Changes in the Level of Debt Protection	196
10.2	Changes within Hanke and Pötzelberger (2002)	197
11	Conclusions and Directions for Further Research	201
	Bibliography	203