

Index

- 30/360, 28
 “60:40” strategy, 157
- accrued interest, 28–30, 302
 actual/360, 141, 298
 actual/365, 313
 actual/actual, 28
 add-on method, 17, 299
 adjustable-rate mortgage, 16, 419, 431–432
 attractiveness, 16, 419
 benefits to the industry, 419
 hedging, 419
 index, 16, 419, 431
 initial rate, 16, 419, 432
 margin, 429, 431, 432
 path-dependent, *see* path-dependent derivative,
 adjustable-rate mortgage
 pricing, 429–432
 rate adjustment, 16, 419, 432
 rate cap, 16, 419
 lifetime, 432
 periodic, 432
 rate floor, 432
 reset interval, 432
 “teaser” rate (initial rate), 419
 agency security, 24, 400, 423
 day count, 28
 guarantee, 400
 market,
 algorithm, 7, 10
 approximation, 153
 comparison, 7, 10, 234, 244–245
 complexity, 7, 8, 374
 asymptotic analysis, 8, 13
 computational, 7–9
 cubic, 9
 exponential, 9, 430
 intractability, 7, 9
 linear, 8
 logarithmic, 8
 quadratic, 9
 space, 7
 description, 9–10
 recursive, 10, 103–104
 America Online, Inc., 6, 466
 American option, 75, 78, 85, 86, 88–89, 113–114, 118
 analytic results, 121
 barrier option, *as*, 140
 binomial tree algorithm, 102, 113, 116, 122, 404, 407
 correctness, 121
 diagonal method, *see* diagonal method
 call, *see* call, American
 early exercise, 75, 88, 96–97, 102, 113, 115, 211, 405
 boundary, 119, 140, 211, 222
 continuous dividend yield, 118, 147, 211
 forward option, *see* forward option, American, early exercise
 futures option, *see* futures option, American, early exercise
 volatility, 112
 implied volatility, 112, 341
 known dividend yield, 115–116, 120
 Monte Carlo simulation, 257, 266
 numerical techniques, 121
 put, *see* put, American
 American Stock Exchange, 78, 79, 143
 American terms, 144
 amortization, 15–17, 318, 429, 442
 schedule, 15–17, 420
 amortization factor (factor), 428
 analog method (method of moments), 74
 André, Desiré, 235
 annuity, 14–15
 due, 14, 15
 general, 14
 ordinary, 14, 50
 perpetual, 15, 24
 antithetic variates, *see* variance reduction, antithetic variates
 Apple II, 4

588 **Index**

- arbitrage, 84–85, 93–95, 97, 155, 224, 350
 freedom, 84–86, 92, 94, 98, 99, 356, 495, *see*
 Arbitrage Pricing Theory, arbitrage
 freedom, *see* binomial model, interest rate
 process, arbitrage, *see* Capital Asset Pricing
 Model, arbitrage freedom, *see* discount
 factor, arbitrage, *see* forward price,
 arbitrage, *see* forward rate process, arbitrage
 freedom, *see* interest rate model, arbitrage
 freedom, *see* interest rate model,
 no-arbitrage, arbitrage freedom, *see* interest
 rate model, risk-neutral process, arbitrage
 freedom, *see* parallel shift, problems, *see*
 present value, arbitrage, *see* risk-neutral
 probability, arbitrage freedom, *see* spot rate,
 arbitrage, *see* Treasury bill futures, arbitrage
 history, 91
 Arbitrage Pricing Theory, 470, 472–473
 arbitrage freedom, 472
 Capital Asset Pricing Model, *see* Capital Asset
 Pricing Model, Arbitrage Pricing Theory
 compared
 factor price, 472
 market price of risk (factor price), 472
 arbitrage theorem, 495
 arbitrage value, 97
 arbitrager, 224
 architect, 11
 Ariane 5, 10n
 Aristotle, 77
 Arrow security (state contingent claim), 83n
 Arrow, Kenneth J., 83n
 as-you-like-it option (chooser option), 148
 Asian option (average-rate option), 149
 asset-backed security, 3
 asset/liability management, 36–39, 61, 304, 419
 asset mismatch
 futures contract, 226
 interest rate swap, 314–315, 318
 maturity mismatch
 futures contract, 226
 interest rate swap, 314
 AT&T Corp., 17, 153n, 466
 auto loan, 4
 Autocorrelation, *see* stochastic process,
 autocorrelation function
 autocovariance function (covariance function),
 287
 autoregressive conditional heteroskedastic process,
 292–293
 autocorrelation function, 292
 kurtosis, 292
 maximum likelihood estimator, 292–293
 stationarity, 292
 autoregressive moving average process, 289
 conditional variance, 291
 covariance function, *see* covariance function,
 autoregressive moving average process
 stationarity, 289, 290
 autoregressive process, 288–289, 291, 292
 autocorrelation function, 289
 conditional variance, 291
 covariance function, *see* covariance function,
 autoregressive process
 ergodicity, 291
 interest rate model, 362
 maximum likelihood estimator, 290–291
 ordinary least-squares estimator, 290–291
 stationarity, 289–291, 294n
 volatility, 291–292
 average-rate option, 151, 153
 arithmetic, 148, 149, 212
 analytical approximation, 153, 267
 antithetic variates, 260, 261
 approximation algorithm, 149, 152, 153
 binomial tree algorithm, 149, 152–153
 conditioning, 267
 control variates, 261, 262, 267, 524
 issue date, 152
 Monte Carlo simulation, 257, 258, 260
 Black–Scholes differential equation, *see*
 Black–Scholes differential equation,
 average-rate option
 geometric, 149, 213, 261
 binomial tree algorithm, 151, 153, 238
 put–call parity, *see* put–call parity, average-rate
 option
 average-strike option (lookback option, average),
 150
 Bachelier, Louis, 1, 68, 184, 188
 career problems, 6n
 influence on Kiyosi Ito, 205
 Mathematical Theory of Speculation, 1, 288
 backward induction, 97, 100, 101, 106, 113, 115, 118,
 119, 152, 243, 246, 251, 338
 average-rate option, 151
 barrier option valuation, 138, 502
 interest rate model calibration, 334, 382, 542
 interest rate security valuation, 331, 354, 368,
 376, 397, 408, 430–431
 backward substitution, 269
 backwardation, 225
 balloon, 16, *see* mortgage, balloon
 bank, 3, 4, 39, 156
 commercial, 59, 314, 416
 investment, 3
 mortgage, 416, 417
 savings, 3
 Bank for International Settlements, 474
 bank loan, 4, 402
 Bank of England, 156
 barbell portfolio, 43, 62
 barrier option, 137–140, 149, 235, 248
 American, 138, 139, 153
 double, 140, 240–242, 248
 down-and-in, 137–139, 236–240, 244
 down-and-out, 137–140, 243, 244

- forward starting, 140
- knock-in, 137, 139, 240, 241, 503
- knock-out, 137, 139, 241, 503
- nonconstant barrier, 139–140, 241
- numerical techniques, *see* binomial tree
 - algorithm, barrier option, *see* Monte Carlo simulation, option, barrier, *see* trinomial tree algorithm, barrier option
- partial, 140
- popularity, 137
- rebate, 138, 139, 244, 503
- rolling, 140
- static replication, *see* hedging, static
- up-and-in, 137, 138, 244
- up-and-out, 137, 138, 244
- Bartter, Brit J., 331
- base interest rate (benchmark interest rate), 46
- baseline rate, *see* binomial interest rate tree,
 - baseline rate
- Basic programming language, xiv
- basis, *see* futures contract, basis
- basis point, 41, 60, 303
- basis-point value, 41, 303
- basis risk, *see* futures contract, basis risk
- basket option, 245
- benchmark interest rate, 46
- benchmark yield curve, 330
- Berners-Lee, Tim, 6
- Bernoulli random variable, 104, 107, 194
- Berry–Esseen theorem, 256
- beta, 73, 227, 228, 261, 468, 529
 - adjusting, 228
 - Capital Asset Pricing Model, *see* Capital Asset Pricing Model, beta
 - factor model, *see* factor model, factor beta
 - yield, 41
- bid–ask spread, 111, 324
 - interest rate swap, 314
- binary option, 108, 122n, 232, 237
- binomial distribution, 95, 329
 - complementary, 95
- binomial interest rate tree, 328–331, 344, 380
 - baseline rate, 330, 336, 382
 - bias, 333, 334, 337
 - calibration, 334–337, 408
 - Newton–Raphson method, 335–337
 - secant method, 337
 - continuous-time limit, 330, 331
 - fixed-income option, *see* fixed-income option, valuation, binomial interest rate tree
 - forward price, 341
 - futures price, 341
 - local expectations theory, 350
 - mean reversion, 330
 - memory requirement, 330, 331
 - model price, 331–332, 337
 - option-adjusted spread, *see* option-adjusted spread, binomial interest rate tree
 - put–call parity, *see* put–call parity, fixed-income option, binomial interest rate tree
 - risk-neutral probability, 329, 334, 337, 395
 - short rate volatility, 329–332, 334, 336, 344
 - spread, 337–341, 408
 - Newton–Raphson method, 338–340
 - parallel shift, 340
 - term structure dynamics, *see* term structure, dynamics, binomial interest rate tree
 - unbiased expectations theory, *see* expectations theory, unbiased, binomial interest rate tree
 - yield volatility term structure, *see* term structure, yield volatility, binomial interest rate tree
- binomial lattice, 96
- binomial model, 92, 95, 178, 182, 185, 234–235
 - continuous-time limit, 194, 204, 344n, 369–370
 - correlated, 179, 246–248, 344
 - interest rate process, 353–359, 429, 432
 - arbitrage, 356, 360
 - interest rate derivative, *see* adjustable-rate mortgage, pricing, *see* fixed-income option, valuation, binomial model, *see* mortgage-backed security, valuation, binomial model *see* risk-neutral valuation, fixed-income security, binomial model, *see* stripped mortgage-backed security, valuation, binomial model
 - local expectations theory, 354
 - model price, 331
 - trinomial model, vs., 384
 - trinomial model’s special case, 244
- binomial option pricing model, 92–104, 110, 114, 185, 209, 248, 248n, 344, 344n, 360n, 369
 - alternative choices of u and d , 105–106, 110–112, 205, 521
- Black–Scholes differential equation, *see* Black–Scholes differential equation, binomial option pricing model
- Black–Scholes formula, *see* Black–Scholes formula, derivation, binomial option pricing model
- calibration, 104
- delta, 93, 96, 97, 123
- delta hedge, *see* delta-neutral, delta hedge, binomial option pricing model
- foreign exchange, 146, 181
- forward price, 172–173
- futures price, 172–173, 221
 - martingale, 182
- history, 121
- martingale, 180–181, 183
- oscillation, 110
- put–call parity, *see* put–call parity, binomial option pricing model
- random walk, 178
- rate of return, 94, 95, 104–106, 204–205
- binomial state price tree, 335, 337

590 **Index**

- binomial tree, 96
 - combining, 116, 363, 366, 369, 371, 383, 391, 393, 396
 - implied, 113, 121, 293, 337, 499
- binomial tree algorithm, 101, 127, 249
 - average-rate option, *see* average-rate option, arithmetic, binomial tree algorithm, *see* average-rate option, geometric, binomial tree algorithm
 - barrier option, 138–139, 238
 - analytic approach, *vs.*, 237
 - convergence, 139, 238–240, 244, 248
 - down-and-in, 236–240, 503
 - down-and-out, 138, 238, 503
 - effective barrier, 138, 236, 238, 240, 243, 248n, 503
 - trinomial tree algorithm, *vs.*, *see* trinomial tree algorithm, barrier option, binomial tree algorithm, *vs.*
 - up-and-in, 238
 - up-and-out, 238
 - chooser option, 148
 - complexity, 100–103, 238
 - compound option, 148
 - continuous dividend yield, 117–118
 - convergence, 106, 110, 122, 238
 - implicit method compared, 266
 - convertible bond, *see* convertible bond, valuation, binomial tree algorithm
 - extended, 130, 244
 - forward option, 172–173
 - futures option, 172–173
 - lookback option, 153, 238, 505–506
 - option, 100–103, 110–111, 113, 115, 116, 341, *see* American option binomial tree algorithm
 - warrant, *see* warrant, binomial tree algorithm
- bisection method, 21, 23–24
- Black model, 171–172, 359
 - interest rate cap/floor, 309
 - mortgage-backed security forward option, 446
 - popularity, 176
 - proof, 212
 - swaption, 319
- Black, Fischer, 92, 131, 171, 380, 464
 - biography, 122
- Black–Derman–Toy model, 344, 380–384, 448
 - calibration, 381–382, 397
 - Newton–Raphson method, 382
 - secant method, 382
 - stability, 388
 - continuous-time limit, 382
 - mean reversion, 382
 - popularity, 380
 - problems, *see* lognormal distribution, interest rate, problems
 - risk-neutral probability, 395
 - short rate process, 380
 - short rate volatility, 344, 380, 382, 393
 - yield volatility term structure, *see* term structure, yield volatility, Black–Derman–Toy model
- Black–Karasinski model, 382–383
 - calibration, 383, 388
 - discrete time, 383
 - mean reversion, 383
 - problems, *see* lognormal distribution, interest rate, problems
 - short rate volatility, 383
 - trinomial tree, 388
- Black–Scholes differential equation, 207–209, 250
 - average-rate option, 212–213
 - binomial option pricing model, 209
 - continuous dividend yield, 212
 - convertible bond, 219
 - delta-neutral, *see* delta-neutral, Black–Scholes differential equation
 - derivation, 207–209, 222
 - derivative, *see* derivative, Black–Scholes differential equation
 - finite-difference method, 252–255, 266
 - explicit method, 253–254
 - implicit method, 255
 - forward contract, *see* forward contract, Black–Scholes differential equation
 - futures option, *see* futures option, Black–Scholes differential equation
 - initial and boundary conditions, 211, 254
 - American option, 211
 - European option, 211–212
 - numerical accuracy, 211
 - multivariate derivative, 213, 266
 - option, 209–211
 - sensitivity, *see* sensitivity, Black–Scholes differential equation
 - violation, 211
- Black–Scholes formula, 92, 106–113, 121, 123, 138, 159, 209
- Black–Scholes differential equation, 209
 - day count, 112
 - derivation, 108, 121
 - binomial option pricing model, 104–108
 - Black–Scholes differential equation, 210–211
 - Margrabe formula, 214, 215
 - independence of return, 209
 - interest rate, 111
 - self-fulfilling, 223
 - variables, 93
 - volatility, 106, 108, 112, 121, 125, 221–222, 284, 286–288, 359
 - historical, 111–112, 121, 204, 284, 372
 - implied, 112–113, 121, 125, 372
 - maximum likelihood estimator, 111, 284–286
 - “smile”, 112, 121, 221, 293
- Black–Scholes option pricing model, 1, 92, 110, 121, 149, 328, 352, 359, 369, 388
 - calibration, 372
 - empirical study, 121, 223

- fixed-income option, *see* fixed-income option, valuation, Black–Scholes model
- foreign exchange option, 146–147, 158, 217
 - empirical study, 146
- interest rate model, *see* interest rate model, Black–Scholes for yield *see* interest rate model, Black–Scholes
- Merton’s contribution, 92
- problems, 112, 221–222
- publication problems, 122n
- stochastic volatility, *see* volatility, stochastic
- stock index option, 143, 154n
- warrant, *see* warrant, Black–Scholes option pricing model
- Bloomberg LP, 47
- Bollerslev, Tim, 293
- bond, 2, 6n, 24–31, 399
 - accrued interest, *see* accrued interest
 - callable, *see* callable bond
 - components of return, 30–31
 - convertible, *see* convertible, bond
 - convexity, 27, 42
 - corporate, *see* corporate bond
 - coupon, 17, 25
 - coupon payment date, 28, 29, 405
 - coupon rate, 17, 24–26, 29, 40
 - volatility, 33
 - coupon stripping, 25
 - coupon-bearing, 25, 32
 - denomination (par value), 31n
 - discount, 26, 27, 30, 32, 33, 322, 324
 - exchangeable, 399
 - extendible, 403
 - face value (par value), 31n
 - fixed-rate, 40, 46, 61, 219, 312, 402, 404, 411
 - floating-rate, *see* floating-rate instrument
 - forward contract, *see* forward contract, bond indenture, 399
 - level-coupon, 25–27, 31, 32, 34, 35, 37, 42, 47, 48, 50
 - long-term, 32, 54, 59, 359, 399
 - market, 2, 24, 401
 - maturity, 24, 25, 32, 45, 63n
 - maturity value (par value), 31n
 - municipal, *see* municipal bond
 - option features, *see* fixed-income security with option features
 - par, 26, 27, 29, 30, 32, 33, 52, 315, 322
 - par value, 17, 24–26, 29, 359
 - portfolio, 30, 478
 - premium, 26, 27, 30, 32, 324
 - price behavior, 26–27, 478
 - price estimator, 349
 - price volatility, 32–44, 359, 360, 414
 - principal value (par value), 31n
 - pure discount (zero-coupon bond), 25
 - putable, *see* putable bond
 - quote, 25, 29
 - redemption, 24, 408
 - refunding, 24
 - replicated as a portfolio of zero-coupon bonds, 46
 - replicated as covered call, 131
 - rich/cheap analysis, 47
 - safety covenants, 139
 - secured and unsecured, 399
 - settlement date, 29
 - valuation, 25–26
 - zero-coupon, *see* zero-coupon bond
- bond-equivalent yield, *see* yield, bond equivalent
- Bond Market Association, 3
- bond price process, 201–202, 351–353, 375, 388
 - geometric Brownian motion, *see* geometric Brownian motion, bond price process
 - interest rate model, *see* “bond price process” under various interest rate models
 - Markov process, 201, 351
- bond swap, 414
- bondholder, 132, 402, *see* stockholder, bondholder, vs.
- Brennan, Michael J., 371
- Brennan–Schwartz model, 371, 373
 - long rate, 371
 - mean reversion, 371
 - popularity, 371
- British pound, 144, 146, 227
 - futures contract, 162, 163, 227
- Brown, Robert, 184
- Brownian bridge, 188, 258, *see* interest rate model, Brownian bridge, *see* Ito process, discrete approximation, Brownian bridge, *see* quasi-Monte Carlo method, Brownian bridge
- Brownian motion, 1, 177, 183–188, 190, 197
 - continuity, 184, 187
 - covariance function, *see* covariance function, Brownian motion
 - differentiability, 184
 - distribution, 184, 197
 - drift, 183–185, 193
 - exponential (geometric Brownian motion), 186
 - Fokker–Planck equation, 185
 - fractal, 184
 - geometric, *see* geometric Brownian motion
 - history, 184, 188
 - information and return, 201
 - Ito process, 197
 - Kolmogorov backward equation, 185
 - Markov process, 184
 - martingale, 185
 - modeled as Ornstein–Uhlenbeck process, 199
 - Monte Carlo simulation, 258
 - normalized (Wiener process), 184
 - quadratic variation, 187, 188, 195
 - random walk, *see* random walk, Brownian motion
 - rate of return, 203, 209
 - sample path, 183, 184, 187, 190

592 **Index**

- Brownian motion (*cont.*)
 stationarity, 187, 199, 294n
 stationary independent increments, 184
 statistical self-similarity, 184
 stochastic integral, *see* stochastic integral,
 Brownian motion
 stochastic modeling, 184
 “tied down”, 188
 total variation, 187, 188, 190, 192
 uncertainty, 184
 variance, 183, 184, 193
- Bureau of Labor Statistics, 400
- Butterfield, Herbert, 177
- buying hedge, *see* hedging, futures contract,
 buying hedge
- C programming language, xiv
- C++ programming language, xiv
- calculus, 187, 190
- call, 75–80, 85–87, 90, 134, 159, 405
 American, 87–89, 94, 115, 116, 120, 135,
 212, 254
 early exercise, 88–89, 99, 211, 405
 binomial tree algorithm, *see* binomial tree
 algorithm, option
 Black–Scholes differential equation, 212
 covered, *see* option, covered call
 delta, 93, 99, 123–124, 229
 European, 86, 88, 89, 91, 101, 103,
 138, 211
 gamma, 125
 intrinsic value, 87
 Monte Carlo simulation, 103
 portfolio, 91
 replicated as levered long stock, 94
 rho, 126
 theta, 124, 125
 valuation, 93–104
 bound, 89
 vega, 125
- callable bond, 24, 26, 27, 31n, 136, 301, 318, 321,
 399, 402–403, 411
 call date, 26, 219, 402, 408, 410
 call price, 26, 136, 218, 402, 408
 call protection, 24, 402
 continuous call, 220, 402
 convexity, 407
 delta, 408
 discrete call, 402
 duration, 407
 effective maturity date, 26
 empirical study, 414
 gamma, 408
 implied noncallable bond price, 407, 410, 411
 option features, 135
 option-adjusted measures, *see* option-adjusted
 convexity, *see* option-adjusted duration,
 see option-adjusted spread, callable bond,
 see option-adjusted yield, callable bond
 price compression, 403
 rich/cheap analysis, 407
 sinking fund provision, 403
 valuation, 402, 407, 408, 410–411
- Canadian dollar, 217
- Canvas, xiv
- cap (interest rate option, interest rate cap), 307
- Capital Asset Pricing Model, 1, 227, 464–468
 arbitrage freedom, 468
 Arbitrage Pricing Theory compared, 473
 beta, 465–468, 470, 473, 476, 479
 estimation, 466, 470
 negative, 467
 risk, 465, 466, 550
 zero, 467
 capital market line, 465, 467
 factor model, *as*, 471, 479n
 linear, 468
 market price of risk, 465
 performance evaluation, 479
 popularity, 469
 problems, 469–470
 publication problems, 479n
 security market line, 466, 468
- capital gain, 30, 31
 tax, 26, 322, 324
- capital market, xiii, 2, 4
- capital structure, 131–134
- capitalism, 451
- Capitals software, xiv, 480–482
- caplet, 141, 308, 365
 payment in arrears, 308, 536
 put on zero-coupon bond, *as*, 309, 350, 536
- capped option, 88
- caption, 308
- carrying charge (cost of carry), 166
- carrying cost (cost of carry), 166
- cash flow, 11
- cash market (spot market), 143
- cash matching, 39
- cash price (spot price), 162
- Castelli, C., 87
- central difference, *see* finite-difference method,
 central difference
- central limit theorem, 67–68, 105, 107, 185, 257, 263
 Ljapunov condition, 105, 107
 stationary stochastic process, 290
- certificate of deposit, 39, 315
- certificate of deposit rate, 299, 308
- Chan, K.C., 371
- Chan–Karolyi–Longstaff–Sanders model, 371
 empirical study, 371
- change of probability measure, 183, 185, 221, 222,
 334, *see* numeraire, forward-neutral
 probability measure, *see* numeraire,
 risk-neutral probability measure, *see*
 risk-neutral probability
- charm, 124
- Chase Manhattan Corp., 155, 176n

- cheapest-to-deliver bond, *see* Treasury bond
 futures, cheapest-to-deliver bond
- Chebyshev inequality, 188, 479n
- Chen–Scott model, 373
- chi-square distribution, 67
 central, 67
 degree of freedom, 67
 noncentral, 67, 201
 noncentrality parameter, 67
- Chicago Board of Trade, 155, 161, 165, 169, 176n, 295, 301, 310, 320n, 341
- Chicago Board Options Exchange, 78, 142, 306
 success, 92
- Chicago Mercantile Exchange, 145, 155, 161, 162, 227, 295
- chivalry, 1
- Cholesky decomposition, 270, 272, 477, 526
 full-rank least-squares problem, 274
- chooser option, 148
- Citigroup Inc., 153n, 321, 466
- clean price (quoted price), 29
- clearing, 2
- clearinghouse, 161
- client/server system, 4, 5, 481
 three-tier, 4, 5
 World Wide Web, 482
- closing price, 17, 142
 futures option, 160
 spot option, 160
- Codd, Edgar F., 5
- coefficient of determination, 70–72, 226
- collateralized mortgage obligation, 415, 419–420, 422, 447, 448, 451–452, 457
 accretion bond (Z bond), 438
 accrual bond (Z bond), 438
 agency, 421
 Freddie Mac, 419, 423
 class (tranche), 419
 collateral, 419, 423
 companion bond (support bond), 451
 coupon rate, 420, 438, 439
 floater, 357, 452–453
 cap, 452, 453
 valuation, 357–358
 inverse floater, 357, 452–453, 457
 floor, 452
 slope, 452
 valuation, 357–358
- IOette (strip, bond IO), 457
- issuance, 421
- LIBOR, 452, 453
- market, 421
- multiple maturity, 419, 420
- overcollateralization, 457
- PAC bond, 451, 453–457
 cash flow, 454–456
 lower collar, 453
 PAC band, 453–454, 456
 PAC drift, 454
 PAC schedule, 453–454
 sequential, 456
 simultaneous pay, 454
 upper collar, 453
- PAC I bond, 456
- PAC II bond, 456
- path-dependent, *see* path-dependent derivative,
 collateralized mortgage obligation
- prepayment, 419, 420, 423, 438–440, 457
- pro rata bond, 451–452, 454
- residual, 457
- scheduled bond, 451
- sequential paydown, 420, 448, 451, 454, 456
 cash flow, 420, 420–422, 438–441
- sinking fund, 423
- strip, 457
 bond IO, 457
 inverse IO, 457
 PAC IO, 457
 super PO, 457
- superfloater, 452–453
- support bond, 451, 453–457
- TAC bond, 451, 457
- tranche, 419, 420, 426n, 438, 451
 valuation, 438–439, 447, 480
- Z bond, 438
- combinatorial method, 234–235, 238, 248
- commercial arithmetic, 11
- commercial paper, 399
- commercial paper rate, 308
- commodity
 consumption, 166
 convenience yield, *see* convenience yield
 cost of carry, 166
 futures contract, *see* futures contract,
 commodity
 investment, 166, 167
 market, 2
 short sale, 167
 storage cost, 166–167
- Compaq Computer Corp., 4
- compiler, 12
- complete market, 98, 99, 182, 209
- compound interest, *see* interest rate, compound
- compound option, 75, 147–148, 308
- compounding, 11–14
 annual, 11
 continuous, 12, 14, 106, 323, 375, 412
 duration, *see* duration, continuous
 compounding
 continuous vs. periodic, 348, 383
 continuous-time model, 345
 conversion, 13–14
 daily, 11
 discrete-time model, 345
 monthly, 11
 periodic, 12, 158
 quarterly, 11
 semiannual, 11

594 **Index**

- compounding (*cont.*)
 simple, 14
 weekly, 11
 computability, 7
 computer, 2, 4–6
 Computer Associates International, Inc., 5
 computer science, xiii, xiv, 7, 10
 computer trading, 2
 concave function, 489, 511
 conditional expectation, 65, 179
 conditional prepayment rate, 433–435
 conditioning, *see* variance reduction,
 conditioning
 conduit, 416
 agency, 416
 private, 416, 419
 confidence interval, 257
 Congress, 417
 consol, 24, 345
 valuation, 24, 25, 350, 364
 constant elasticity variance process, 287
 maximum likelihood estimator, 287
 trinomial model, 529
 constant-maturity Treasury rate, 16, 40, 431, 450
 constant prepayment rate, 435
 Constantinides model, 370–371
 Constantinides, George M., 370
 Consumer Price Index, 400
 contingent claim (derivative), 75
 continuous dividend yield, 117–118, 211–212,
see binomial tree algorithm, continuous
 dividend yield, *see* foreign exchange option,
 continuous dividend yield, *see* forward
 contract, continuous dividend yield, *see*
 futures option, continuous dividend yield,
see option, continuous dividend yield, *see*
 risk-neutral probability, continuous
 dividend yield, *see* stock, price, continuous
 dividend yield, *see* trinomial tree algorithm,
 continuous dividend yield
 continuous-payout model (continuous dividend
 yield), 117
 continuous trading, 98, 99, 207, 209, 468
 impossibility with transactions cost, 201
 nonprobabilistic treatment, 205
 problems, 232
 continuous-time model, 190, 345, 346, 348
 discrete-time model, *vs.*, 237, 348
 transactions cost, 201
 contraction risk, *see* prepayment risk, contraction
 risk
 Control Data Corp., 4
 control variates, *see* variance reduction, control
 variates
 convenience yield, 166, 167, 226
 forward price, 175
 futures contract, 167, 225, 226
 convergence in probability, 73, 191
 conversion, 87, 169
 conversion factor, 301–303
 problems, 320n
 convertible bond, 24, 135–137, 399, 403–406,
 414
 Black–Scholes differential equation, *see*
 Black–Scholes differential equation,
 convertible bond
 call provision, 136–137, 218–220, 404
 conversion price, 403–406
 premium, 404
 conversion ratio, 135, 218, 403–405
 conversion value, 218, 219, 404, 405, 543
 dilution factor, 135, 406, 543
 early conversion, 136, 405
 forced conversion, 218
 market conversion price, 404
 option features, 135–137
 parity (conversion value), 404
 put provision, 404
 quote, 404
 refix clause, 404
 sensitivity, *see* sensitivity, convertible bond
 straight value, 404, 405, 543
 valuation, 218–220, 222
 binomial tree algorithm, 404–406
 warrant, *as*, 136, 406, 543
 convex function, 58
 convexity, 26, 27, 32, 41–44, 62, 125
 bond, *see* bond, convexity, *see* zero-coupon bond,
 convexity
 callable bond, *see* callable bond, convexity
 closed-form formula, 44
 effective, 42, 411
 immunization, 37, 39, 42–44, 62–63, 203
 limitations, 44
 mortgage-backed security, *see* mortgage-backed
 security, convexity
 option, *see* option, convexity
 option-adjusted, *see* option-adjusted convexity
 parallel shift, 62
 percentage, 43
 positive, 42
 stochastic interest rate, 352
 Cornish–Fisher expansion, 479
 corporate bond, 24, 54, 401–402
 credit spread, 54, 55, 407, 544
 day count, 28
 default, 54, 399, 407
 forward spread, 55
 market, 2
 mortgage-backed security, *vs.*, *see*
 mortgage-backed security, corporate
 bond, *vs.*
 option features, 131–137
 option, *vs.*, 133
 quote, 17, 402
 risk premium, 54
 safety covenants, *see* bond, safety covenants
 sinking–fund provision, 403

- correlation, 65, 71–72, *see* binomial model, correlated, *see* interest rate model, one-factor, problem of correlation, *see* normal distribution, bivariate, correlation, *see* normal distribution, multivariate, correlation, *see* rate of return, correlation, *see* regression, correlation, vs., *see* sample correlation, *see* spot price, futures price, correlation, *see* stochastic process, autocorrelation function, *see* stochastic process, correlated, *see* stochastic process, uncorrelated, *see* stock index, correlation, *see* stock, price, correlation, *see* uncorrelated random variables, *see* volatility, stochastic, correlation
- correlation coefficient (correlation), 65
- correlation matrix, 66, 271, 277
 - positive definite, 271
- correlation option, 197, 213–218, 245
- cost of carry, 166–167, 225, 226, *see* commodity, cost of carry, *see* currency, cost of carry, *see* forward price, cost of carry, *see* futures price, cost of carry, *see* stock index, cost of carry
- Cost of Funds Index, 16, 40, 431, 432, 450
 - 11th District Cost of Funds Index, 432, 450
- coupon effect, 50, 322, 324
- covariance, 65, 245, 458, 459, 464, 470
 - sample, 72
- covariance function, 177, 178, 287
 - autoregressive process, 289
 - autoregressive moving average process, 289
 - Brownian motion, 185
 - moving average process, 289
 - Ornstein–Uhlenbeck process, 198
 - stationary stochastic process, 178, 287–288, 290
- covariance matrix, 65–67, 271, 272, 274–277, 470, 471, 476, 477
 - eigenvalue, 271, 476
 - estimator, 66, 277, 469
 - positive definite, 271, 272, 274
 - sample, 66
- Cox, John C., 164, 328, 364
- Cox–Ingersoll–Ross model, 364–371, 396, 403
 - bond price formula, 364
 - bond price process, 365
 - consol, 364
 - discrete time, 366–370, 396
 - antithetic variates, 368
 - bond price process, 367–369
 - convergence, 369
 - memory requirement, 368
 - duration, 364, 365
 - empirical study, 364
 - extended, 384
 - fixed-income option, 384
 - problems, 388
 - short rate volatility, 388
 - interest rate cap, 374
 - local expectations theory, 368
 - long rate, 364, 365
 - market price of risk, 364
 - mean reversion, 367
 - multifactor, 370–371, 374
 - parameter estimation, 365, 372, 374
 - problems, 364, 370, 371
 - short rate volatility, 393
 - term structure dynamics, *see* term structure, dynamics, Cox–Ingersoll–Ross model
 - term structure equation, 365, 370
 - term structure shape, 364–365, 371
 - Vasicek model, vs., 364
- Crank–Nicolson method, 252
- Cray, Seymour, 4
- credit card receivable, 4
- credit card statement, 12
- credit derivative, 414
- credit risk, 27, 45, 161, 414
 - mortgage, 415–417, 419, 424, 446
 - Treasury securities, 45, 46
- credit spread, *see* corporate bond, credit spread, *see* default premium, *see* term structure, credit spread
- credit union, 3
- cross hedge, *see* hedging, futures contract, cross hedge
- cross-currency option, 145, 217
- cross-rate swap, 218
- Culbertson, J., 59
- Curran, Michael, 118
- currency
 - cost of carry, 166
 - discount, 144, 158
 - market, 2, 6n
 - size, 6n
 - premium, 144, 157, 158
 - triangular arbitrage, 217, 223n
- currency forward contract, *see* forward contract, currency
- currency futures contract, *see* futures contract, currency
- currency option, *see* cross-currency option, *see* foreign domestic option, *see* foreign equity option, *see* foreign exchange option, *see* quanto option
- currency risk, 144, 148, 157, 162
 - currency swap, 174
- currency swap, 173–175, 218, 318
 - default risk, 175
 - history, 173
 - principal, 174, 312
 - replicated as a portfolio of cash market instruments, 175
 - replicated as a portfolio of forward contracts, 175
 - valuation, 175, 315
- current coupon, *see* mortgage, current coupon, *see* mortgage-backed security, current coupon, *see* Treasury securities, current coupon

596 **Index**

- curse of dimensionality, 246, 256, 373
 curtailment, *see* prepayment, causes, curtailment
 curve fitting, 268, 278, 281
 linear regression, 278
 piecewise polynomial, 278–279
 polynomial regression, 278
 smoothness, 278, 283
 spline, *see* spline
 CUSIP, 414n
 cusp, 425, 445
 custom shift, 60, 63, 412, 413
- Dai, Tian-Shyr, 153
 daily earnings at risk, 475
 Darwin, Charles, 6n
 data structure, 448
 database, 2, 4, 5
 language, 6n
 relational, 5
 day count, 17, 27–31, 313, *see* 30/360, *see* actual/360,
 see actual/actual, *see* agency security, day
 count, *see* corporate bond, day count, *see*
 LIBOR, day count, *see* municipal bond, day
 count
 day trading, 2
 de Moivre, Abraham, 66
 debenture, 399
 debt, 2, 3
 junior (subordinated), 134
 long term, 2, 24
 market, 2, 3, 415
 public, 414
 senior, 134
 short term, 2, 17, 399
 subordinated, 134
 replicated as bull call spread, 134
 debt-equity ratio, 132, 133
 debt-to-total-value ratio, 132
 decimalization, 79
 decision theory, 91
 dedicated portfolio, 39, 322
 default premium, 132
 default risk, 54, 399, 414, *see* currency swap, default
 risk, *see* derivative, default risk,
 see forward rate agreement, default risk,
 see interest rate swap, default risk, *see*
 mortgage-backed security, default risk,
 see option, default risk
 delta, 123–125, 128, 208, 228, 475, *see* binomial
 option pricing model, delta, *see* callable
 bond, delta, *see* foreign exchange option,
 delta, *see* futures contract, delta, *see* futures
 option, delta, *see* interest rate option, delta,
 see option, delta
 numerical, 127–130, 208, 244, 267
 delta hedge, *see* delta-neutral, delta hedge
 delta-neutral, 123, 125, 228, 229, 231, 232
 Black–Scholes differential equation, 208
 delta hedge, 228–232, 372
 binomial option pricing model, 229
 error, 229–230
 self-financing, 228, 229, 372
 delta-gamma hedge, 231–232
 error, 231
 self-financing, 231
 delta-gamma-vega hedge, 232
 delta-vega hedge, 232
 derivative, xiii, 1, 75, 95, 97, 98, 123, 155–156, 176,
 233
 Black–Scholes differential equation, 211, 252
 default risk, 155
 European, 97, 98, 103, 221
 information, 176
 interest rate, *see* interest rate derivative security
 market, 155, 295
 multivariate, 234, 245, 248, *see* binomial model,
 correlated, *see* Black–Scholes differential
 equation, multivariate derivative,
 see correlation option, *see* Monte Carlo
 simulation, multivariate derivative,
 see trinomial model, correlated
 offset, 76
 path-dependent, *see* path-dependent derivative
 quanto, 218, 319
 risk management, *see* risk management,
 derivative
 short sale, 76
 speculation, 155
 valuation in continuous time, 206–223, 372, 377
 general approach, 220–221
 value at risk, *see* value at risk, derivative
 Derman, Emanuel, 380
 diagonal method, 118–120
 trinomial model, 243, 522
 difference equation, 249, 285
 differential tree method, 339–341, 382, 410
 diffusion, 205
 diffusion equation, 207, 210, 250
 finite-difference equation, 251
 diffusion process (Ito process), 193
 Digital Equipment Corp., 4
 Dirac delta function, 83
 dirty price (invoice price), 29
 discount currency, *see* currency, discount
 discount factor, 47, 84, 323, 329, 337, 369, 376, 377
 arbitrage, 85
 spot rate, *see* spot rate, discount factor
 discount function, 47, 55, 56, 183, 322, 325, 361, *see*
 forward price, discount function, *see* forward
 rate, discount function, *see* short rate,
 discount function, *see* term structure fitting,
 discount function, *see* zero-coupon bond,
 discount function
 discount method, 17
 discount process, *see* stochastic process, discount
 discount rate, 17, 18, 297, 306, 401
 discounting, 11–14
 risk-adjusted, 288, 355, 467

- discrete-time model, 99, 181, 195, 345,
see continuous-time model, discrete-time
 model, vs.
- distribution function, 66, 259
- diversification, 1, 459, 467, 471, 473, 478, 549
- divide and conquer, 9
- dividend, 76, 78, 88, 89, 97, 133–135
 cash, 86, 165, 405
 option, *see* option, continuous dividend yield
see option, dividend, *see* option, dividend
 yield
 stock, 165, 404
 stock index, *see* stock index, dividend
 yield, 116, 405
 continuous, *see* continuous dividend yield
- Donsker theorem, 188, 194
- Doob, Justin L., 188
- DOS, 4
- Dothan model, 370–371, 383, *see* lognormal
 distribution, interest rate, problems
- Dothan, M., 370
- Dow Jones Industrial Average, 90, 91, 141, 142, 171
 components, 153n
- Dow Jones Industrial Average Index futures,
 165, 171
- Dow Jones Industrial Average Index futures
 option, 171
- Dow Jones Industrial Average Index option, 90,
 142, 171
- down-and-in option, *see* barrier option,
 down-and-in
- down-and-out option, *see* barrier option,
 down-and-out
- drift, *see* Brownian motion, drift, *see*
 Heath–Jarrow–Morton model, drift, *see*
 Ho–Lee model, drift, *see* Hull–White model,
 drift, *see* interest rate model, short rate, drift,
see Ito process, drift, *see* random walk, drift
- duration, 32, 34–43, 60–61, 123, 125, 412, 478
 Bierwag, 60
 callable bond, *see* callable bond, duration
 closed-form formula, 44
 continuous compounding, 36
 curvature, 278
 custom shift, 56, 60, 412, 413
 distribution, 39
 dollar, 41, 47
 effective, 35, 36, 60, 411, 412
 Fisher–Weil (Macaulay’s second), 63
 hedging, *see* hedging, duration-based
 interest rate swap, *see* interest rate swap, duration
 key rate, 60, 399, 412–413, 449, 478
 basic key rate shift, 412, 413
 popularity, 412
 problems, 413
 limitations, 44, 412
 long-end, 60
 Macaulay, 34, 36–39, 60, 62, 304, 445
 coupon bond, 34
 floating-rate instrument, *see* floating-rate
 instrument, Macaulay duration
 immunization, 37–39, 61, 62, 203
 mortgage, 36, 44n
 zero-coupon bond, 34
 Macaulay’s second, 60, 63
 matching, 38, 39, 62, 203, 352
 modified, 35, 36, 41, 407
 mortgage-backed security, *see* mortgage-backed
 security, duration
 nonproportional shift, 61
 option features, 408
 option-adjusted, *see* option-adjusted duration
 option-adjusted spread, *see* option-adjusted
 spread duration
 parallel shift, 60, 62, 202–203, 298, 411, 412
 percentage, 36, 43
 portfolio, 35
 prepayment, *see* prepayment duration
 proportional shift (Macaulay’s second), 60
 short-end, 60
 slope, 278
 stochastic interest rate, 202–203, 352 *see*
 Cox–Ingersoll–Ross model, duration, *see*
 Hull–White model, duration, *see* Merton
 model, duration, *see*
 Ritchken–Sankarasubramanian model,
 duration, *see* Vasicek model, duration
 stripped mortgage-backed security, *see* stripped
 mortgage-backed security, interest-only,
 duration *see* stripped mortgage-backed
 security, principal-only, duration
 term structure fitting, 324
 Treasury bill, *see* Treasury bill, duration
 Treasury bill futures, *see* Treasury bill futures,
 duration
 Treasury bond futures, *see* Treasury bond futures,
 duration
- duration drift, 39
- Dutch guilder, 226
- dyadic partition, 189n
- Dynamic Random Access Memory, 4, 12
- econometrics, xiii, 72, 255
- economics, xiii, 44, 75, 284, 288, 479n
 impacts on other sciences, 6n
- economist, 1, 6n, 176n, 189n
- Economist, The*, 474
- efficient frontier, 459–465
- efficient markets hypothesis, 1, 96, 122n,
 288, 293
 Ito process, 195
 martingale, 293
 semistrong form, 288
 strong form, 288
 weak form, 122n, 195, 288
- efficient portfolio, 459–461, 463–467, 470
- efficient set (efficient frontier), 460
- eigenvalue, 270–272

598 Index

- eigenvector, 270–272, 476, 477
 - principal component, 271
- Einstein, Albert, 1
- embedded option, *see* option, embedded
- Engle, Robert F., 293
- equity, 2, 3
- equity swap, 320
- equivalent martingale probability measure (risk-neutral probability), 181
- equivalent portfolio, 94, 97, 98, 350, *see* hedging, static, *see* redundant security, *see* security, riskless, *see* synthetic security, *see* volatility, stochastic, replication
- error sum of squares, 69, 70, 72
- estimator, 72–74
 - biased, 64, 111
 - consistent, 73, *see* maximum likelihood estimator, consistent, *see* method of moments, consistent, *see* method of moments, generalized, consistent
 - cross section, 371–372
 - cross section/time series, 372
 - expected return, *see* expected return, estimation
 - interest rate model, *see* interest rate model, calibration
 - Ito process, *see* Ito process, estimation
 - least squares, *see* least-squares estimator
 - linear, 72, 274
 - maximum likelihood estimator, *see* maximum likelihood estimator
 - method of moments, *see* method of moments
 - time series, *see* time series, parameter estimation
 - unbiased, 64, 66, 182, 256, 274
 - variance, *see* variance, estimator
- Euclid algorithm, 7
- Euclidean norm, 268
- Euler method, 193, 194, 258
- Euler summation formula, 484
- Euler theorem, 214, 215
- Euler–Maruyama method (Euler method), 193
- euro, 144
- Eurocurrency, 298
- Eurodollar, 141, 298–299, 320
 - market, 298–299
- Eurodollar futures, 163, 296, 299–301, 348
 - basis-point value, 303
 - delivery date, 299
 - history, 299
 - popularity, 299
 - quote, 299, 300, 310
 - size, 161
 - tick size, 299
 - tick value, 299
 - Treasury bill futures, vs., 299
 - Treasury bond futures, vs., 303
- Eurodollar futures option, 310–311
 - quote, 310
- Europe, 1, 414
- European terms, 144
- ex-dividend date, 78, 88, 89, 112, 114–117, 405
- exchange option, 213–216, 517
 - initial and boundary conditions, 214
 - partial differential equation, 214
 - put–call parity, *see* put–call parity, exchange option
- exchange rate, 143, 144, 157, 218, 476
 - forward, 144, 157–158, 166, 175
 - geometric Brownian motion, *see* geometric Brownian motion, exchange rate
 - Ito process, 211
 - spot, 144, 146, 157–158, 175, 215, 216
 - volatility, 146
 - term structure, 153
- exchange-traded funds, 1
- exclusive OR, 264, 267n
- expectations theory, 57–59, 356
 - biased, 58
 - empirical study, 63
 - inconsistency, 57–59, 350
 - local, 58, 202, 203, 350, 352
 - equilibrium, 349
 - interest rate model, *see* binomial interest rate tree, local expectations theory, *see* binomial model, interest rate process, local expectations theory, *see* Cox–Ingersoll–Ross model, local expectations theory, *see* Heath–Jarrow–Morton model, local expectations theory
 - liquidity premium, 58
 - risk-neutral probability, 348–350, 352, 392
 - term structure equation, 352
 - return-to-maturity, 58
 - local expectations theory, vs., 59
 - unbiased, 57–58, 328, 350
 - binomial interest rate tree, 333
 - empirical study, 57
 - liquidity premium, 58
 - local expectations theory, vs., 58, 350
 - risk neutrality, 57, 334
 - spot rate curve, 57
 - yield curve, 57, 59
- expected return, 94, 95, 183, 288, 293, 294n, 466, 469, 479
 - estimation, 286, 293, 469, 528, 550
- explained variation, *see* variation, explained
- explicit method, 250–252
 - implicit method compared, 266
 - stability, 251, 253–254
 - trinomial tree algorithm, 251, 386
- exponentiation function, 7, 48
- extension risk, *see* prepayment risk, extension risk
- Exxon Corp., 79, 153n
- factor, 428, 432
 - annuity (payment), 429
 - paydown (pool factor), 428
 - payment, 429, 430
 - pool, *see* pool factor

- factor analysis, 268, 276–278, 283, 458
 factor, 276–278
 factor loading, 276–278, 470
 interest rate dynamics, 276, 278, 478
 maximum likelihood estimator, 283n
 orthogonal factor model, 276
 principal component, 476–477
 residual error (specific factor), 277
 specific factor, 277, 472, 473
 specific variance, 277
 factor model, 458, 470–473
 Capital Asset Pricing Model, *see* Capital Asset Pricing Model, factor model, as
 factor beta, 470–473
 fair game, 179
 Fama, Eugene F., 1, 288
 Fannie Mae (Federal National Mortgage Association), 400
 Farka lemma, 495
 Faure sequence, *see* quasi-random sequence, Faure
 feasible portfolio, 459, 464
 feasible set, 459, 460, 462–463, 465
 boundedness, 460
 federal funds rate, 156, 414, *see* futures contract, federal funds rate
 Federal Home Loan Bank, 400, 432
 Federal Home Loan Mortgage Corporation, 3, 400, 416–419
 collateralized mortgage obligation, *see* collateralized mortgage obligation, agency, Freddie Mac
 guarantee, 423
 mortgage pass-through, 423, 426
 history, 422
 mortgage pass-through, *see* mortgage pass-through, agency, Freddie Mac
 mortgage-backed security, *see* mortgage-backed security, agency, Freddie Mac
 payment delay, 450n
 privatization, 422
 stripped mortgage-backed security, *see* stripped mortgage-backed security, agency, Freddie Mac
 Federal Housing Administration, 44n, 416, 422
 insurance, 416, 417, 424
 Federal National Mortgage Association, 3, 400, 416–419, 422
 guarantee, 423
 history, 423
 mortgage pass-through, *see* mortgage pass-through, agency, Fannie Mae
 mortgage-backed security, *see* mortgage-backed security, agency, Fannie Mae
 payment delay, 450n
 privatization, 426n
 size, 423
 stripped mortgage-backed security, *see* stripped mortgage-backed security, agency, Fannie Mae
 Federal Reserve, 3, 57, 156
 Federal Reserve Bank of New York, 46, 307, 431
 Federal Reserve Bulletin, 416
 Feller, William, 201
 FHA 12-year prepaid-life concept, 445, 449
 financial computation, xiii, 2, 5, 28
 financial engineering, xiii, 1, 233
 financial instrument, 1, 2
 valuation, 2, 11
 financial intermediary, 3, 4
 financial market, 2–4
 financial mathematics, xiii, 190
 financial theory, 1, 44, 75, 91, 92, 190
 computer, 2, 6n
 static, v
Financial Times, 141
 financing cost, 156
 finite-difference method, 249–255, 344n
 backward difference, 252
 Black–Scholes differential equation, *see* Black–Scholes differential equation, finite-difference method
 central difference, 36, 249, 250
 diffusion equation, *see* diffusion equation, finite-difference equation
 forward difference, 36, 250
 Poisson equation, *see* Poisson equation, finite-difference equation
 term structure equation, 352
 implicit method, 352, 366
 First Boston, 419
 Fisher, Irving, 31n, 57
 Fisher, Lawrence, 63
 Fisher, Ronald A., 74n
 fitted value, *see* regression, fitted value
 fixed-income option, 75, 306, 342
 American, 342, 398
 fixed-income futures option, vs., 310
 history, 306
 interest rate option, *see* caplet, put on zero-coupon bond, as *see* floorlet, call on zero-coupon bond, as, *see* swaption, fixed-income option, as
 mortgage, 306
 put–call parity, *see* put–call parity, fixed-income option
 term structure equation, 352
 Treasuries, 306
 valuation, 384, 388
 binomial interest rate tree, 341–342
 binomial model, 332, 355–356, 359, 369, 383–384, 393
 Black–Scholes model, 359–360, 407
 extended Cox–Ingersoll–Ross model, *see* Cox–Ingersoll–Ross model, extended, fixed-income option
 extended Vasicek model, *see* Vasicek model, extended, fixed-income option

600 Index

- fixed-income option (*cont.*)
 - Heath–Jarrow–Morton model, *see* Heath–Jarrow–Morton model, fixed-income option
 - Ho–Lee model, *see* Ho–Lee model, fixed-income option
 - Hull–White model, *see* Hull–White model, fixed-income option
 - Monte Carlo simulation of American option, 398
 - one-factor interest rate model, 373
 - replicated as a portfolio of long bonds and short bonds, 356, 359
 - Vasicek model, *see* Vasicek model, fixed-income option
- fixed-income security, 45, 399, 423, 427
 - value at risk, *see* value at risk, fixed-income security
- fixed-income security with option features, 27, 32, 295, 399, 406, 414
 - holding period return, 412
 - interest rate risk, *see* risk, interest rate, fixed-income security with embedded option
 - rich/cheap analysis, 407, 412
 - valuation methodologies, 406–412
 - option pricing, 402, 407–408, 410
 - option-adjusted spread, *see* option-adjusted spread, fixed-income security with option features
 - problems, 414
 - static cash flow yield, 406–407
- flat price (quoted price), 29
- floater, *see* collateralized mortgage obligation, floater
- floating-rate instrument, 40–41, 140, 312, 318
 - attractiveness, 40
 - hedging, 141, 311
 - Macaulay duration, 40–41, 316, 318
 - reference rate, 141
 - reset, 16, 40
 - reset date, 40, 41, 406, 429, 432
 - valuation, 40, 316
- floating-rate note, *see* note, floating rate
- floor (interest rate option, interest rate floor), 307
- floorlet, 141, 308
 - call on zero-coupon bond, as, 309, 350
- flotion, 308
- Fokker–Planck equation, 185, 188, 207
- Fong, H. Gifford, 327, 371
- Fong–Vasicek model, 371
- forecasting, *see* prediction
- foreign domestic option, 216–217
- foreign equity option, 216
- foreign exchange, *see* currency
- foreign exchange option, 75, 77, 143–148, 153, 217, 222
 - American, 147
 - binomial option pricing model, *see* binomial option pricing model, foreign exchange
 - Black–Scholes option pricing model, *see* Black–Scholes option pricing model, foreign exchange option
 - call, 145, 147
 - contingent, 148
 - continuous dividend yield, 147
 - delta, 146, 147
 - exchange-traded, 145
 - German mark, *see* German mark, foreign exchange option
 - hedging, *see* hedging, foreign exchange option
 - Japanese yen, *see* Japanese yen, foreign exchange option
 - market, 145
 - over-the-counter, 145
 - pricing relations, 147
 - put, 145, 147
 - put–call parity, *see* put–call parity, foreign exchange option
 - replicated as a portfolio of foreign & domestic assets, 146–147
 - risk-neutral probability, *see* risk-neutral probability, foreign exchange option
 - settlement, 144
 - size, 144
 - volatility term structure, *see* exchange rate, volatility, term structure
- forex market (currency, market), 2
- forex option (foreign exchange option), 144
- forward contract, 53, 155–161
 - Black–Scholes differential equation, 209
 - bond, 341, 347
 - conditional, 146
 - continuous dividend yield, 160
 - currency, 157, 164, 166
 - popularity, 156
 - currency swap, *see* currency swap, replicated as a portfolio of forward contracts
 - delivery, 161
 - delivery price, 156, 158, 169
 - dividend, 160
 - futures contract, vs., *see* futures contract, forward contract, vs.
 - hedging, *see* hedging, forward contract
 - liquidity, 317
 - market, 144, 158
 - option, vs., 155, 158
 - participating, 146
 - payoff, 159
 - range, 146
 - replicated as a portfolio of options, 159, 350
 - value, 156, 158–160, 209
- forward difference, *see* finite-difference method, forward difference
- forward exchange rate, *see* exchange rate, forward
- forward induction, 334, 534
 - interest rate model calibration, 334, 381–382, 384
- forward option, 168–173
 - American, 170

- early exercise, 170, 171
- binomial tree algorithm, *see* binomial tree algorithm, forward option
- call, 169
- European, 170
- exercise, 169, 170
- expiration date, 169, 170
- futures option, *vs.*, *see* futures option, forward option, *vs.*
- mortgage pass-through, *see* mortgage pass-through, forward option
- over-the-counter, 169
- pricing relations, 170–171
- put, 169
- put–call parity, *see* put–call parity, forward option
- strike price, 169
- forward price, 156, 158–161, 166, 169, 345, 346
 - arbitrage, 346
 - binomial interest rate tree, *see* binomial interest rate tree, forward price
 - binomial option pricing model, *see* binomial option pricing model, forward price
 - convenience yield, *see* convenience yield, forward price
 - cost of carry, 167, 175
 - discount function, 346, 356
 - forward rate, 346
 - future bond price, 349
 - futures price, *vs.*, *see* futures price, forward price, *vs.*
 - Ito process, 198, 212
 - spot price, *see* spot price, forward price
- forward probability of default, 54, 55, 492
- forward rate, 50–55, 57, 61, 305, 309, 333, 345–347, 396
 - certain economy, 53
 - continuous compounding, 55–56, 297, 346, 347
 - discount function, 52, 305, 321, 333
 - forward price, *see* forward price, forward rate
 - future spot rate, 51, 53, 57, 58, 317, 334, 347, 350
 - implied, 51
 - instantaneous, 51–53, 55, 56, 346
 - interest rate model, *see* Heath–Jarrow–Morton model
 - locking, 53–54, 299–301, 346
 - martingale, 334
 - negative, 53, 326, 413
 - one-period (instantaneous), 51
 - simple compounding, 56, 347
 - spot rate curve, *see* spot rate curve, forward rate
 - spot rate, *vs.*, 51, 56
 - swaption, *see* swaption, forward rate
 - Treasury bill futures, 297, 298
 - yield to maturity, *see* yield to maturity, forward rate
- forward rate agreement, 173, 304–306, 534
 - cash settlement, 304
 - default risk, 305
 - hedging, *see* hedging, forward rate agreement
 - history, 304
 - interest rate swap, *see* interest rate swap, replicated as a portfolio of forward rate agreements
 - LIBOR, 305
 - notional principal, 305
 - payment in advance, 305
 - quote, 305
 - reference rate, 304, 305
 - replicated as a portfolio of interest rate options, 308
 - valuation, 305–306
- forward rate curve, 51–53, 325, 326, *see*
 - Heath–Jarrow–Morton model, forward rate curve, *see* Ritchken–Sankarasubramanian model, forward rate curve, *see* term structure fitting, forward rate curve
- forward rate process, 56, 326, 346, 353, 375, *see*
 - Heath–Jarrow–Morton model, *see* Ho–Lee model, forward rate process, *see* Hull–White model, forward rate process, *see* Ritchken–Sankarasubramanian model, *see* Vasicek model, extended, forward rate process, *see* Vasicek model, forward rate process
 - arbitrage freedom, 389
- forward reduction, 269
- forward-starting barrier option, *see* barrier option, forward starting
- forward-neutral probability, *see* numeraire, forward-neutral probability measure
- forward-start option, *see* option, forward start
- Freddie Mac (Federal Home Loan Mortgage Corporation), 400
- Friedman, Milton, 458, 479n
- full carry, 167
- full price (invoice price), 29
- fundamental analysis, 479
- fundamental theorem of asset pricing, 99, 121, 181, 221, 348
- future value, 11–13, 19
- futures contract, 155, 161–167, 169, 212
 - agricultural, 162
 - basis, 162, 167
 - hedging, 226
 - narrowing, 162
 - speculation, 225
 - volatility, 162, 226
 - widening, 162
 - basis risk, 162, 226
 - British pound, *see* British pound, futures contract
 - contract
 - cash and carry, 167
 - cash flow, 163–164
 - close out, 161
 - commodity, 166, 169
 - consumption, 166

602 Index

- futures contract (*cont.*)
 investment, 166
 storage cost, 167
 convenience yield, *see* convenience yield, futures contract
 corn, 155, 161, 163, 167
 currency, 155, 164, 166
 cross-currency hedging, 227
 hedging, 162, 226
 delivery, 161, 170, 225
 delivery date, 162, 168, 226
 delivery price, 156
 delta, 226–227, 248
 estimator, 227
 Eurodollar, *see* Eurodollar futures
 federal funds rate, 296
 financial, 162
 history, 295
 forward contract, *vs.*, 155, 161, 163, 164, 224
 German mark, *see* German mark, futures contract
 grain, 167
 hedging, *see* hedging, futures contract
 history, 176n
 interest rate, *see* interest rate futures
 Japanese yen, *see* Japanese yen, futures contract
 live cattle, 155
 market, 2, 167, 225, 479n
 discount (inverted), 167
 inverted, 167
 normal, 167
 mortgage-backed security, 155
 offset, 161
 oil, 155
 option, *vs.*, 155
 pork bellies, 155
 position, 161
 precious metal, 155
 settlement, 161, 163, 168
 cash, 162
 size, 161, 228
 soybean, 161
 spread, 225
 standardization, 155, 161
 stock index, *see* stock index futures
 Treasuries, *see* Treasury bill futures, *see* Treasury bond futures, *see* Treasury note futures
 value, 156, 164, 221
 value at risk, *see* value at risk, futures contract
 wheat, 161, 162
- futures exchange, 155
 futures option, 75, 168–173, 212
 American, 171
 early exercise, 171
 binomial tree algorithm, *see* binomial tree algorithm, futures option
 Black model, *see* Black model
 Black–Scholes differential equation, 212
 call, 168
 closing price, *see* closing price, futures option
 continuous dividend yield, 172–173
 delta, 171
 Eurodollar, *see* Eurodollar futures option
 European, 160
 exercise, 168, 170
 expiration date, 168–170, 311
 forward option, *vs.*, 169, 170
 futures price, *see* futures price, futures option
 history, 169
 interest rate, *see* interest rate futures option
 LIBOR, 168, 311
 pricing relations, 170–171
 put, 168
 put–call parity, *see* put–call parity, futures option
 soybean, 168
 spot option, *vs.*, 169–172
 stock index, *see* stock index futures option
 strike price, 168
 Treasuries, *see* Treasury bond futures option, *see* Treasury note futures option
 futures price, 156, 162, 163, 167, 172, 212, 221, 225, 226, 296, 299
 binomial interest rate tree, *see* binomial interest rate tree, futures price
 binomial option pricing model, *see* binomial option pricing model, futures price
 cost of carry, 166–167, 225
 forward price, *vs.*, 164–165, 170, 176, 224
 bond, 320n
 stochastic interest rate, 164–165, 356, 534
 futures option, 168, 212
 Ito process, 198, 212, 353
 risk-neutral probability, *see* risk-neutral probability, futures price
 spot price, *see* spot price, futures price
 term structure equation, 353
- Galton, Francis, 74n
 gambling, 179, 295
 gamma, 125–126, 128, 208, 231
 callable bond, *see* callable bond, gamma
 numerical, 128–130, 208, 244
 stock, 231
 gamma-neutral, 231, 232
 Gauss, Carl Friedrich, 72, 74n, 269
 Gauss–Markov theorem, 72, 274
 Gaussian elimination, 269–270
 banded matrix, 269
 Gaussian process, 287, 290–292
 General Motors Corp., 153n, 466
 generalized autoregressive conditional heteroskedastic process, 293, 293
 mean reversion, 293
 option pricing model, 293
 popularity, 293
 genetic algorithm, 267
 geometric Brownian motion, 186–187, 198, 213

- bond price process, 217, 359
- correlated, 197, 198
- discrete approximation, 186, 194, 234, 242–243, 370
 - Brownian bridge, 259
- distribution, 198
- exchange rate, 215
- geometric average, 197–198
- Ito process, 197
- logarithm, 198
- mean function, 186
- Monte Carlo simulation, 258
- product, 197
- sample path, 186
- stock price, 186, 188, 203, 204, 207, 461, 476
 - value at risk, *see* value at risk, geometric Brownian motion
- variance function, 186
- yield to maturity, *see* yield to maturity, geometric Brownian motion
- German mark, 144–146, 157, 227
 - contract, 226
 - foreign exchange option, 145
 - futures contract, 163, 226, 227
 - LIBOR, 141
- Ginnie Mae (Government National Mortgage Association), 417
- Girsanov theorem, 222
- Givens transformation, 277
- gold, 166
- Gold PC, *see* mortgage pass-through, agency, Gold PC of Freddie Mac
- Government National Mortgage Association, 3, 295, 417, 418
 - guarantee, 417, 418, 422, 423, 426, 437
 - mortgage pass-through, *see* mortgage pass-through, agency, Ginnie Mae
 - mortgage-backed security, *see* mortgage-backed security, agency, Ginnie Mae
 - payment delay, 450n
- government-sponsored enterprise, xiv, 400, 418
- gradient, 273
- graphical user interface, 4, 481
- Gray code, 264
- gross return, 93, 94, 104, 354
- guaranteed investment contract, 315
- Halton sequence, *see* quasi-random sequence, Halton
- Hamming, Richard W., xiv
- Hansen, Lars Peter, 294
- Hanson, Richard J., 276
- hardware, 4, 480
- Hartmanis, J., 7
- hazard rate, 492
- heat equation (diffusion equation), 207
- Heath, David, 388
- Heath–Jarrow–Morton model, 388–395, 397
 - bond price process, 389
 - discrete time, 392–395, 398
 - risk-neutral probability, 395
 - drift, 388–391, 394
 - empirical study, 389, 397
 - fixed-income option, 390–391, 398
 - forward rate curve, 388–390, 392
 - interest rate derivative security, *see* interest rate derivative security, Heath–Jarrow–Morton model
 - local expectations theory, 392
 - market price of risk, 389
 - Markov process, 391, 398
 - one-factor, 389
 - parameter estimation, 398
 - popularity, 388
 - risk-neutral probability, 389, 390, 395
 - short rate model, 389, 391–392, 398
 - short rate volatility, 393
 - term structure dynamics, *see* term structure, dynamics, Heath–Jarrow–Morton model
 - volatility structure, *see* term structure, forward rate volatility, Heath–Jarrow–Morton model, *see* term structure, yield volatility, Heath–Jarrow–Morton model
- hedge, 224
- hedge fund, 6n, 155
- hedge ratio (delta), 41
- hedger, 224, 225, 227
- hedging, 41, 123, 144, 155, 156, 224, 233
 - adjustable-rate mortgage, *see* adjustable-rate mortgage, hedging
 - duration-based, 36, 41, 298
 - effectiveness, 224
 - floating-rate instrument, *see* floating-rate instrument, hedging
 - foreign exchange option, 144, 157
 - forward contract, 156, 157, 224
 - forward rate agreement, 305
 - futures contract, 162, 224–228
 - asset mismatch, *see* asset/liability management, asset mismatch, futures contract
 - basis, *see* futures contract, basis, hedging
 - buying hedge, 225
 - cross currency, *see* futures contract, currency, cross-currency hedging
 - cross hedge, 226–227
 - currency, *see* futures contract, currency, hedging
 - interest rate, *see* interest rate futures, hedging
 - long hedge (buying hedge), 225
 - maturity mismatch, *see* asset/liability management, maturity mismatch, futures contract
 - perfect hedge, 226, 228
 - selling hedge, 225
 - short hedge (selling hedge), 225
 - stock index, 227–228, 523
 - Treasury bond, 303–304

604 Index

- hedging (*cont.*)
 index option, 90, 143
 interest rate, 295, 306, 328
 interest rate futures option, *see* interest rate futures option, hedging
 interest rate option, 343, 414
 long hedge (buying hedge), 225
 mortgage-backed security, *see* mortgage-backed security, hedging, *see* stripped mortgage-backed security, interest-only, hedging, *see* stripped mortgage-backed security, principal-only, hedging
 option, 123, 155, 228–232
 perfect hedge, 228
 prepayment risk, *see* prepayment risk, hedging
 short hedge (selling hedge), 225
 static, 232
 tracking error, 229
 hedging portfolio (equivalent portfolio), 94
 Hicks, John R., 34, 59
 historian, 284
 Ho, Thomas S.Y., 60, 328, 331, 375, 412
 Ho–Lee model, 331, 375–380, 384, 411
 bond price formula, 391
 bond price process, 377–378, 391
 calibration, 377
 consistency with fitting scheme, 398
 continuous-time limit, 379, 390
 drift, 379, 380
 empirical study, 397
 fixed income option, 392
 forward rate process, 378–379, 390–392, 398n
 Heath–Jarrow–Morton model’s special case, 390, 391
 mean reversion, 379
 popularity, 375
 problems, 379–380, 384
 risk-neutral probability, 379, 395, 398n
 short rate process, 375, 379, 384
 short rate volatility, 376–377, 379, 380, 398n
 parameter estimation, 379
 term structure dynamics, *see* term structure, dynamics, Ho–Lee model
 Vasicek model, *vs.*, 379
 yield volatility term structure, *see* term structure, yield volatility, Ho–Lee model
 holding period (horizon), 31
 holding period return, 19, 31, 57, 461, 470
 fixed-income security with option features, *see* fixed-income security with option features, holding period return
 mortgage-backed security, *see* mortgage-backed security, holding period return
 stochastic interest rate, 343
 holding period yield, 19, 31
 holding premium, 58
 Holy Roman Empire, 83n
 homogeneous function, 214, 215
 horizon, 31, 37–39, 57, 59, 343, 412, 449, 462, 470, 474, 475, 478
 horizon price, 31, 37, 38, 412, 449, 461
 horizon return (holding period return), 31n
 horizon total return (holding period return), 31n
 Horner, William George, 13
 Housing and Urban Development, Department of, 418
 HTML language, 480
 Hull, John C., 150, 222, 384
 Hull–White model, 384, 388
 bond price formula, 392
 calibration, 384–388, 397
 stability, 388
 consistency with fitting scheme, 398
 drift, 385
 duration, 392
 fixed-income option, 387, 392
 forward rate process, 391–392
 Heath–Jarrow–Morton model’s special case, 391
 mean reversion, 386
 trinomial model, 385, 386
 use in practice, 387
 yield volatility term structure, *see* term structure, yield volatility, Hull–White model
 human capital, 470
 IBM Corp., 4, 5, 6n, 153n, 466
 IBM/360, 4
 immunization, 37–40, 44, 61–63
 arbitrage profit, 62, 203, 356
 barbell portfolio, 43, 44, 62
 cash matching, *see* cash matching
 convexity, *see* convexity, immunization
 dedicated portfolio, *see* dedicated portfolio
 duration, *see* duration, Macaulay, immunization
 flat spot rate curve, 61, 62
 full, 39
 multiple liabilities, 38–39
 parallel shift, 61, 62, 203, 356
 portfolio, *see* portfolio immunization
 rebalancing, 39, 62
 stochastic interest rate, 63, 203, 356
 two bonds, 38–39, 42, 63, 203
 zero-coupon bond, 39
 implicit method, 251–252, *see* binomial tree
 algorithm, convergence, implicit method
 compared, *see* Black–Scholes differential equation, finite-difference method, implicit method, *see* explicit method, implicit method compared, *see* finite-difference method, term structure equation, implicit method
 stability, 252
 implied volatility, *see* volatility, implied
 importance sampling, *see* variance reduction, importance sampling
 in–out parity, 137, 138, 241, 502
 index arbitrage, 165

- index-amortizing swap, *see* interest rate swap, index-amortizing
- inflation, 86, 157, 400
- information, 2, 288
- information set, 65, 179–181, 189n, 190, 193, 288, 291, 292
- Informix Corp., 5
- Ingersoll, Jonathan E., Jr., 164, 328, 364
- insurance, 80, 550
- insurance company, 3, 39, 59, 142, 315, 416
- integrated circuit, 4
- Intel Corp., 4, 71, 153n, 466
- interest on interest, 30, 31, 37
- interest rate, 11, 15
 - benchmark, *see* benchmark interest rate
 - compound, 14
 - continuous compounding, 14, 348
 - correlation, 60, 372, 374n, 378
 - effective, 11, 299, 348
 - lognormal distribution, *see* lognormal distribution, interest rate
 - long term, *see* long rate
 - movement, *see* yield curve, shift, factors
 - negative, 202, 352, 359, 370, 379, 380
 - nominal, 12, 364, 379
 - normal distribution, 348, 359, 376, 384
 - real, 364, 374n, 414
 - riskless, 85, 93, 95, 132, 156, 462
 - short term, *see* short rate
 - simple, 14, 18, 308, 349
 - stochastic, 181, 182, 430
 - volatility, 32, 60, 62, 328, 371, 406
 - term structure, *see* term structure, yield
 - volatility
- interest rate collar, 140, 309
- interest rate derivative security, 295, 320, 371, 397
 - credit, *see* credit derivative
 - Heath–Jarrow–Morton model, 389, 390
 - market, 295
 - replicated as a portfolio of long bonds and short bonds, 352, 356
 - risk management, *see* risk management, interest rate derivative security
 - risk-neutral valuation, *see* risk-neutral valuation, fixed-income security
 - term structure equation, 352
- interest rate futures, 295, 305, 320
 - hedging, 225, 298–299
- interest rate futures option, 310–311
 - hedging, 311
- interest rate model, 45, 58, 201–203, 328–329, 345–350, 360, 397, 447
 - arbitrage freedom, 328, 349, 351, 352
 - arbitrage-free (no-arbitrage), 328
 - autoregressive, *see* autoregressive process, interest rate model
 - Black–Scholes, 329, 359–360, 407
 - problems, 359–360, 407
 - Black–Scholes for yield, 360
 - problems, 360
 - bond price nondeterminacy, 352
 - Brownian bridge, 360
 - calibration, 329, 333, 371–372, 380, 408, 411, 412, *see* backward induction, interest rate model calibration, *see* binomial interest rate tree, calibration, *see*
 - Black–Derman–Toy model, calibration, *see*
 - Cox–Ingersoll–Ross model, parameter estimation, *see* forward induction, interest rate model calibration, *see*
 - Heath–Jarrow–Morton model, parameter estimation, *see* Ho–Lee model, calibration, *see* Ho–Lee model, short rate volatility, parameter estimation, *see* Hull–White model, calibration, *see* Ogden model, maximum likelihood estimator, *see* Ritchken–Sankarasubramanian model, calibration, *see* Vasicek model, extended, calibration, *see* Vasicek model, parameter estimation
 - comparison, 397
 - compounding, *see* compounding, continuous vs. periodic
 - equilibrium, 329, 361, 374, 375
 - problems, 375
 - factor, 380, 388
 - factor analysis, *see* factor analysis, interest rate dynamics
 - history, 201, 328
 - Markov process, 201, 351, 375, 378, 388, 395
 - multifactor, 370–372, 374, 397, 411
 - mortgage-backed security, *see* mortgage-backed security, valuation, multifactor interest rate model
 - problems, 373
 - term structure shape, 373
 - no-arbitrage, 328, 374–375
 - approaches, 372, 375
 - arbitrage freedom, 375, 377
 - problems, 380, 388
 - use in practice, 380
 - nonparametric, 374
 - one-factor, 372–375
 - fixed-income option pricing, *see* fixed-income option, valuation, one-factor interest rate model
 - problem of correlation, 364, 372–373, 378
 - problems, 372–373, 388
 - term structure shape, 372
 - parametric, 373–374
 - risk-neutral process, 329, 344n, 352, 353, 355, 358, 361, 375, 377, 448
 - arbitrage freedom, 355–356, 389
 - short rate, 46, 201, 202, 286, 351, 352, 361, 365, 370, 371, 375, 407
 - advantages, 375

606 **Index**

- interest rate model (*cont.*)
 - disadvantages, *see* interest rate model, one-factor, problems
 - drift, 372
 - empirical study, 397
 - Heath–Jarrow–Morton model, *see* Heath–Jarrow–Morton model, short rate model
 - specification error, 372, 374, 380, 411
 - stability, 388
 - term structure equation, *see* term structure equation
 - yield curve, 388
- interest rate option, 75, 77, 306, 320
 - caplet, *see* caplet
 - delta, 342–343
 - European, 306
 - floorlet, *see* floorlet
 - hedge ratio (delta), 342
 - hedging, *see* hedging, interest rate option
 - interest rate cap, 140–141, 173, 307–308, 317, 330
 - cap rate, 140, 141, 308, 536
 - ceiling rate (cap rate), 140
 - LIBOR, 308, 536
 - notional principal, 141
 - reset date, 308
 - simple interest rate, 308, 536
 - swaption, *vs.*, *see* swaption, interest rate cap, *vs.* valuation, 350, *see* Black model, interest rate cap/floor, *see* Cox–Ingersoll–Ross model, interest rate cap, *see* Vasicek model, interest rate cap
 - interest rate floor, 140–141, 173, 307–308, 317
 - floor rate, 140
 - notional principal, 141
 - valuation, 350, *see* Black model, interest rate cap/floor
 - reference rate, 140, 141, 307, 308
 - strike rate, 140, 141, 308
 - swaption, *see* swaption
 - Treasury yields, 306–307
 - yield curve option, *see* yield curve option
 - yield volatility term structure, *see* term structure, yield volatility, interest rate option
- interest rate parity, 157, 158, 166
- interest rate risk, *see* risk, interest rate
- interest rate swap, 173, 312, 320
 - accreting, 318
 - amortizing, 318, 319, 350
 - asset/liability management, *see* asset/liability management, interest rate swap
 - basis, 318
 - bid–ask spread, *see* bid–ask spread, interest rate swap
 - callable, 318
 - default risk, 155, 315–317
 - deferred (forward), 318
 - differential, 319–320
 - duration, 312, 316, 318
 - extendible, 318
 - fixed leg, 312
 - Treasury yields, 312
 - fixed-for-floating, 318
 - fixed-rate payer, 312, 313, 315, 316, 318
 - floating leg, 312, 315
 - floating-for-fixed, 318
 - floating-rate payer, 313, 316, 318, 349
 - forward, 318, 349, 350
 - frequency of exchange, 312, 313
 - history, 173
 - index-amortizing, 319–320, 432
 - amortizing schedule, 319, 432
 - leg, 313
 - LIBOR, 312–314, 318
 - liquidity, 317
 - maturity mismatch, *see* asset/liability management, maturity mismatch, interest rate swap
 - notional principal, 312, 318, 319
 - option, *see* swaption
 - payment in advance, 312
 - payment in arrears, 312
 - “plain vanilla”, 312–318
 - popularity, 156
 - putable, 318
 - quanto (differential), 319
 - quote, 314
 - redundant security, 317
 - reference rate, 312
 - replacement value, 317
 - replicated as a portfolio of bonds, 349
 - replicated as a portfolio of caps and floors, 317
 - replicated as a portfolio of cash market instruments, 315–317
 - replicated as a portfolio of forward rate agreements, 316–317
 - replicated as a portfolio of swaptions, 350
 - reverse, 318
 - simple interest rate, 349
 - swap rate, 312, 318, 349
 - transactions cost, 317
 - valuation, 315–317, 349–350
 - yield curve, 318
- interest-only, *see* stripped mortgage-backed security, interest-only
- internal rate of return, 18–19, 26
 - problems, 19
- International Monetary Market, 162, 295, 299, 310
- Internet, 5, 6
- interpolation, 151–153
- intranet, 6
- inverse floater, *see* collateralized mortgage obligation, inverse floater
- inverse-transform technique, 259, 524
- investment, 2
 - capital, 153
 - financial, 6n
 - real, 2, 6n

- investment horizon, *see* horizon
 investment horizon return (holding period return), 31n
 invoice price, 29, 435
 IOette, *see* collateralized mortgage obligation, IOette
 iterative method, 21
 Ito differential, 193
 Ito integral, 190–193, 205
 choice of intermediate point, 191, 192
 continuous function, 191
 history, 205
 integration by parts, 197
 mean value formula, 191
 simple stochastic process, *see* stochastic process, simple, Ito integral
 trading strategy, *see* trading strategy, Ito integral
 Ito lemma, 195–198, 207, 211, 213
 higher-dimensional version, 196, 197, 201, 512
 history, 205
 proof, 205
 Ito process, 193–197, 398
 arithmetic average, 198
 bond price process, *see* bond price process
 Brownian motion, *see* Brownian motion, Ito process
 diffusion, 193, 293, 369, 370, 374, 516
 discrete approximation, 193–194
 Brownian bridge, 258–259
 Euler method, *see* Euler method
 Mil'shtein method, *see* Mil'shtein method
 drift, 193, 205, 209, 293, 369, 374
 efficient markets hypothesis, *see* efficient markets hypothesis, Ito process
 estimation, 293, 374
 exchange rate, *see* exchange rate, Ito process
 forward price, *see* forward price, Ito process
 futures price, *see* futures price, Ito process
 geometric average, 198
 geometric Brownian motion, *see* geometric Brownian motion, Ito process
 Markov process, 195, 221
 martingale, 191–193, 205
 Monte Carlo simulation, 258–259
 quotient, 198
 rate of return, 204, 205
 stock index, *see* stock index, Ito process
 Ito, Kiyosi, 205

 J.P. Morgan & Co. Inc., 153n, 155, 176n, 475
 J.P. Morgan Chase & Co., 176n
 Japanese yen, 144–146
 foreign exchange option, 144, 145
 futures contract, 163
 Jarrow, Robert A., 388, 498
 Java applet, 482
 Java programming language, 480–482, 483n
 JavaScript programming language, 481, 483n

 Jensen inequality, 58, 530, 545
Journal of Finance, 479n
Journal of Political Economy, 122n
 junior debt, *see* debt, junior

 Kaldor, Nicholas, 225
 Kansas City Board of Trade, 165
 kappa (vega), 125
 Karolyi, G. Andrew, 371
 Keynes, John Maynard, 157, 176n, 225, 361
 knock-in option, *see* barrier option, knock-in
 knock-out option, *see* barrier option, knock-out
 Knuth, Donald E., xiv
 Kolmogorov backward equation, 185, 188,
 see Brownian motion, Kolmogorov backward equation, *see*
 Ornstein–Uhlenbeck process, Kolmogorov backward equation
 Kolmogorov forward equation (Fokker-Planck equation), 185
 Kuhn–Tucker conditions, 548
 kurtosis, 64, 292

 lag, 178, 287
 Lagrange multiplier, 460
 lambda (vega), 125
 Lampert, Leslie, xiv
 Langetieg model, 373
 Langevin equation, 193
 Langevin, Paul, 193
 Laplace, Marquis Pierre Simon de, 67
 law of iterated conditional expectations, 65, 179, 261, 534
 law of large numbers, 256
 law of the average covariance, 459, 471
 Lawson, Charles L., 276
 lease, 4
 least-squares estimator, 72–73, 282
 conditional, 73, 180
 generalized, 276
 history, 74n
 minimum variance, 72, 73, 274, 288
 ordinary, 274
 autoregressive process, *see* autoregressive process, ordinary least-squares estimator
 prediction, 73, 529
 term structure fitting, *see* term structure fitting, least squares
 unbiased, 274, 276
 least-squares line (regression line, estimated), 69
 least-squares principle, 69, 70, 72, 323
 least-squares problem, 273–276, 282
 B-spline, *see* spline, B-spline, least-squares problem
 constrained, 276, 282
 banded, 282

608 Index

- least-squares problem (*cont.*)
 cubic spline, *see* spline, cubic, constrained
 least-squares problem
 Lawson–Hanson algorithm, 276
 uniqueness of solution, 276
 full rank, 274–275
 uniqueness of solution, 274
 geometric characterization, 273
 rank-deficient, 274–275
 singular value decomposition, *see* singular
 value decomposition, rank-deficient
 least-squares problem
 uniqueness of solution, 274
 regression, *see* regression, least-squares problem
 weighted, 275–276
 term structure fitting, *see* term structure fitting,
 weighted least squares
 uniqueness of solution, 275
- Lee, Sang-Bin, 328, 331, 375
- Legendre, Adrien, 72
- Leibniz rule, 501
- Lévy, Paul, 188
- LIBOR, 40, 141, 163, 296, 298, 431
 day count, 141, 298–299, 313
 deviation from domestic rate, 141
 financial instrument, *see* collateralized mortgage
 obligation, LIBOR, *see* forward rate
 agreement, LIBOR, *see* futures option,
 LIBOR, *see* interest rate option, interest rate
 cap, LIBOR, *see* interest rate swap, LIBOR, *see*
 note, floating rate, LIBOR
 “flat”, 314
 German mark, *see* German mark, LIBOR
 implied, 299–301
 popularity, 141, 298
 term structure, *see* term structure, LIBOR
- life insurance, 148
- likelihood, 73, 74n
- likelihood function, 73, 74
 logarithm, 73, 285, 286, 290, 293
- linear algebra, 268–273, 282
- linear programming, 43, 44
- linear regression model, 72, 274–276
- linear system, 9, 24, 269
- Lintner, John, 1, 464, 465
- Linux, 5
- liquidity preference theory, 32, 59, 328
 risk aversion, 59
 yield curve, 59
- liquidity premium, 58, 347
 empirical study, 58
 expectations theory, *see* expectations theory,
 local, liquidity premium, *see* expectations
 theory, unbiased, liquidity premium
 Merton model, 347
 Vasicek model, 362
- loan guarantee as option, 132
- log-likelihood function, *see* likelihood function,
 logarithm
- logarithm, 7
- lognormal diffusion (geometric Brownian motion),
 186
- lognormal distribution, 68, 74, 106, 111,
 154n, 245
 bond price, 359
 density function, 68
 distribution function, 68
 geometric average, 213
 interest rate, 309, 329, 330, 343, 348, 370, 380,
 384, 398n
 problems, 348, 383–384
 mean, 68
 moment, 68, 292
 stock price, 106, 111, 117, 204, 223, 461
 empirical study, 478
 generation, 256, 257
 volatility, 291–292
 variance, 68
 yield to maturity, 360
- London, 141
- London Interbank Offered Rate (LIBOR), 40
- London International Financial Futures and
 Options Exchange, 299
- long hedge, *see* hedging, futures contract, long
 hedge
- long rate, 60, 61, 278, 345, 372, 374, 449
 interest rate model, *see* Brennan-Schwartz
 model, long rate, *see* Cox-Ingersoll-Ross
 model, long rate, *see* Vasicek model, long
 rate
- Long-Term Capital Management LP, 6n, 155,
 479n
- Longstaff, Francis A., 371
- Longstaff–Schwartz model, 373
- lookback option, 150, 151
 approximation algorithm, 153
 average, 150, 213
 binomial tree algorithm, *see* binomial tree
 algorithm, lookback option
 fixed strike, 150
 maximum, 150, 504
 minimum, 150, 238, 504, 505, 521
 static replication, *see* hedging, static
- loss aversion, 479
- low-discrepancy sequence (quasi-random
 sequence), 262
- LU decomposition, 270
- Lyapunov condition, *see* central limit theorem,
 Lyapunov condition
- Lyu, Yuh-Dauh, 153, 339, 382
- Macaulay, Frederick R., 34, 57
- mainframe computer, 4
- Major Market Index, 91, 141–143
- Major Market Index futures, 165
- Major Market Index option, 142
- Malthus, Thomas Robert, 6n
- Manhattan Project, 266

- margin requirement, 85, 87, 121
 - Margrabe formula, 214, 215, 222
 - Margrabe, William, 214
 - market portfolio, 464–467, 470
 - efficiency, 464–466
 - proxy, 470, 479n
 - market price of risk, 220, 221, 351, 352, 354, 357, 361, 371, 372, 375, *see* Arbitrage Pricing Theory, market price of risk, *see* Capital Asset Pricing Model, market price of risk, *see* Cox–Ingersoll–Ross model, market price of risk, *see* Heath–Jarrow–Morton model, market price of risk, *see* risk-neutral valuation, market price of risk, *see* volatility, stochastic, market price risk
 - market segmentation theory, 59, 328
 - risk aversion, 59
 - marking to market, 161, 162, 164, 170
 - Markov process, 178
 - continuous time, 178
 - stochastic process, *see* bond price process, Markov process, *see* Brownian motion, Markov process, *see* interest rate model, Markov process, *see* Ito process, Markov process, *see* random walk, drift, Markov process
 - Markov, Andrei A., 72
 - Markowitz problem, 460
 - Markowitz, Harry M., 1, 459, 460, 478
 - trouble in defending his doctoral thesis, 479n
 - Marshall, Alfred, xiii
 - martingale, 1, 179–183, 185, 188, 341
 - efficient markets hypothesis, *see* efficient markets hypothesis, martingale
 - prediction, 180
 - pricing, 180–183, 206, 221, 222, *see* binomial option pricing model, futures price, martingale, *see* binomial option pricing model, martingale, *see* forward rate, martingale, *see* numeraire, forward-neutral probability measure, *see* numeraire, risk-neutral probability measure, *see* risk-neutral valuation
 - rate of return, *see* rate of return, distribution, martingale
 - stochastic process, *see* Brownian motion, martingale, *see* Ito process, martingale, *see* stochastic process, discount, martingale, *see* Wald martingale
 - Mathematica, 205, 266
 - mathematical programming, 233
 - mathematics, 6n, 10, 11, 131, 190, 479n
 - matrix, 268
 - augmented, 276
 - banded, 269, 270, 273
 - bandwidth, 273, 282
 - constrained least-squares problem, *see* least-squares problem, constrained, banded
 - generalization, 273, 282
 - lower bandwidth, 269, 273
 - solution, *see* Gaussian elimination, banded matrix
 - upper bandwidth, 269, 273
 - diagonal, 268, 269
 - diagonally dominant, 268, 270, 279, 280
 - full rank, 268, 269, 274–276
 - identity, 268, 272
 - leading principal submatrix, 268–270
 - nonsingular, 252
 - orthogonal, 268, 274, 277
 - orthonormal, 283n
 - positive definite, 268–270, 274, 275, 461
 - eigenvalue, 271
 - positive semidefinite, 268
 - pseudoinverse, 275
 - underdetermined system, 275
 - rank, 268, 272
 - rank-deficient, 268
 - square, 268
 - symmetric, 268, 270
 - transpose, 65
 - tridiagonal, 252, 269, 270
 - spline, *see* spline, tridiagonal system, as upper triangular, 269
- maturity strategy, *see* trading strategy, maturity strategy
- maximum likelihood estimator, 73
 - ARCH process, *see* autoregressive conditional heteroskedastic process, maximum likelihood estimator
 - asymptotic normality, 73
 - autoregressive process, *see* autoregressive process, maximum likelihood estimator
 - biased, 73
 - Black–Scholes formula’s volatility, *see* Black–Scholes formula, volatility, maximum likelihood estimator
 - conditional, 291
 - consistent, 73, 291
 - constant elasticity variance process, *see* constant elasticity variance process, maximum likelihood estimator
 - factor analysis, *see* factor analysis, maximum likelihood estimator
 - normal distribution, *see* normal distribution, maximum likelihood estimator
 - stochastic process, *see* stochastic process, maximum likelihood estimator
 - variance, *see* variance, maximum likelihood estimator
- McCulloch, J. Huston, 325
- mean, 57
 - sample, 64, 73, 290
 - vector, 65
 - sample, 66

610 **Index**

- mean function, *see* stochastic process, mean function
- mean reversion, 199, 201, 361, 384
 empirical study, 371
 GARCH model, *see* generalized autoregressive conditional heteroskedastic process, mean reversion
- interest rate model, *see* binomial interest rate tree, mean reversion, *see*
 Black–Derman–Toy model, mean reversion, *see* Black–Karasinski model, mean reversion, *see* Brennan–schwartz model, mean reversion, *see* Cox–Ingersoll–Ross model, mean reversion, *see* Ho–Lee model, mean reversion, *see* Hull–White model, mean reversion, *see* Hull–white model, mean reversion, *see* Ogden model, mean reversion, *see* Vasicek model, mean reversion
- mean-square error, 73, 180, 273, 288, 324, 326
- mean–standard deviation combination, 459
 efficient, 459
 obtainable, 459, 464
- mean–standard deviation diagram, 459
- mean–variance analysis, 458–464, 469, 472, 479
 Black model, 464
 general model, 464
 numerical solution, 460–461, 463, 465
 parameter estimation, 469, 470
 difficulty, 469–470
 riskless security, 462–464, 466, 471
 standard model, 464
 standard model with upper bounds, 464
 Tobin–Sharpe–Lintner model, 464
- measurement, 427
- Merck and Co., Inc., 79, 90, 132, 133, 154n, 466
- Merton model, 202, 324
 bond price process, 202
 duration, 202
 forward rate, 347
 Ho–Lee model’s special case, 380
 immunization, 203
 liquidity premium, *see* liquidity premium, Merton model
 problems, 202, 347, 362
- Merton, Robert C., 6n, 88, 92, 117, 138, 140, 189n, 190, 201, 202, 207, 328
 Nobel Prize, 92
- method of moments, 74, 292, 293
 consistent, 74
 generalized, 294
- Metropolis, Nicolas, 266
- Microsoft Corp., 4, 5, 79, 90, 134, 154n, 466
 WWW browser, 6, 481
- Mill, John Stuart, 414
- Miller, Merton H., 75, 91
- Mil’shtein method, 194
- minicomputer, 4
- minimum-variance point, 459, 460
- minimum-variance set, 459–461
- modeling, 2, 284
 parametric, 284, 374
 specification error, *see* specification error
 testing, 284, 293
- modern portfolio theory, 458, 478
 history, 478
 Japan, 479
 real estate, 479
- Modigliani, Franco, 59, 91
- Modigliani–Miller irrelevance theorem, 218
- moment, 68, 74, 284, 293
 central, 66
 sample, 74, 284, 294
- moment generating function, 66, 186, 247
 joint, 67
 normal distribution, *see* normal distribution, moment generating function
- money market, 2, 312
- money market account, 181–183, 334, 347, 349, 350, 354, 356, 394
 bank account process, 181, 349, 350
- money market fund, 3
- Monte Carlo simulation, 103, 193, 249, 255–256, 259, 260, 262–264, 266
 bias, 410
 Brownian bridge, *see* Ito process, discrete approximation, Brownian bridge
 Brownian motion, *see* Brownian motion, Monte Carlo simulation
 convergence rate, 103, 256–257, 262
 geometric Brownian motion, *see* geometric Brownian motion, Monte Carlo simulation
 history, 266
 integration, 256, 262, 264
 interest rate, 390, 448
 Ito process, *see* Ito process, Monte Carlo simulation
 limitations, 262–263
 mortgage-backed security, *see* mortgage-backed security, valuation, Monte Carlo simulation
 multivariate derivative, 256, 272
 option, 103, 256–258, 266–267
 advantages, 255, 257
 American, *see* American option, Monte Carlo simulation, *see* fixed-income option, valuation, Monte Carlo simulation of American option
 average-rate, *see* average-rate option, arithmetic, Monte Carlo simulation
 barrier, 257
 control variates, 267
 problems, 257
 sensitivity, *see* sensitivity, numerical techniques, Monte Carlo simulation
 parallel processing, 482
 path-dependent derivative, *see* path-dependent derivative, Monte Carlo simulation
 quasi-Monte Carlo method, vs., 263

- random number, *see* random number, Monte Carlo simulation
- replication, 256, 267
- sample size (replication), 256
- stochastic volatility, *see* volatility, stochastic, Monte Carlo simulation
- value at risk, *see* value at risk, Monte Carlo simulation
- variance reduction, *see* variance reduction
- Montesquieu, Charles de, 45, 223n, 414
- mortgage, 15, 24, 39, 75, 415, 481
 - adjustable payment, 422
 - adjustable rate, *see* adjustable-rate mortgage
 - assumable, 424
 - balloon, 44n
 - cash flow, 15, 420, 427–429, 436–437
 - composition, 417
 - payment in arrears, 427
 - prepayment, 415
 - conforming, 416, 417, 419
 - conventional, 416–418, 423, 424, 442
 - coupon rate (rate), 422
 - credit risk, *see* credit risk, mortgage
 - current coupon, 423, 437, 442, 447
 - default, 44n, 415, 416, 419, 424
 - due-on-sale, 424
 - factor, *see* factor
 - foreclosure, 415, 422, 424
 - fully amortized, 15, 44n, 415
 - graduated payment, 16
 - guarantee, 416
 - insurance, 416
 - government, 416, 442
 - private, 416, 424
 - interest rate risk, *see* risk, interest rate, mortgage
 - jumbo loan, 417
 - level payment, 15, 16, 415, 427
 - liquidity, 416, 417, 423
 - risk, *see* risk, liquidity, mortgage
 - Macauley duration, *see* duration, Macauley, mortgage
 - market, 2, 415, 416
 - primary, 415
 - secondary, 3, 4, 415, 417, 423
 - size, 24, 415, 416
 - nonconforming, 419
 - option, *see* fixed-income option, mortgage
 - origination market (market, primary), 415
 - originator, 416
 - pooling, 415–417, 437
 - principal, *see* principal residential, 415
 - securitization, *see* securitization, mortgage servicing, 417
 - fee, 417, 427, 436
 - IO, as, 444
 - statement, 417
 - term, 31n, 425
 - traditional, 15, 36, 419, 427, 437
 - unattractiveness as investment, 415
 - whole loan, 415, 419
- mortgage pass-through, 415, 417, 419, 422, 444, 446, 447
 - agency, 418
 - Fannie Mae, 419, 423, 442
 - Freddie Mac, 423, 442
 - Ginnie Mae, 417, 419, 436, 442
 - Ginnie Mae Pool #1, 417
 - GNMA I, 422, 450n
 - GNMA II, 422, 450n
 - Gold PC of Freddie Mac, 423, 450n
 - MBS of Fannie Mae, 423
 - MBS of Ginnie Mae, 422
 - PC of Freddie Mac, 423
 - collateral, 416, 419, 422
 - adjustable-rate mortgage, 419
 - conventional (private label), 419
 - discount, 424, 425
 - synthetic, 452
 - forward option, 446
 - fully modified, 418, 419, 423
 - modified, 419
 - pass-through rate, 436, 437, 441, 451
 - premium, 425
 - synthetic, 452
 - prepayment, 419, 420, 423, 424, 437
 - private label, 419
 - Treasury securities, vs., 424, 425
- mortgage rate, 15, 419, 422–427, 429, 436, 437, 440, 442
- mortgage-backed security, 24, 103, 415–426, 449
 - agency, 417, 418, 422–423
 - Fannie Mae, 418, 423
 - Freddie Mac, 418, 422–423
 - Ginnie Mae, 418, 419, 422, 433
 - swap program, 418
- attractiveness, 415
- cash flow, 422
 - prepayment, 427, 432–440, 453
- collateral, 415, 416, 452
 - fifteen-year mortgage, 424, 442
 - thirty-year mortgage, 424
- collateralized mortgage obligation, *see* collateralized mortgage obligation
- convexity, 424, 444–445
 - effective, 444, 445, 449
 - option-adjusted spread, 449
- corporate bond, vs., 446
- credit enhancement, 419
- current coupon, 445
- default risk, 418
- derivative, 422, 432, 450
- discount, 445
- duration, 444, 449
 - cash flow (Macauley), 444
 - effective, 444–446, 449
 - key rate, 449

612 **Index**

- mortgage-backed security (*cont.*)
 Macaulay, 444, 446
 modified, 446
 option-adjusted spread, 449
 prepayment, *see* prepayment duration
 static (Macaulay), 444
 embedded call option, 446, 448
 futures contract, *see* futures contract,
 mortgage-backed security
 guarantee, 416, 436
 agency, 416–419, 423
 non-agency, 419
 hedging, 443, 444, 446, 450
 history, 416, 417, 426
 holding period return, 449
 issuance, 416, 418
 issuer, 417, 422
 liquidity, 415, 417, 446
 market, 415, 417, 418
 multifamily, 449
 par, 437
 pass-through, *see* mortgage pass-through
 payment delay, 450n
 premium, 424, 440, 445
 prepayment, 284, 319, 419, 422, 423
 price compression, 424, 425
 quote, 435
 risk premium, 448
 sale, 417
 servicing, 416, 419, 422, 436
 MBS servicing, 417
 servicing spread, 436, 437
 stripped, *see* stripped mortgage-backed security
 Treasury securities, *vs.*, 446
 uniqueness, 423, 427
 valuation, 446–449
 backward induction, 449
 binomial model, 355–358, 439
 CMO, *see* collateralized mortgage obligation,
 valuation
 difficulty, 415, 446
 Monte Carlo simulation, 439, 444, 448, 449, 482
 multifactor interest rate model, 449
 parallel processing, 449
 problems with option pricing model, 446, 447
 quasi-Monte Carlo method, 449
 SMBS, *see* stripped mortgage-backed security,
 valuation
 valuation methodologies, 446
 option pricing, 446–447
 option-adjusted spread, *see* option-adjusted
 spread, mortgage-backed security
 static cash flow yield, 435, 446
 static spread, 446, 448
 volatility, 444
 yield, 449
 option-adjusted, *see* option-adjusted yield,
 mortgage-backed security
 mortgagee, 415
 mortgagor, 415, 418
 Morton, Andrew, 388
 Mossin, Jan, 1, 465
 motion, 177, 451
 moving average process, 289–290
 autocorrelation function, 289
 covariance function, *see* covariance function,
 moving average process
 ergodicity, 290
 invertibility, 289
 stationarity, 289
 multiprocessor, 5
 municipal bond, 24, 400–401
 day count, 28
 general obligation bond, 400
 market, 2
 quote, 401
 revenue bond, 400
 music, 206
 mutual fund, 1, 3, 451
 index, 479n
 performance evaluation, 479
 Nasdaq 100 Index, 91, 142
 Nasdaq National Market, 79
 NCSA, 12
 Nelson, Charles R., 326
 net present value, 19–20
 Netherlands, the, 226
 Netscape Communications Corp.
 WWW browser, 6, 481
 Neumann, John von, 266
 neural network, 267
 New York Futures Exchange, 165
 New York Stock Exchange, 3, 79, 141
 New York Stock Exchange Composite Index, 91,
 141, 142
 New York Stock Exchange Composite Index
 futures, 165
 New York Stock Exchange Composite Index
 futures option, 171
 New York Stock Exchange Composite Index
 option, 142, 143, 171
 Newton–Raphson method, 21–23, 49, 491
 systems of nonlinear equations, 23–24
 Nikkei 225 Stock Average futures, 162, 165
 valuation, 165
 Nikkei 225 Stock Average futures option, 217
 valuation, 217
 Nobel Prize in Economic Sciences of 1997, 6n, 92
 nonproportional shift, 60, 61, *see* duration,
 nonproportional shift
 normal distribution, 66–68, 105, 111, 290, 475
 absolute value, 511
 approximation, 66, 74
 bivariate, 67, 72
 approximation, 67
 correlation, 67, 196, 247
 density function, 67

- generation, 67–68, 272
 - linear regression, 72
 - moment generating function, 247
- density function, 66
- interest rate, *see* interest rate, normal distribution
- kurtosis, 66
- linear combination, 66, 67
- maximum likelihood estimator, 73
- moment, 66, 67
- moment generating function, 66, 186
- multivariate, 66, 67, 272, 274, 287, 475
 - correlation, 66
 - density function, 67
 - generation, 272, 477
 - principal component, 283n
- rate of return, *see* rate of return, distribution
- skewness, 66
- standard, 66–68, 123, 272, 475
 - density function, 123, 474
 - distribution function, 66
 - generation, 67–68
- sum, 66–67
- normal equations, 273–274
 - linear regression, *see* regression, linear, normal equations
 - weighted, 275
- normal process, *see* stochastic process, normal
- normalized linear combination, 271, 272
- note, 399
 - floating-rate, 141, 406
 - LIBOR, 406
 - structured, 406
- notification date, 148
- numeraire, 182, 183, 189n, 214, 334
 - forward-neutral probability measure, 183, 534
 - risk-neutral probability measure, 182–183, 334, 394
- numerical differentiation, 127–129
 - problems, 128–129
- numerical techniques, 31, 268

- object-oriented software approach, 4, 5, 10
- Ogden model, 286, 370–371
 - maximum likelihood estimator, 286–287
 - mean reversion, 370
- Ogden, Joseph P., 370
- one-fund theorem, 463, 464
- online trading, 2
- operating risk, *see* risk, operating
- operating system, 480
- optimization, 44, 479
 - constrained, 43
 - constraint, 43
 - objective function, 43
- option, 75–76, 141, 155
 - 90/10 strategy, 81
 - American, *see* American option
 - Asian, *see* Asian option
 - at the money, 77, 109, 124
 - at the money forward, 159
 - average rate, *see* average-rate option
 - average strike, *see* lookback option, average
 - barrier, *see* barrier option
 - basket, *see* basket option
 - best of two risky assets and cash, 245, 248
 - binary, *see* binary option
 - binomial tree algorithm, *see* binomial tree algorithm, option
 - Black–Scholes differential equation, *see* Black–Scholes differential equation, option
 - call, *see* call
 - capped, *see* capped option
 - cash secured put, 80, 86
 - cash settlement, 141, 142, 162
 - chooser, *see* chooser option
 - combination, 79, 83
 - compound, *see* compound option
 - continuous dividend yield, 117–118, 124, 143, 171, 212
 - convexity, 89–90
 - correlation, *see* correlation option
 - covered, 79
 - covered call, 80, 86, 131, 201, 469
 - popularity, 80
 - currency, *see* currency option
 - default risk, 176
 - delta, 173, 208, 209, 228, *see* call, delta, *see* put, delta
 - dividend, 78, 86, 114–118
 - known, 116–117, 256–257
 - dividend yield, 114–116
 - embedded, 27, 75, *see* fixed-income security with option features
 - European, 75, 85–87, 102, 122, 128, 149, 180, 201, 234, 235
 - exchange, *see* exchange option
 - exchange-traded, 77–78
 - exercise, 75, 77
 - exercise price (strike price), 75
 - exotic, 176
 - expiration date, 78
 - fixed-income security, *see* fixed-income option
 - forward contract, *see* forward option
 - forward contract, vs., *see* forward contract, option, vs.
 - forward start, 221
 - futures contract, *see* futures option
 - futures contract, vs., *see* futures contract, option, vs.
 - generalized, 88
 - hedge, 79–81
 - hedge ratio (delta), 93
 - hedging, *see* hedging, option
 - history, 77, 78
 - in the money, 77, 109
 - in–out parity, *see* in–out parity
 - interest rate, *see* interest rate option
 - intrinsic value, 77, 84, 87, 257, 410, 411

614 **Index**

- option (*cont.*)
 liquidation, 78
 listed (exchange-traded), 78
 lookback, *see* lookback option
 maximum of two assets, 215, 245, 248
 minimum of two assets, 215, 248
 mispricing, 99
 Monte Carlo simulation, *see* Monte Carlo simulation, option
 multiperiod, 173
 offset, 78
 open interest, 78
 out of the money, 77, 109, 222
 over-the-counter, 77, 137
 Parisian, *see* Parisian option
 path-dependent, *see* path-dependent derivative, option
 portfolio, 90–91
 power, *see* power option
 premium, 75, 77
 pricing model, 1, 75, 84, 92–93, 131, 153, 446,
see binomial option pricing model,
see Black–Scholes option pricing model,
see generalized autoregressive conditional
 heteroskedastic process, option pricing
 model, *see* mortgage-backed security,
 valuation, problems with option pricing
 model, *see* trinomial model, *see* volatility,
 stochastic
 history, 1, 122
 predictable return, 121, 209
 specification error, 121
 pricing relations, 85–88, 147
 protected, 78, 86
 protective put, 80
 insurance, *vs.*, 80
 portfolio insurance, 468, 469
 put, *see* put
 put–call parity, *see* put–call parity
 quasi-Monte Carlo simulation, *see* quasi-Monte
 Carlo method, option
 ratio hedge, 80
 replicated as a portfolio of futures and bonds,
 172–173
 replicated as a portfolio of stocks and bonds, 93,
 94, 96, 229, 230
 trinomial model, 242
 reset, *see* reset option
 reverse hedge, 80
 risk-neutral probability, *see* risk-neutral
 probability, option
 Russian, *see* Russian option
 sensitivity, *see* sensitivity, option
 split-fee, *see* split-fee option
 spread, 79, 81–83, 479
 bear, 82
 bull call, 81, 134, 232, 238, *see* debt,
 subordinated, replicated as bull call spread
 bull put, 82
 butterfly, 81, 82
 calendar (horizontal), 83
 diagonal, 83
 exploding, 238
 horizontal, 82, 83
 money (vertical), 81
 price (vertical), 81
 time (horizontal), 83
 vertical, 81
 stochastic volatility, *see* volatility, stochastic
 stock index, *see* stock index option
 stock split, 78, 112
 straddle, 82, 83
 strangle, 83
 strap, 83
 strategy, 78–83
 strike price, 75, 76, 78
 strip, 83
 time value, 77, 124, 501
 uncovered, 73
 writer, 75
 option-adjusted convexity, 407
 option-adjusted duration, 407
 option-adjusted spread, 408, 410–412, 414
 binomial interest rate tree, 408
 bisection method, 408
 Newton–Raphson method, 408, 410
 Ridders method, 410
 secant method, 410
 callable bond, 408–410, 544
 fixed-income security with option features,
 408–412
 mortgage-backed security, 447–449
 cash flow generator, 447, 448
 computational framework, 447
 parallel shift, 409
 problems, 414
 puttable bond, 408–410, 545
 static spread, *vs.*, 448
 yield spread, *vs.*, *see* yield spread,
 option-adjusted spread, *vs.*
 zero-volatility, 448
 option-adjusted spread convexity, 411
 mortgage-backed security, *see* mortgage-backed
 security, convexity, option-adjusted spread
 option-adjusted spread duration, 411
 mortgage-backed security, *see* mortgage-backed
 security, duration, option-adjusted spread
 option-adjusted yield, 407, 410–411
 callable bond, 407
 mortgage-backed security, 447
 Options Clearing Corporation, 78
 Oracle Corp., 5
 Orange County, California, 155
 Ornstein–Uhlenbeck process, 187,
 198–200
 Constantinides model, 371
 covariance function, *see* covariance function,
 Ornstein–Uhlenbeck process

- distribution, 198, 200
 homogeneous, 513
 interest rate model, 199, 361
 problems, 201
 Kolmogorov backward equation, 200
 mean function, 198, 199
 model for Brownian motion, *see* Brownian motion, modeled as Ornstein–Uhlenbeck process
 multivariate, 205
 stationarity, 199
 stock price, 199, 209
 trendy, 209
 variance function, 198, 199
 Vasicek model, 361
 volatility modeling, *see* volatility, stochastic, Ornstein–Uhlenbeck process
 Wiener process transformed, 187, 200
 orthogonal vector set, 268, 476–478
 orthonormal vector set, 268, 271
 OS/2, 5
 Osborne, M., 188
 over-the-counter market, 77
 overdetermined system, 273, 323–325
- par bond, *see* bond, par
 par value, *see* bond, par value
 par yield curve, *see* yield curve, par
 parallel processing, 4, 266, 482–483
 massively, 4
 mortgage-backed security, *see* mortgage-backed security, valuation, parallel processing
 parallel shift, 44, 60–63, 202, 277, 278, 372, 373
 convexity, *see* convexity, parallel shift
 duration, *see* duration, parallel shift
 immunization, *see* immunization, parallel shift
 importance, 61
 option-adjusted spread, *see* option-adjusted spread, parallel shift
 problems, 62, 202, 203, 356
 risk premium, 49
 spread, *see* binomial interest rate tree, spread, parallel shift
 Parisian option, 140
 Parkinson, Michael, 248
 partial differential equation, 206–207, 222, 249, 266, 351
 boundary-value problem, 206
 diffusion equation, *see* diffusion equation
 discriminant, 206
 elliptic, 206, 207, 249
 hyperbolic, 207
 initial-value boundary problem, 206
 initial-value problem, 206
 parabolic, 206, 207, 249, 351
 parallel algorithm, 266
 Poisson equation, *see* Poisson equation
 participation certificate, 416
- Pascal, Blaise, 91, 123
 path independence, 148, 189n, 330, 331
 path-dependent derivative, 148–153, 431
 adjustable-rate mortgage, 430, 439
 collateralized mortgage obligation, 439
 Monte Carlo simulation, 149, 266
 option, 148–153, 238
 scaling, 431, 546
 payoff, 76
 PC, *see* mortgage pass-through, agency, PC of Freddie Mac, *see* participation certificate
 Pearson’s r (sample correlation), 71
 Pearson, Karl, 74
 pension fund, 3, 39, 416
 perfect hedge, *see* hedging, futures contract, perfect hedge, *see* hedging, option, perfect hedge
 periodic expense, 16
 personal computer, 4, 5
 Philadelphia Stock Exchange, 78, 145
 philosopher, 268
 physics, 7, 188, 268, 483
 “plain vanilla” interest rate swap, *see* interest rate swap, “plain vanilla”
 Planned Amortization Class bond, *see* collateralized mortgage obligation, PAC bond
 platform independence, 4, 480, 482
 Poincaré, Jules Henri, 6n
 Poisson equation, 206, 207, 249
 finite-difference equation, 249, 251
 polar rejection method, 68
 pool factor, 428
 portfolio dominance, 84
 portfolio immunization, 228
 portfolio insurance, 468–469, 479
 failure, 479n
 protective put, *see* option, protective put, portfolio insurance
 static, 468
 power option, 237, 238
 prediction, *see* least-squares estimator, prediction, *see* martingale, prediction, *see* prepayment speed, prediction, *see* regression, *see* stock, price, prediction, *see* time series, prediction
 preferred habitats theory, 59
 premium currency, *see* currency, premium
 prepayment, 44n, 319, 356, 415, 417, 423–428, 432, *see* collateralized mortgage obligation, prepayment, *see* mortgage pass-through, prepayment, *see* mortgage-backed security, prepayment, *see* stripped mortgage-backed security, prepayment
 cash flow, *see* mortgage, cash flow, prepayment, *see* mortgage-backed security, cash flow, prepayment
 causes, 424
 curtailment, 423–424, 447
 default, 424
 home sale, 424, 441

616 **Index**

- prepayment (*cont.*)
 liquidation, 423–424
 refinancing, *see* refinancing
 turnover (home sale), 424
 characteristics, 424, 442, 449
 burnout, 441–443, 449
 economy, 442
 geography, 424
 interest rate, 423, 424, 440–442, 449
 lag response, 440
 loan size, 441, 442
 mortgage rate, 441, 442
 pool type, 442
 seasonality, 424
 seasoning, 424, 425, 433–435, 441–442
 empirical study, 449
 implied, 448
 irrational, 423, 447
 prepayment duration, 449
 prepayment model, 435, 439–444, 447–449
 deterministic vs. stochastic, 447
 history, 449
 loan level, 442
 prepayment risk, 319, 419, 423–424, 443, 446, 449, 451
 contraction risk, 423, 451, 454, 457
 extension risk, 423, 438, 451, 454, 457
 hedging, 443
 redistribution, 423
 prepayment speed, 432–435, 437, 441, 443, 453
 prediction, 448
 prepayment vector, 435–439, 442, 449
 present value, 11–13, 19, 31n
 arbitrage, 84
 price compression, *see* callable bond, price compression
 compression, *see* mortgage-backed security, price compression
 price risk, *see* risk, price
 price value of a basis point (basis-point value), 41
 primary market, 3
 prime rate, 40, 298, 308
 primitive polynomial, 264, 265
 principal, 15
 original, 15, 428
 remaining, 15, 16, 31n, 417, 420, 421, 427–429, 432, 435–437, 439
 principal and interest, 417, 427, 436, 437
 scheduled, 417, 419–422, 424, 425, 427, 429, 432, 436, 437
 principal-axes theorem (Schur decomposition), 270
 principal component, 271–272, 398, *see* eigenvector, principal component, *see* factor analysis, principal component, *see* normal distribution, multivariate, principal component, *see* value at risk, Monte Carlo simulation, principal component, *see* variance, principal component
 principal-only, *see* stripped mortgage-backed security, principal-only
 private placement, 3
 probability measure, 179, 181
 equivalent, 181
 probability theory, 64, 67, 74, 91
 Producer Price Index, 414
 program trading, 165, 479n
 programming language, 4, 7
 prophet, 284
 proportional shift, 60
 prospect theory, 479
 protected option, *see* option, protected
 PSA, 433–435
 history, 433
 implied, 435, 440
 pseudorandom number, 262, 266
 pseudocode, 7
 pseudoinverse, *see* matrix, pseudoinverse
 psychology, 479
 public offering, 3
 Public Securities Association, 418, 421, 433
 put, 75–79, 85–87, 90, 98, 113–114, 159, 479
 American, 86, 88–89, 94, 113–115, 118, 120, 121, 125, 128, 211, 252, 253
 early exercise, 88–89, 211
 binomial tree algorithm, *see* binomial tree algorithm, option
 Black–Scholes differential equation, 211
 delta, 94, 123, 128
 European, 86, 87, 89, 91, 100, 102, 138, 211
 gamma, 125
 intrinsic value, 87
 protective, *see* option, protective put
 rho, 126
 theta, 124, 125
 valuation, 93–104
 bound, 89
 vega, 125
 put–call parity, 86–88, 98, 107, 132, 159
 American option, 89, 118, 120
 average-rate option, 149
 binomial option pricing model, 99
 dividend, 87, 88, 118
 European, 87, 89, 118
 exchange option, 215
 fixed-income option, 363
 binomial interest rate tree, 342, 342
 foreign exchange option, 147
 forward option, 170
 forward price derivation, 159
 futures option, 170
 history, 87
 stock index option, 143
 synthetic security, 87
 puttable bond, 399, 403
 option-adjusted spread, *see* option-adjusted spread, puttable bond
 put price, 410
 valuation, 410

- QR decomposition, 276
 - constrained least-squares problem, 276
- quadratic programming, 324, 460, 461
- quadratic variation, *see* variation, quadratic
- quality option, *see* Treasury bond futures, quality option
- quantitative analysis, 2
- quanto option, 217–218
- quasi-Monte Carlo method, 249, 262–267
 - Brownian bridge, 259
 - convergence rate, 263
 - integration, 263, 264
 - Monte Carlo simulation, *vs.*, *see* Monte Carlo simulation, quasi-Monte Carlo method, *vs.*, *see* variance reduction, quasi-Monte Carlo method, *vs.*
 - mortgage-backed security, *see* mortgage-backed security, valuation, quasi-Monte Carlo method
- option, 266, 267
 - problems, 263–264
 - dimension, 259, 263
- quasi-random sequence, 262, 267n
 - comparison, 267
 - correlation, 263
 - Faure, 265–266
 - Halton, 263–266
 - scrambled, 264
 - Sobol', 264–265
 - direction number, 264–265
- quoted price, 29, 302
- radical inverse function, 263
- random number
 - Monte Carlo simulation, 106
 - problems, 262–263
 - seed, 262
- random variable, 58, 64, 65
- random walk, 1, 178–180, 185, 188
 - binomial, *see* binomial model
 - Brownian motion, 185–186, 188, 258, 259, 294n
 - drift, 178, 294n
 - Markov process, 178
 - rate of return, 204, 288
 - stock price, 178, 288
 - symmetric, 178, 179, 185, 264, 354
 - variance, 179
 - trinomial, 523
- random-walk hypothesis, 288
 - rejection, 288
- rate of return, 104–107, 186–187, 458, 472, 473, 479n
 - ambiguity, 106, 187, 197, (204, (204, 203–205 continuously compounded, 104–106, 111, 203–205, 285
 - correlation, 288, 459, 461
 - distribution, 105, 106, 111, 186, 188, 204–205, 285, 288, 469, 473–475, 477–479, 479n
 - empirical study, 478
 - fat tails, 478
 - kurtosis, 292, 478
 - martingale, 180, 293
 - instantaneous, 106, 197, 201, 203, 204, 209, 286, 351
 - predictability, *see* option, pricing model, predictable return
 - simple, 112, 204, 285–286, 479n, 528
 - stochastic process, *see* binomial option pricing model, rate of return, *see* Brownian motion, rate of return, *see* factor model, *see* Ito process, rate of return, *see* random walk, rate of return, *see* random walk, stock price, *see* volatility, stochastic
 - variance, 201, 203, 222, 294n, 474
- rate swap, 173
- rating downgrade, 414
- ratio hedge, *see* option, ratio hedge
- Real Estate Mortgage Investment Conduit, 451
- real-time data feed, 2
- reciprocal of European terms (American terms), 144
- Redington, F.M., 44
- redundant security, 317
- refinancing, 424–425, 432, 441
 - continuous, 426
 - incentive, 425–426, 441, 443
 - rate difference *vs.* rate ratio, 425
 - threshold, 425, 441
- reflecting boundary, 201
- reflection principle, 235–236, 238, 241, 519, 521, 523
- regression, 69–70, 74, 273, 526
 - correlation, *vs.*, 71
 - fitted value, 69, 72
 - history, 74n
 - least-squares problem, 273–275, 526
 - linear, 69, 70, 73, 227, 273, 288, 324
 - bivariate normal distribution, *see* normal distribution, bivariate, linear regression
 - curve fitting, *see* curve fitting, linear regression
 - normal equations, 273, 526, 529
 - multiple (linear), 70
 - nonlinear, 70
 - polynomial, 70, 273, *see* curve fitting, polynomial regression
 - quadratic, 70
 - term structure fitting, *see* term structure fitting, regression
- regression line
 - estimated, 69, 70, 72
 - minimum variance, 72
- regression sum of squares, 70
- reinvestment, 19, 30, 31, 412, 449, 457
- reinvestment rate, 19, 31, 457
- reinvestment risk, *see* risk, reinvestment
- relative return, 186
- Rendleman, Richard J., Jr., 331
- Rendleman–Bartter model, 331
- replicating portfolio (equivalent portfolio), 94

618 **Index**

- repo, 156
 Federal Reserve, 156
 forward contract, as, 158
 market, 156
 overnight, 156
 rate, 156
 implied, 298
 reverse, 156
 term, 156
- repurchase agreement (repo), 156
- res securitization, 419, 422
- reset option, 139, 238
- residual sum of squares (error sum of squares), 69
- return, 17, 479n, *see* expected return, *see* gross return, *see* holding period return, *see* internal rate of return, *see* rate of return, *see* relative return, *see* risk, return, *see* riskless return, *see* total monetary return
- reverse repo, *see* repo, reverse
- rho, 126–127
 numerical, 128
- Richard model, 373
- Ridders method, 23, 410
- Riemann-Stieltjes integral, 192, 193
- risk, 1, 57, 59, 92, 224, 458, 461, 465, 467, 474
 aversion, 94, 459, 464
 term structure theory, *see* liquidity preference theory, risk aversion, *see* market segmentation theory, risk aversion
 basis, *see* futures contract, basis risk
 Capital Asset Pricing Model, *see* Capital Asset Pricing Model, beta, risk
 credit, *see* credit risk
 currency, *see* currency risk
 default, *see* default risk
 diversifiable (specific), 471
 exercise, *see* stock index option, exercise risk
 interest rate, 44, 59, 328, 372, 412, 478
 fixed-income security with embedded option, 478
 mortgage, 424
 liquidity, 479n
 mortgage, 424
 market (systematic), 467
 market price, *see* market price of risk
 operating, 132
 preference, 94, 95, 209, 221, 388
 premium, 46, 49, 54, 59, 351, 371, 372, *see* corporate bond, risk premium, *see* mortgage-backed security, risk premium, *see* parallel shift, risk premium, *see* volatility, stochastic, risk premium
 prepayment, *see* prepayment risk
 price, 59, 226
 reinvestment, 19, 25, 30, 59
 return, 284, 288, 357, 458–463, (467, 465–467, 479 excess, 220, 288, 463, 465, 466
 shape, 63
 specific, 458, 459, 467, 471, 476, 550
 standard deviation, as, 458, 479, 479n
 systematic, 207, 222, 458, 459, 467, 471, 478, 550
 twist, 63
 unsystematic (specific), 458
- risk management, 224, 233, 398, 458, 478
 benefits, 224
 derivative, 1, 155, 224, 406
 interest rate derivative security, 32, 295, 380, 412
- risk-neutral economy (risk-neutral probability), 95
- risk-neutral investor, 95, 355
- risk-neutral probability, 95, 97, 181, 183, 204, 205, 209, 211, 217, 221, 344n, 476
 arbitrage freedom, 98–99, 118, 181
 continuous dividend yield, 117
 foreign exchange option, 146, 181
 futures price, 172–173, 182, 341
 interest rate modeling, *see* interest rate model, risk-neutral process
 local expectations theory, *see* expectations theory, local, risk-neutral probability
 negative, 105, 173
 numeraire, *see* numeraire, risk-neutral probability measure
 option, 95, 98, 106, 107, 181, 360n
 unbiased expectations theory, *see* expectations theory, unbiased, risk neutrality
 uniqueness, 99
- risk-neutral valuation, 94–95, 97, 102, 180–183, 234, 448
 continuous time, 209, 221–222, 518
 fixed-income security, 183, 263, 377, 395
 binomial model, 354–359
 market price of risk, 221
 self-financing trading strategy, 98–99
- riskless interest rate, *see* interest rate, riskless
- riskless return, 57, 357, 408, 467
- riskless security, *see* security, riskless
- RiskMetrics™, 475
- Ritchken, Peter, 243, 395
- Ritchken–Sankarasubramanian model, 395–397
 bond price formula, 395
 bond price process, 395
 calibration, 396
 discrete time, 396–397
 duration, 396
 empirical study, 398
 forward rate curve, 396
 proportional model, 396, 397
 short rate model, 395
 short rate volatility, 395, 396
 volatility structure, *see* term structure, forward rate volatility,
 Ritchken–Sankarasubramanian model
- Roberts, Harry, 288
- rolling option, *see* barrier option, rolling
- rollover strategy, *see* trading strategy, rollover strategy

- Ross, Stephen A., 164, 328, 364, 472
 Roy, Arthur D., 478
 Rubinstein, Mark, 121
 Rudd, Andrew., 498
 Rural Housing Service, 416, 422
 guarantee, 417
 Russell 2000 Index, 90, 91, 142
 Russian crisis of 1998, 479n
 Russian option, 150
- S&P 100 Index, 90, 91, 141–143
 S&P 100 Index option, 90, 142
 liquidity, 90
 S&P 500 Index, 90, 91, 141–143, 165, 171,
 304, 479n
 tick size, 165
 S&P 500 Index futures, 162, 163, 165, 171, 228, 304
 liquidity, 162
 S&P 500 Index futures option, 168, 171
 S&P 500 Index option, 90, 142, 171
 Salomon Brothers, Inc., 321, 380
 sample correlation, 71–72
 sample path, *see* stochastic process, sample path
 Samuelson, Paul A., 1, 293
 Sanders, Anthony B., 371
 Sankarasubramanian, L., 395
 saving, 2
 savings and loan, 3, 419
 scatter diagram, 69
 scenario analysis, 31, 343, 412, 449
 Schlegel, Friedrich von, 262
 Schoenberg, Isaac Jacob, 283
 Scholes, Myron, 6n, 92, 131
 Nobel Prize, 92
 Schumpeter, Joseph Alois, 11, 189n
 Schur decomposition, 270, 271, 277, 476
 Schwartz, Eduardo S., 371
 science, 249, 345
 search, 8
 Sears, Roebuck & Co., 155
 secant method, 23
 secondary market, 3
 Securities Data Company, 3
 securitization, 3, 4
 mortgage, 416, 417, 423, 426
 security, 2
 coupon, 24
 discount, 17, 24
 riskless, 47, 49, 329, 354, 465, 472
 mean-variance analysis, *see* mean-variance
 analysis, riskless security
 security analysis, 479
 self-financing trading strategy, *see* trading strategy,
 self-financing
 selling hedge, *see* hedging, futures contract, selling
 hedge
 senior debt, *see* debt, senior
 sensitivity, 123–130
 Black–Scholes differential equation, 208
 convertible bond, 405
 interest rate, 295
 numerical techniques, 127–130
 Monte Carlo simulation, 267
 option, 123–130
 SEQUEL, 6n
 servicing spread, *see* mortgage-backed security,
 servicing spread
 settlement, 2
 settlement price, 161, 162
 Treasury bond futures, *see* Treasury bond futures,
 settlement price
 shape risk, *see* risk, shape
 Sharpe ratio, 465
 Sharpe, William F., 1, 121, 464, 465, 471, 479n
 Investments, 121
 short hedge, *see* hedging, futures contract, short
 hedge
 short rate, 46, 56, 60, 61, 111, 156, 329–331,
 345–348, 351, 359, 361, 372, 379, 411
 discount function, 321, 347
 interest rate model, *see* interest rate model, short
 rate
 volatility, 372, 384 *see* “short rate volatility”
 under various interest rate models
 short sale, 75–76, *see* commodity, short sale, *see*
 derivative, short sale, *see* stock, short sale
 Siegel, Andrew F., 326
 sigma (vega), 125
 Silicon Graphics, Inc., 71
 silver, 166
 simple interest, *see* interest rate, simple
 simulation, *see* Monte Carlo simulation
 single monthly mortality, 420, 432–436, 438, 448
 singular value, 272, 273
 singular value decomposition, 272–273, 282
 complexity, 272
 constrained least-squares problem, 276
 full-rank least-squares problem, 274
 rank-deficient least-squares problem, 274
 sinking fund, 17, 24, 414, *see* callable bond, sinking
 fund provision, *see* collateralized mortgage
 obligation, sinking fund, *see* corporate bond,
 sinking fund provision
 skewness, 64, 479
 Smith, Adam, 414
 Sobol’ sequence, *see* quasi-random sequence,
 Sobol’
 software, 7, 10
 bug, 2, 10n, 14
 cost, 4
 developer, xiv
 maintenance, 4
 reuse, 10
 World Wide Web, 5, 6, 480, 482
 sorting, 9, 10
 SPEC benchmark, 4
 Special Drawing Rights, 144
 specific risk, *see* risk, specific

620 Index

- specification error, 243, 284, *see* interest rate model, specification error, *see* option, pricing model, specification error
- spectral theorem (Schur decomposition), 270
- speculation, 155
- speculator, 148, 224, 225
- speed, 126
- spline, 268, 278–283
 B-spline, 282
 least-squares problem, 282
 basic spline function (B-spline), 282
 breakpoint, 278, 281, 282, 325
 cubic, 278–282, 325
 constrained least-squares problem, 281–282
 knot (breakpoint), 278
 natural, 279, 280
 “optimal” approximation, 280
 perturbation, 281
 quadratic, 325
 term structure fitting, *see* term structure fitting, spline
 tridiagonal system, *as*, 279, 280
 uniform spacing, 280
- split-fee option, 148
- spot exchange rate, *see* exchange rate, spot
- spot market, 143, 144, 155, 169, 224, 225, 297, 315, 479n
- spot price, 156, 158, 161, 162, 225, 226
 forward price, 167
 futures price, 162, 166, 170, 182, 221, 225–226
 correlation, 227
- spot rate, 46–52, 55, 57–59, 61, 478
 arbitrage, 323
 bootstrapping procedure, 47–49, 314, 322, 323
 certain economy, 53
 continuous compounding, 55–56, 111
 continuous time, 345, 347, 350, 361
 discount factor, 47, 52, 55, 56, 322, 323
 forward rate, *see* forward rate, future spot rate
 forward rate, *vs.*, *see* forward rate, spot rate, *vs.*
 instantaneous (short rate), 345
 simple compounding, 56
 volatility term structure, *see* term structure, yield volatility
 yield to maturity, *vs.*, *see* yield to maturity, spot rate, *vs.*
- spot rate curve, 46, 49–53, 56, 60–63, 202, 203, 278, 295, 326, 340, 346, 352, 355, 361, 406, 408, 446, 448, *see* term structure
 forward rate, 52–53, 56, 322, 347
- shape, 50, 53, 60, 373
 curvature, 278, 372, 373
 flat, 52, 59–62, 203, 412
 humped, 372
 interest rate model, *see* “term structure shape”
 under various interest rate models
 inverted, 50–53, 57, 59, 372
 normal, 50–52, 57, 59, 372
 slope, 278, 372, 373
- shift, *see* yield curve, shift
- unbiased expectations theory, *see* expectations theory, unbiased, spot rate curve
- spot yield curve (spot rate curve), 46
- spread, *see* bid–ask spread, *see* binomial interest rate tree, spread, *see* corporate bond, forward spread, *see* credit spread, *see* option-adjusted spread, *see* static spread, *see* term structure fitting, complications, bid–ask spread, *see* yield spread
- spreader, 225
- spreadsheet, xiv
- SQL, 5, 6n
- square-root process, 199–201, 364
 interest rate model, 201
 mean function, 201
 transformed from Ornstein–Uhlenbeck process, 199, 201
 variance function, 201
- stability, 251, 252, 274, 386
 condition, 251, 253
- Standard & Poor’s, 141, 466
- standard deviation, 64
 estimator, 64
 risk, *see* risk, standard deviation, *as*
 sample, 64, 257
- state contingent claim, 82, 83, 83n, 98, 99, 334, 386
 valuation, 83, 110
- state price, 334, 381, 495, *see* binomial state price tree
- static cash flow yield methodology, *see*
 fixed-income security with option features, valuation methodologies, static cash flow yield, *see* mortgage-backed security valuation methodologies, static cash flow yield
- static spread, 49, 54, 132, 339, 340, 406, 491, *see* mortgage-backed security, valuation methodologies, static spread, *see* option-adjusted spread, static spread, *vs.*
- statistics, 64, 65, 67, 74, 268, 273, 288
 inference, 64, 74, 268
 multivariate, 268
- stencil, 251, 252
- step function, 190, 278
- stochastic differential equation, 193, 195, 205, 249
 numerical techniques, 205
- stochastic integral, 190–193, 205
 Brownian motion, 190
 choice of intermediate point, 192
 Ito, *see* Ito integral
 Stratonovich, *see* Stratonovich stochastic integral
- stochastic optimization, 205
- stochastic process, 177–179, 205, 255, 284
 AR process, *see* autoregressive process
 ARCH process, *see* autoregressive conditional heteroskedastic process
 ARMA process, *see* autoregressive moving average process

- autocorrelation function, 287, *see* autoregressive conditional heteroskedastic process, autocorrelation function, *see* autoregressive process, autocorrelation function, *see* moving average process, autocorrelation function
 - Brownian motion, *see* Brownian motion
 - constant elasticity variance, *see* constant elasticity variance process
 - continuity, 191
 - continuous time, 177
 - correlated, 287
 - covariance function, *see* covariance function
 - diffusion, *see* diffusion process
 - discount, 181
 - martingale, 181, 182, 205
 - discrete time (time series), 177
 - ergodic, 284, 290, 291, 294
 - GARCH process, *see* generalized autoregressive conditional heteroskedastic process
 - Gaussian process, *see* Gaussian process
 - independent increments, 177, 179, 180
 - Ito, *see* Ito process
 - jump, 189n
 - lognormal diffusion, *see* lognormal diffusion
 - MA process, *see* moving average process
 - Markov, *see* Markov process
 - maximum likelihood estimator, 73
 - mean function, 177, 178, 184
 - money market account, *see* money market account, bank account process
 - nonanticipating, 190–193, 195
 - normal, 198, 376
 - Ornstein–Uhlenbeck, *see* Ornstein–Uhlenbeck process
 - random walk, *see* random walk
 - rate of return, *see* rate of return, stochastic process
 - realization (sample path), 177
 - sample path, 177, 186, 188, 284, 287
 - simple, 190–192
 - Ito integral, 191, 192, 195
 - square root, *see* square-root process
 - state, 177, 344
 - stationary, 178, 179, 287, 288, 290, 291, 294 *see* autoregressive conditional heteroskedastic process, stationarity, *see* autoregressive process, stationarity, *see* autoregressive moving average process, stationarity, *see* Brownian motion, stationarity, *see* central limit theorem, stationary stochastic process, *see* covariance function, stationary stochastic process, *see* moving average process, stationarity, *see* Ornstein–Uhlenbeck process, stationarity, *see* term structure, yield volatility, stationarity, *see* volatility stochastic, stationary
 - asymptotic distribution, 290
 - strictly, 177, 287
 - stationary increments, 177, 179
 - stationary independent increments, 184
 - uncorrelated, 287, 288, 291, 292
 - variation, *see* variation
 - vector, 196
 - white noise, *see* white noise
 - Wiener, *see* Wiener process
 - Wiener–Bachelier, *see* Wiener–Bachelier process
- stock, 2, 6n, 75, 77
 - common, 24
 - limited liability, 131
 - margin, 87
 - market, 2,
 - Crash of 1987, 479n
 - option features, 131–134, 136, 148
 - price, 478
 - continuous dividend yield, 211
 - correlation, 288
 - delta, 123
 - discreteness, 111
 - distribution, *see* rate of return, distribution expected, 107, 204
 - geometric Brownian motion, *see* geometric Brownian motion, stock price
 - logarithm, 285, 550
 - lognormal distribution, *see* lognormal distribution, stock price
 - model, 85, 92, 188, 199, 200, 203–204, 209, 211, 293
 - prediction, 97, 180, 470
 - random walk, *see* random walk, stock price
 - volatility, *see* volatility, stock
 - rate of return, *see* rate of return
 - replicated as call, 131, 148
 - short sale, 76, 79, 172, 459–461, 464
 - split, 78, 112, 135, 141, 404
 - stock index, 141, 165
 - adjustment factor, 141
 - correlation, 142
 - cost of carry, 166
 - dividend, 142
 - futures contract, 165
 - Ito process, 211
 - weighting methods, 141
 - capitalization-weighted, 141, 143, 245, 458
 - geometrically weighted, 141–143
 - price-weighted, 141, 143, 162, 245
 - stock index futures, 155, 165, 171, 304
 - dividend, *see* stock index, dividend, futures contract
 - hedging, *see* hedging, futures contract, stock index
 - history, 165
 - portfolio insurance, 468
 - valuation, 165
 - stock index futures option, 171–172
 - stock index option, vs., 171

622 Index

- stock index option, 1, 75, 90, 91, 141–143, 146, 171, 245
 - Black–Scholes option pricing model, *see* Black–Scholes option pricing model, stock index option
 - exchange-traded, 142
 - exercise, 142
 - exercise risk, 142
 - hedging, *see* hedging, index option
 - history, 142
 - put–call parity, *see* put–call parity, stock index option
 - size, 143
 - stock index futures option, *vs.*, *see* stock index futures option, stock index option, *vs.* valuation, 143
- stockholder, 132, 401, 402
 - bondholder, *vs.*, 133–134, 218
 - convertible bond, 136
- storage cost, 166, *see* commodity, storage cost, *see* futures contract, commodity, storage cost
- stratified sampling, *see* variance reduction, stratified sampling
- Stratonovich stochastic integral, 192
- stripped mortgage-backed security, 357, 415, 419, 422, 442, 443, 452, *see* collateralized mortgage obligation, strip, *see* mortgage pass-through, discount, synthetic, *see* mortgage pass-through, premium, synthetic agency
 - Fannie Mae, 422
 - Freddie Mac, 423
 - Trust 1 of Fannie Mae, 422
- cash flow, 422, 481
- collateral, 422
- interest-only, 357–359, 422, 437, 442–443, 452, 467
 - duration, 443
 - hedging, 443
 - nominal principal, 452
 - notional principal, 452
- prepayment, 442, 443
- principal-only, 357–358, 422, 437, 442–443, 457
 - duration, 442
 - hedging, 443
 - valuation, 437, 443, 447
 - binomial model, 357
- stripped Treasury security, 25, 322
 - liquidity, 322
 - quote, 401
- STRIPS, 25
- structured note, *see* note, structured
- subordinated debt, *see* debt, subordinated
- Sun Microsystems, Inc., 466, 482
- supercomputer, 4
- superfloater, *see* collateralized mortgage obligation, superfloater
- Sutch, Richard, 59
- swap, 155–156, 173, 406
 - bond, *see* bond swap
 - commodity, 173
 - counterparty, 173, 314
 - cross rate, *see* cross-rate swap
 - currency, *see* currency swap
 - default, 314
 - equity, *see* equity swap
 - interest rate, *see* interest rate swap
 - market, 173
 - market maker, 314
 - rate, *see* rate swap
- swap curve, 314
- swap option, *see* Treasury bond futures, swap option
- swaption, 318–319
 - Black model, *see* Black model, swaption
 - European, 318
 - fixed-income option, *as*, 318–319
 - forward rate, 319
 - interest rate cap, *vs.*, 319
 - payer, 318, 350
 - receiver, 318, 350
 - valuation, 294
- Sybase, Inc., 5
- synthetic security, 87, 94, 143, 317, 468
- systematic risk, *see* risk, systematic
- systems of nonlinear equations, 23–24
- T-bill, *see* Treasury bill
- T-bond, *see* Treasury bond
- T-note, *see* Treasury note
- Target Amortization Class bond, *see* collateralized mortgage obligation, TAC bond
- tax, 26, 322, 400, 402, *see* capital gain, tax, *see* term structure fitting, complications, tax
- Taylor, Stephen, 293
- technical analysis, 122n, 479
- term (bond, maturity), 63n
- term premium (liquidity premium), 58
- term structure, 45–47, *see* spot rate curve
 - credit spread, 54–55, 63
 - dynamics, 328, 375, 380, 388, 432, 546
 - binomial interest rate tree, 331–332, 335, 337
 - Cox–Ingersoll–Ross model, 367–369
 - Heath–Jarrow–Morton model, 393
 - Ho–Lee model, 377
 - forward rate volatility
 - Heath–Jarrow–Morton model, 388–391, 393, 394
 - Ritchken–Sankarasubramanian model, 395–396
- LIBOR, 300, 301
- model, *see* interest rate model
- theories, 51, 56–59
- yield volatility, 330, 344, 360, 381, 384, 398
 - affine model, 365
 - binomial interest rate tree, 334, 343–344
 - Black–Derman–Toy model, 380–381, 384
 - drift, 344, 388

- extended Cox–Ingersoll–Ross model, 388
- extended Vasicek model, 384, 388
- Heath–Jarrow–Morton model, 388
- historical, 330
- Ho–Lee model, 376, 378–380, 384
- Hull–White model, 392
- implied, 330
- interest rate option, 330
- stationarity, 388
- Vasicek model, 362
- term structure equation, 350–353, *see* expectations
 - theory, local, term structure equation, *see* finite-difference method, term structure equation, *see* fixed-income option, term structure equation, *see* futures price, term structure equation, *see* interest rate derivative security, term structure equation
- term structure fitting, 49, 321–322, 398
 - comparison, 327
 - complications, 49, 322
 - bid-ask spread, 327
 - incompleteness problem, 49, 321–323, 325
 - multiple cash flow problem, 49, 321, 323
 - tax, 321–322, 324
 - discount function, 321–323
 - exponential function, 321, 323–324
 - exponential spline, 327
 - McCulloch, 323–325
 - quadratic function, 324
 - forward rate curve, 321–322, 325, 326
 - consistency with interest rate model, 398
 - Nelson–Siegel, 326, 398
 - least squares, 323–324
 - linear interpolation, 322–323, 413
 - problems, 322
 - regression, 321
 - multiple regression, 324
 - polynomial regression, 324–327
 - spline, 325
 - popularity, 325
 - problems, 326–327
 - spot rate curve, 321–323
 - Bradley–Crane, 324–326
 - Elliott–Echols, 324–326
 - linear programming, 327
 - weighted least squares, 324
 - yield curve, 321–322
- term to maturity (bond, maturity), 32
- theory, 84, 328, 458
- theta, 124–125, 208
 - numerical, 128, 208
- theta-neutral, 232
- thrifts, 416, 418, 419, 432
- “tick”, 297
- Tilley, James A., 257
- time, 206
- time decay (theta), 124
- time line, 11, 51, 308, 427
- time series, 177, 284–294
 - financial, 284
 - parameter estimation, 284, 293, 371–372
 - prediction, 284, 288, 291
 - transformation, 285, 287
- time value, 352
- time value of money, 11–14, 88, 89
- Time Warner, Inc., 466
- timing option, *see* Treasury bond futures, timing option
- Tobin, James, 463, 464
- Tokyo Stock Exchange, 162
- total monetary return, 30
- total return (holding period return), 31n
- total sum of squares, 69, 70
- total variation, *see* variation, total
- Toy, William, 380
- traded security, 209, 220, 221, 350
 - bond, 220
 - interest rate, 220, 352
 - stock, 220, 222
 - volatility, 222
- trading strategy, 205, 288
 - Ito integral, 194–195
 - maturity strategy, 50, 57–59
 - rollover strategy, 51, 57–59, 181, 349
 - self-financing, 97, 195, 222, *see*
 - delta-neutral, delta hedge,
 - self-financing, *see* delta-neutral,
 - delta–gamma hedge, self-financing, *see* risk-neutral valuation, self-financing trading strategy
- transactions cost, 3, 85, 121, 205, 288, 464
 - continuous trading, 201, 232
 - continuous-time model, *see* continuous-time model, transactions cost
 - interest rate swap, *see* interest rate swap, transactions cost
 - proportional model, 201
- transistor, 4
- transition probability density function, 185, 200
- Treasury bill, 17, 24, 40, 48, 158, 167, 371
 - ask yield, 18, 401
 - duration, 298
 - par value, 17
 - quote, 17, 18, 297, 401
- Treasury bill futures, 295–298
 - arbitrage, 297–298
 - dollar discount, 297
 - duration, 297
 - Eurodollar futures, vs., *see* Eurodollar futures, Treasury bill futures, vs.
 - forward rate, *see* forward rate, Treasury bill futures
 - index price, 297, 299, 341
 - invoice price, 297–298, 341
 - quote, 295, 297, 341
 - tick size, 297

624 **Index**

- Treasury bill futures (*cont.*)
 tick value, 298
 valuation, 297–298, 341
 yield, 297
- Treasury bond, 24, 27, 31n
 callable, 31n, 414
 quote, 25, 401, 435
- Treasury bond futures, 155, 163, 296, 301–304
 accrued interest, 301–303
 basis point value, 303–304
 cheapest-to-deliver bond, 302–303
 correlation with bonds, 303
 delivery, 301, 302
 delivery option, 302, 303
 duration, 320
 Eurodollar futures, *vs.*, *see* Eurodollar futures,
 Treasury bond futures, *vs.*
 hedging, *see* hedging, futures contract, Treasury
 bond
 history, 301
 invoice price, 301, 302
 liquidity, 302
 quality option (cheapest-to-deliver bond), 302
 quote, 162, 301–302
 settlement price, 301, 302
 size, 301
 swap option (cheapest-to-deliver bond), 302
 tick size, 301
 tick value, 301
 timing option, 302
 valuation, 303
 wild card option, 302
- Treasury bond futures option, 168, 169, 310–311
 quote, 310
 tick size, 310
- Treasury Department (U.S.), 3, 25, 31n, 46,
 400, 418
- Treasury note, 24, 48
 quote, 25, 313, 401, 435
- Treasury note futures, 296, 301, 304
 delivery, 301
 delivery option, 304
- Treasury note futures option, 168, 310–311
 quote, 310
- Treasury option, *see* fixed-income option,
 Treasuries
- Treasury securities, 24, 28, 45, 47, 399–401, 414
 credit risk, *see* credit risk, Treasury securities
 current coupon, 45
 inflation-indexed, 400, 402, 414
 liquidity, 322
 market, 24
 size, 24, 400
 mortgage pass-through, *vs.*, *see* mortgage
 pass-through, Treasury securities, *vs.*
 mortgage-backed security, *vs.*, *see*
 mortgage-backed security, Treasury
 securities, *vs.*
 off-the-run, 45
 on-the-run, 45–47, 322, 327n, 406
 quote, 400, 401
 stripped, *see* stripped Treasury security
- Treasury yield option, *see* interest rate option,
 Treasury yields
- Treynor, Jack L., 1
- trinomial model, 234, 242–243, 248
 binomial interest rate model, *vs.*, *see* binomial
 model, interest rate process, trinomial
 model, *vs.*
 correlated, 245–246
 replication of option, *see* option, replicated as a
 portfolio of stocks and bonds, trinomial
 model
- trinomial tree algorithm, 398
 barrier option, 242–245, 248
 binomial tree algorithm, *vs.*, 244–245
 convergence, 244
 down-and-in, 244, 522–523
 down-and-out, 243, 244
 up-and-in, 244
 up-and-out, 244
- Black–Karasinski model, *see* Black–Karasinski
 model, trinomial tree
- constant elasticity variance process, *see*
 constant elasticity variance process,
 trinomial model
- continuous dividend yield, 244
- diagonal method, *see* diagonal method, trinomial
 model
- explicit method, *see* explicit method, trinomial
 tree algorithm
- extended, 244
- extended Vasicek model, *see* Vasicek model,
 extended, calibration
- Hull–White model, *see* Hull–White model,
 calibration
- twist risk, *see* risk, twist
- two-fund theorem, 461, 463
- UBS AG, 155
- Ulam, Stanislaw, 266
- uncorrelated random variables, 65, 73, 179, 271,
 274, 277, 459, 470, 471
- underdetermined system, 275, 323, *see* matrix,
 pseudoinverse, underdetermined system
- underlying asset, 75, 155
- underwriting, 3, 402
- unexplained variation, *see* variation, unexplained
- uniform distribution, 67, 256, 259
- unimodal function, 126
- Unix, 481
- up-and-in option, *see* barrier option, up-and-in
- up-and-out option, *see* barrier option,
 up-and-out
- utility function, 469, 472, 473, 479
- vacuum tube, 4
- value at risk, 31, 458, 474–479, 528

- delta approach, 475–476
- derivative, 475–476, 478, 479
- fixed-income security, 478–479
 - cash flow mapping, 478
- futures contract, 476
- geometric Brownian motion, 476
- historical simulation, 476
- Monte Carlo simulation, 476–478
 - principal component, 476–477
- problems, 474, 477–478
- stress test, 478
- variance-covariance approach, 475, 478
- Value Line Index, 91, 141, 142
- Value Line Stock Index futures, 165
- Vanguard 500 Index Fund, 479n
- variance, 64, 65
 - Brownian motion, *see* Brownian motion, variance
 - estimator, 64, 469
 - maximum likelihood estimator, 73
 - principal component, 271, 272
 - sample, 64, 72
- variance reduction, 256, 259–262, 267, 449
 - antithetic variates, 259–260, *see* average-rate option, arithmetic, antithetic variates, *see* Cox–Ingersoll–Ross model, discrete time, antithetic variates, *see* Vasicek model, discrete time, antithetic variates
 - conditioning, 261, *see* average-rate option, arithmetic, conditioning
 - control variates, 261–262, *see* average-rate option, arithmetic, control variates, *see* Monte Carlo simulation, option, control variates
 - problems, 262
 - importance sampling, 262
 - quasi-Monte Carlo method, *vs.*, 263
 - stratified sampling, 262
- variation, 187–188
 - explained (regression sum of squares), 70
 - quadratic, 187
 - total, 187
 - regression (total sum of squares), 70
 - unexplained (error sum of squares), 69
- Vasicek model, 361–365, 370, 371
 - autocorrelation, 538
 - bond price formula, 361–362
 - bond price process, 362
 - Cox–Ingersoll–Ross model, *vs.*, *see* Cox–Ingersoll–Ross model, Vasicek model, *vs.*
 - discrete time, 363–364, 369
 - antithetic variates, 368
 - duration, 362
 - empirical study, 361
 - extended, 384, 392, 396, 397
 - calibration, 384
 - fixed-income option, 384
 - forward rate process, 392
 - Hull–White model, *see* Hull–White model
 - multifactor, 397
 - problems, 388
 - short rate volatility, 384, 388
 - yield volatility term structure, *see* term structure, yield volatility, extended Vasicek model
- fixed-income option, 363
- forward rate process, 362
- Ho–Lee model, *vs.*, *see* Ho–Lee model, Vasicek model, *vs.*
- interest rate cap, 374
- liquidity premium, *see* liquidity premium, Vasicek model
- long rate, 362
- mean reversion, 361–363
- parameter estimation, 372
- short rate volatility, 362, 393
- term structure equation, 361, 362
- term structure shape, 362
- yield volatility term structure, *see* term structure, yield volatility, Vasicek model
- Vasicek, Oldrich, 327, 328, 361, 371
- vega, 125–126, 130, 229
 - numerical, 128
 - unimodality, 126
- vega-neutral, 232
- venture capital, 414
- very-large-scale-integrated circuit, 4
- Veterans Affairs, 416, 422
 - guarantee, 416, 417, 424
- Viner, Jacob, xiii
- Visio, xiv
- Visual Basic, xiv
- VLSI Technology, Inc., 71
- volatility, 83, 125, 126, 462
 - basis, *see* futures contract, basis, volatility
 - bond, *see* bond, price volatility
 - exchange rate, *see* exchange rate, volatility
 - implied, *see* American option, implied volatility, *see* Black–Scholes formula, volatility, implied, *see* term structure, yield volatility, implied
 - interest rate, *see* interest rate, volatility
 - mortgage-backed security, *see* mortgage-backed security, volatility
 - stochastic, 112, 199, 200, 204, 221–223, 291–293, 478, 524
 - ARCH process, *see* autoregressive conditional heteroskedastic process autoregressive model, *see* autoregressive process, volatility
 - average variance, 204
 - conditional variance, 291, 292
 - correlation, 222, 261
 - empirical study, 222
 - GARCH process, *see* generalized autoregressive conditional heteroskedastic process
 - jump process, 293

626 Index

- volatility (*cont.*)
 lognormal model, *see* lognormal distribution,
 stock price, volatility
 market price of risk, 222
 Monte Carlo simulation, 261, 267
 Ornstein–Uhlenbeck process, 222
 replication, 222
 risk premium, 222
 stationary, 291, 292
 stock, 99, 105, 405, 414, *see* Black-Scholes
 formula, volatility
 volatility structure, 330, *see* term structure, forward
 rate volatility, *see* term structure, yield
 volatility
- Wal-Mart Stores, Inc., 71, 154n, 466
 Wald martingale, 185, 186
Wall Street Journal, 17, 25, 79, 91, 142–145, 157, 163,
 168, 307, 311, 401, 402
 Wallace, Alfred Russel, 6n
 Walras, Leon, 189n
 warrant, 134–135, 153, 399
 binomial tree algorithm, 135
 Black-Scholes option pricing model, 135
 convertible bond, *see* convertible bond,
 valuation, warrant, as
 perpetual, 135
 wave equation, 207
 weighted average coupon, 436, 440–442,
 451, 452
 weighted average life, 439–440, 442, 444–446
 weighted average maturity, 435
 weighted average remaining maturity (weighted
 average maturity), 450n
 Weil, Roman L., 63
 white noise, 287, 288
 Gaussian, 287, 290–292
 strict, 287–288
 White, Alan, 150, 222, 384
 whole loan, *see* mortgage, whole loan
 Wiener process, 184–188, 190, 221, 259
 correlation, 196, 197, 200, 214, 217, 222,
 371, 476
 generalized (Brownian motion), 184
 Ornstein–Uhlenbeck process, *see*
 Ornstein–Uhlenbeck process, Wiener
 process transformed
 Wiener theorem, 184
 Wiener, Norbert, 184
 Wiener–Bachelier process (Wiener process), 184
 wild card option, *see* Treasury bond futures, wild
 card option
 Wilshire 5000 Index, 90
 Wilshire Small Cap Index, 142
 Windows NT, 5
 wing, 82
 Wold decomposition, 290, 293
 Wold, Herman, 293
 workstation, 4, 12
- World Wide Web, 5, 6, 12, 480, 482–483
 browser, 5, 6, 480–482
 option, *see* option, World Wide Web
 server, 5
 software, *see* software, World Wide Web
- Yankee bond, 24
- yield, 17–19, 31, 47
 bank discount basis (discount rate), 17
 bond equivalent, 11, 18, 401
 day count, 313
 cash flow, 406, *see* static cash flow yield
 methodology
 CD-equivalent, 18
 current, 17
 discount (discount rate), 17
 holding period, *see* holding period yield
 money-market-equivalent (CD-equivalent), 18
 mortgage equivalent, 11
 nominal, 17
 numerical techniques, 18, 20–23
 option-adjusted, *see* option-adjusted yield
 portfolio, 30
 volatility, *see* interest rate, volatility
 yield beta, *see* beta, yield
 yield curve, 44–46, 50–52, 60, 61, 63n, 321, 372
 benchmark, *see* benchmark yield curve
 fitting, *see* term structure fitting, yield curve
 Japan, 327
 off-the-run, 45
 on-the-run, 45, 330, 450
 par, 45, 322, 323
 shape, 45, 50, 326, 407
 flat, 45, 46, 50
 flattening, 60, 307, 318, 406
 humped, 45
 inverted, 45, 46, 50, 51
 inverted-humped, 371
 normal, 45, 46, 50, 51, 57, 59
 steepening, 60
 shift, *see* custom shift, *see* nonproportional shift,
see parallel shift, *see* proportional shift
 factors, 61, 277–278, 372, 373, 478
 Treasuries, 45, 46
 yield curve option, 310, 372
 yield spread option, 365
 yield spread, 27, 46, 49, 339, 340, 365, 406, 407, 412,
 446, option-adjusted spread, vs.,
 option-adjusted spread, vs., 412
 yield to call, 26, 406
 yield to effective maturity, 26
 yield to maturity, 26, 29, 30, 45, 46, 49, 50, 132,
 322, 412
 forward rate, 54
 geometric Brownian motion, 360
 lognormal distribution, *see* lognormal
 distribution, yield to maturity
 problems, 30, 46, 50
 spot rate, vs., 47, 50

- yield to par call, 26, 406
- yield to stated maturity, 26
- yield to worst, 26, 406

- zero (zero-coupon bond), 25
- zero-coupon bond, 25, 34, 46, 48, 50, 52, 84, 85, 159, 201, 350
 - convexity, 43
 - discount function, 47, 331
 - duration, 36
 - immunization, *see* immunization, zero-coupon bond
 - option features, 131–134
 - valuation, *see* “bond price formula” under various interest rate models
 - volatility, 26, 32
- zero-coupon yield curve (spot rate curve), 46