

Index

References to figures are given in **bold** type. References to tables are given in *italic* type.

- ACF *see* autocorrelation functions
- adaptive lasso, 48, 50, 51
- anti-monotone sets, 208
- AR(1) process
 - Eigen subspace, 70, 91–2
 - KLT kernel derivation, 79–82
 - orthogonal subspace, 69–71
 - Karhunen-Loeve transform, 70–1
 - performance matrices, 71
 - power spectral density, 78
 - stochastic signal model, 68
- arbitrage, 3
- ARCH model, 141
 - nonparametric tests, 173–4
 - parametric tests, 172–3
- Archimedean copula, 181, 182
- assets, mean-reverting, 23–4
- autocorrelation functions (ACF), 164–5
 - Kendall's tau, 166–7, 169
 - misspecification testing
 - conditional heteroscedasticity, 171–2
 - Ljung-Box, 171
 - Spearman's rho, 168–9, 169–71
- autocovariance, 164
- autoregressive conditional heteroscedasticity (ARCH), 141
- backward simulation (BS), 222–7
- BEKK Garch model, 175
- bias, 267
- BIC criterion, 50
- bid-ask price, 4
- big data finance, 2
- Black-Scholes model, 136–7, 203
- BS method, 203
- capital market line, 12
- causal strength modeling, 42
- causal strength modeling (CSM), 51–2
- CDVine, 185
- CLIME, 110, 111
- co-monotone sets, 208
- coherent risk measure, 260
- cointegration-based trading strategies, 23
- collateralized debt obligation (CDO), 279
- conditional sparsity, 102
- conditional value at risk (CVaR), 233, 234–42
 - minimization, 240–2, 263
 - support vector machines, 247–52

- conditional value at risk
 - (CVaR) (*continued*)
 - portfolio selection, 241–2
 - as risk measure, 263
 - robust optimization, 259–61
 - under finite scenarios, 236–8
 - under normal distribution, 235
- constant relative risk aversion (CRRA), 159
- constant shift insensitivity, 269
- contract asymptotics, 141–2
- convex relaxation, 16
- copula modeling, 1, 179–85
 - Archimedean, 181, 182
 - multiple variables, 183–5
 - parametric, 181–3
 - product copula, 181
 - software, 185
- copula (software), 185
- correlation measures, 164–5
 - copulas, 179–85
 - fitting, 180–1
 - dependence types, 185–6
 - positive and negative, 185–6
 - tail, 187–8
- Granger causality, 176–8
- Huber-type, 166
- Kendall's tau, 166–7
- misspecification testing
 - ARCH effects, 172–4
 - Ljung-Box, 171
 - multivariate, 176
- multiple variables, 183–5
- Spearman's rho, 168–9, 179, 182
- covariance matrix estimation, 100–2
 - factor analysis, 100–8
 - asymptotic results, 105–7
 - example, 107–8
 - threshold, 105
 - unknown factors, 104–5
 - pure factor models, 126–7
 - optimal weight matrix, 129–30
- covariance selection, 109
- credit default swaps, 279
- CRSP database, 124–6
- CVar *see* conditional value at risk
- Dantzig selector, 111
- dependence, 185–7
- deviation, 270
- Dirichlet distribution, 58
- discrete cosine transform (DCT), 67, 71, 72
- discrete Fourier transform (DFT), 67
- domain description, 245–6
- dynamic programming equation, 155–6
- efficient frontier, 12
- efficient market hypothesis (EMH), 3
- Eigen decomposition *see* principal components analysis
- EJD algorithm, 215, 219–20
- error decomposition, 274
- error measures, 269
- error projection, 269
- essential infimum, 268
- essential supremum, 268
- estimator's breakdown point, 284–5
- ETF *see* exchange-traded funds
- Ev-SVC, 248–9
- exchange-traded funds, 42
- expectation-maximization, 57
- expected shortfall, 263
- extreme joint distribution (EJD) algorithm, 215, 219–20
- factor analysis, 100, 100–8, 120
 - covariance matrix estimation
 - asymptotic results, 105–6
 - threshold, 105
 - unknown factors, 104
- factor-pricing model, 121–2
- fallout, 286
- Fama-French model, 107–8
- fixed income instruments, 9
- fixed strike price, 136
- fixed transforms, 67
- Frank copula, 182
- Frechet-Hoeffding theorem, 215–17
- Fused-DBN, 62, **63**
- GARCH model, 141, 172–4
 - BEKK GARCH model, 175
 - VECH GARCH, 175

- Gauss-Markov theorem, 268
- Gaussian copula, 181
- genomic networks, 118–19
- GICS, 115–16
- Global Financial Crisis, 43
- Global Industry Classification Standard (GICS), 115–16
- global minimum variance portfolio, 120–1
- Granger causality, 46–7, 176–7
 - nonlinear, 177–9
- graphical Dantzig selector, 110
- Green's function, 143
- group lasso, 20, 47
- group OMP, 49, 51–2
- H-J test, 178
- high-density region estimation, 245–6
- high-frequency trading, 9
- hinge loss, 244
- Huber-type correlations, 166
- implied volatility asymptotics, 143–5
- implied volatility skew, 136
- index tracking, 19
- inference function for margins (IFM)
 - method, 180
- intensity randomization, 196–7
- intercept, 267
- interior point (IP), 53
- interior point (IP method), 53
- inverse projection, 270
- investment risk, 2
- iShares, 53–5
- Japan, 43, 55
- jump-diffusion processes, 191–2
- Karhunen-Loeve transform (KLT), 67–8
 - kernel derivation, 72–9
 - continuous process with exponential autocorrelation, 74–6
 - eigenanalysis of discrete AR(1) process, 76–7
 - fast derivation, 79–82
 - NASDAQ-100 index, 93–7
 - subspace sparsity, 82–4
 - pdf-optimized midtread reader, 84–6
 - see also* principal components analysis
- Karhunen-Loeve expansion, 76
- Kendall's tau, 166–7, 169, 179, 182
- kernel trick, 242
- Kolmogorov backward equation (KBE), 172
- Landweber's iteration, 15
- lasso regression, 17, 46, 252
 - adaptive, 47, 48, 50, 51
 - group, 47, 48, 57
 - SQRT, 112–13
- least absolute deviation (LAD), 53
- least median of squares (LMS) regression, 285
- least-squares methods, 14, 268
 - ordinary least squares, 103, 251
 - POET and, 104
 - regularized, 48
 - temporal causal modeling, 48
- least-trimmed-squares (LTS) regression, 285
- leverage effect, 140
- Lévy kernel, 150–1
- linear regression, 283–4
- liquidity, 4
- Ljung-Box test, 171
- local volatility models, 139
- local-stochastic volatility (LSV) models, 140–1, 146–8, 155–7
 - Heston, 148–50, 149
 - Lévy-type, 150–2
- market incompleteness, 139
- market microstructure, 4–5
- market price of risk, 153
- market risk *see* investment risk
- Markov-switched TCM, 60–4
- Markowitz bullet, 12
- Markowitz portfolio selection, 1, 3
 - elastic net strategy, 19
 - as inverse problem, 13–15
 - portfolio description, 11–13
 - as regression problem, 13
 - sparse, 15–17

- Markowitz portfolio selection (*continued*)
 - empirical validation, 17–18
 - optimal forecast combination, 20–1
 - portfolio rebalancing, 18
 - portfolio replication, 19
 - see also* sparse Markowitz portfolios
- matrix deflation, 30
- maximum a posteriori (MAP) modeling, 56, 58–9
- mean-absolute deviation, 277–8, 279
- mean-reverting portfolios, 24, 29
 - crossing statistics, 28, 31
 - mean-reversion proxies, 25–6
 - numerical experiments, 32–9
 - basket estimators, 33
 - historical data, 32–3
 - Jurek and Yang strategy, 33, 36, 37
 - Sharpe ratio robustness, 36–7
 - tradeoffs, 38–9, 38
 - transaction costs, 33–4
- optimal baskets, 28–9
- portmanteau criterion, 27–8, 29, 31
- predictability
 - multivariate case, 26–7
 - univariate case, 26
- semidefinite relaxations, 30–1
 - portmanteau, 31
 - predictability, 30–1
- volatility and sparsity, 24–5
- mean-variance efficiency, 122
- Merton problem, 155–60
- mevalonate (MVA) pathway, 118
- misspecification testing
 - ARCH/GARCH, 172–4
 - Ljung-Box test, 171
 - multivariate, 176
- model asymptotics, 142
- monotone distributions, 208–14, 238–9
- mortgage pipeline risk, 286
- MSCI Japan Index, 42
- NASDAQ-100, 93–7
- negative dependence, 185–6
- news analysis, 9
- Newton method, 53
- no-arbitrage pricing, 139
- no-short portfolios, 16–17
- nonnegative space PCA, 83
- nonnegative sparse PCA, 83
- optimal order execution, 9
- optimized certainty equivalent (OCE), 264
- option pricing
 - asymptotic expansions, 141–2
 - contract, 142
 - implied volatility, 143–5
 - model, 142–3
 - model coefficient expansions, 146–50
 - model tractability, 145–6
- Oracle property, 48
- ordinary least square (OLS), 103, 251
- Ornstein–Uhlenbeck (OU) process, 68
- orthogonal patching pursuit (OMP), 49, 51–2, 54
- outlier detection, 245–6
- panel data models, 127–9
- partial integro-differential equation (PIDE), 141
- Pearson correlation coefficient, 162
- penalized matrix decomposition, 83
- penalties relative to expectation, 269
- pension funds, 9
- perturbation theory, 142–3
- POET, 104, 120–1
- Poisson processes, 193–6
 - backward simulation (BS), 222–7
 - common shock model, 196
 - extreme joint distributions, 207–19
 - approximation, 217–19
 - Frechet-Hoeffding theorem, 215–17
 - monotone, 208–14
 - optimization problem, 207–8
 - intensity randomization, 196–7
 - numerical results, 219–22
 - simulation
 - backward, 200–6
 - forward, 197–9
 - model calibration, 206
- Poisson random vectors, 205
- Poisson-Wiener process, 222–7
- portfolio manager, 2

- portfolio optimization, 3
 - 1=N puzzle, 13
 - Markowitz, 11–12
- portfolio rebalancing, 18–19
- portfolio risk estimation, 119–21
- positive dependence, 185–6
- positive homogeneity, 239
- power enhancement test, 123–4
- precision matrix estimation, 109–10
 - applications, 115–17
 - column-wise, 110–11
 - portfolio risk assessment, 119–26
 - TIGER, 112–14
 - application, 115–17
 - computation, 114
 - genomic network application, 118–19
 - theoretical properties, 114–15
 - tuning-insensitive procedures, 111–12
- price inefficiency, 3
- principal components analysis (PCA), 34
- principal orthogonal complement, 104
- principal orthogonal complement
 - thresholding (POET) estimator, 104
- principal components analysis (PCA),
 - 36–7, 67, 126
 - discrete autoregressive (AR(1)) model, 68–70
 - fast kernel derivation, 79–82
 - Eigen subspace, 70–1, 91–2
 - Eigen subspace sparsity, 82–3
 - KLT kernel
 - continuous process with exponential autocorrelation, 74
 - eigenanalysis of a discrete AR(1) process, 76–9
- orthogonal subspace, 69–72
 - Eigen subspace, 70–2
 - performance metrics, 71
- pure factor models, 126–7
- sparse methods, 83–4
 - AR(1), 89–91
 - Eigen subspace quantization, 86
 - Eigenvector pdf, 87–9
 - pdf-optimized midtread quantizer, 84–6
 - performance, 91–3
- pulse code modulation (PCM), 71
- pure factor model, 130
- Q-TCM, 52
- quadratic penalty, 14
- quantile regression, 251
- quantile TCM, 52–5, 54–5
- quasi–Monte Carlo (QMC) algorithms, 203
- reduced convex hulls, 257, 258
- regressant, 267
- regression analysis, 267–8
 - CVar-based, 251–3
 - error decomposition, 273–4
 - error and deviation measures, 268–71
 - lasso *see* lasso regression
 - least-squares, regularized, 48
 - least-squares methods, 275–7
 - linear regression, 283–4
 - median regression, 277–81
 - ordinary least squares, 251
 - quantile regression, 281–3
 - risk envelopes and identifiers, 271–3
 - robust, 284–6
 - support vector regression, 246–7
- regressors, 267
- return on investment (ROI), 2–3
- ridge regression, 251
- risk acceptable linear regression, 284
- risk envelopes, 271–3
- risk inference, 121
- risk preferences, 268
- risk quadrangle, 264
- risk-neutrality, 139
- risk-normalized return, 2–3
- robust optimization, distributional, 259–61
- robust regression, 284–6
- SCoTLASS, 83
- SDP *see* semidefinite programs
- SDP relaxations for sparse PCA (DSPCA), 83
- securities, 4, 11, 135
- securities markets, 4
- semidefinite programs, 30
 - relaxation tightness, 31–2

- Sharpe ratio, 2–3, 36–7
 - transaction costs and, 38–9
- Sherman-Morrison-Woodbury formula, 103
- shift operator, 145
- shortselling, 3
- signal-to-quantization-noise ratio (SQNR), 85
- Sklar's theorem, 179–80
- soft convex hulls, 257
- soft thresholding, 84
- sparse KLT, 89–91
- sparse Markowitz portfolios, 15–17
 - empirical validation, 17–18
 - portfolio rebalancing, 18–19
- sparse modeling, 5–6
- sparse PCA via regularized SVD (sPCA–rSVD), 83
- sparse vector autoregressive (VAR) models, 42
- Spearman's rho, 168–9, 169–70, 179, 182
- SQRT-lasso, 112–13
- stationary sequences, 165
- statistical approximation theory, 268
- statistical arbitrage, 3
- stochastic volatility, 1, 135
 - Black-Scholes model, 136–7
 - dynamic programmic equation, 155–7
 - implied volatility, 137
 - local volatility models, 139–40
 - Merton problem, 155–60
 - separation of timescales approach, 152–3
 - stochastic volatility models, 140
 - local (LSV), 140–1
 - with jumps, 141
 - volatility modeling, 137–41
 - volatility of volatility, 152
- stock exchanges, 4
- stock return analysis, 62–3, 64
- Strong Law of Large Numbers, 192, 212
- support vector machines (SVM), 233–4, 263
 - classification, 242–3
 - C-support, 243–4
 - duality, 256–9
 - soft-margin, 244–5
 - ν -SVM, 247
 - geometric interpretation, 257–9
 - support vector regression (SVR), 246–7
- Survey of Professional Forecasters (SPF), 21
- Switzerland, 43
- tail dependence, 187–8
- tail VaR, 263
- temporal causal modeling (TCM), 42, 44–5
 - algorithmi overview, 47
 - Bayesian group lasso, 57–8
 - extensions
 - causal strength modeling, 51–2
 - quantile TCM, 52–5
 - Granger causality and, 46–7
 - grouped method, 47–9
 - greedy, 49
 - regularized least-squares, 48
 - Markov switching model, 56–7
 - stock return analysis, 62–3
 - synthetic experiments, 60–2
 - maximum a posteriori (MAP) modeling, 58–9
 - quantile TCM, 54–5
 - regime change identification, 55–63
 - algorithm, 58–60
 - synthetic experiments, 49–50, 60–2
 - data generation, 49–50, 60–1
- TIGER, 112–14
 - computation, 114
- Tikhonov regularization, 14
- time series, 165
- Tobin two-fund separation theorem, 12
- transcendental equations, 73–4
- transform coding, 71
- translation invariance, 239
- truncated singular value decomposition (TSVD), 15
- tuning-insensitivity, 113
- TV-DBN, 61, 62
- two-tailed [alpha]-value-at-risk (VaR) deviation, 286
- unbiased linear regression, 283–4

- v-property, 253–5
- ν -SVM, 257–8
- ν -SVR, 247, 251–2
- value function, 156
- value-at-risk, 234
- Vapnik–Chervonenkis theory, 243
- VECH GARCH model, 175
- vector autoregression (VAR), 25, 49–50, 61, 174
 - multivariate volatility, 175–6
 - temporal causal modeling, 57–8, 61–2
- VineCopula, 185
- volatility, 38–9
- volatility of volatility modeling, 152
- Wald test, 122–3
- weighted principal components (WPC), 127, 130–1
- Yahoo! Finance, 115–17
- zero crossing rate, 28