

# Subject index

- abc.ci, 536
- ABC method, *see* confidence interval
- Abelson-Tukey coefficients, 403
- accelerated life test example, 346, 379
- adaptive estimation, 120–123, 125, 133
- adaptive test, 173–174, 184, 187, 188
- aggregate prediction error, 290–301, 316, 320–321, 358–362
- AIDS data example, 1, 342, 369
- air conditioning data example, 4, 15, 17, 19, 25, 27, 30, 33, 36, 149, 188, 197, 199, 203, 205, 207, 209, 216, 217, 233, 501, 508–512
- Akaike's information criterion, 316, 394, 432
- algorithms
  - K*-fold adjusted cross-validation, 295
  - balanced bootstrap, 439, 488
  - balanced importance resampling, 460, 491
  - Bayesian bootstrap, 513
  - case resampling in regression, 264
  - comparison of generalized linear and generalized additive models, 367
  - conditional bootstrap for censored data, 84
  - conditional resampling for censored survival data, 351
  - double bootstrap for bias adjustment, 104
  - inhomogeneous Poisson process, 431
  - model-based resampling in linear regression, 262
  - phase scrambling, 408
  - prediction in generalized linear models, 341
  - prediction in linear regression, 285
  - resampling errors with unequal variances, 271
  - resampling for censored survival data, 351
  - stationary bootstrap, 428
  - superpopulation bootstrap, 94
  - all-subsamples method, 57
  - AML data example, 83, 86, 146, 160, 187, 221
  - analysis of deviance, 330–331, 367–369
  - ancillary statistics, 43, 238, 241
  - antithetic bootstrap, 493
  - apparent error, 292
  - assessment set, 292
  - autocorrelation, 386, 431
  - autoregressive process, 386, 388, 389, 392, 395, 398, 399, 400, 401, 410, 414, 432, 433, 434
  - simulation, 390–391
  - autoregressive-moving average process, 386, 408
  - average, 4, 8, 13, 15, 17, 19, 22, 25, 27, 30, 33, 36, 47, 51, 88, 90, 92, 94, 98, 129, 130, 197, 199, 203, 205, 207, 209, 216, 251, 501, 508, 512, 513, 516, 518, 520
  - comparison of several, 163
  - comparison of two, 159, 162, 166, 171, 172, 186, 454, 457, 519
  - finite population, 94, 98, 129
- Bayesian bootstrap, 512–514, 515, 518, 520
- $BC_a$  method, *see* confidence interval
- beaver data example, 434
- bias correction, 103–107
- bias estimator, 16–18
  - adjusted, 104, 106–107, 130, 442, 464, 466, 492
  - balanced resampling, 440
  - bias of, 103
  - post-simulation balance, 488
  - sensitivity analysis for, 114, 117
- binary data, 78, 359–362, 376, 377, 378
- binomial data, 338
- binomial process, 416
- bivariate distribution, 78, 90–92, 128
- block resampling, 396–408, 427, 428, 432
- boot, 525
  - ..., 528, 538, 548
  - 'balanced', 545
  - m, 538
  - mle, 528, 538, 540, 543
  - 'parametric', 534
  - ran.gen, 528, 538, 540, 543
  - sim, 529, 534
  - statistic, 527, 528
  - strata, 531
  - stype, 527
  - weights, 527, 536, 546
- boot.array, 526
- boot.ci, 536
- bootstrap
  - adjustment, 103–107, 125, 130, 175–180, 223–230
  - antithetic, 487, 493
  - asymptotic accuracy, 39–41, 211–214
  - balanced, 438–446, 486, 494–499
    - algorithm, 439, 488
    - bias estimate, 438–440, 488
    - conditions for success, 445
    - efficiency, 445, 460, 461, 495
    - experimental design, 441, 486, 489
    - first-order, 439, 486, 487–488

- higher-order, 441, 486, 489
- theory, 443–445, 487
- balanced importance resampling, 460–463, 486, 496
- Bayesian, 512–514, 515, 518, 520
- block, 396–408, 427, 428, 433
- calibration, 246
- case resampling, 84
- consistency, 37–39
- conditional, 84, 124, 132, 351, 374, 474
- discreteness 27, 61
- double 103–113, 122, 125, 130, 175–180, 223–230, 254, 373, 463–466, 469, 486, 497, 507–509
  - theory for, 105–107, 125
- generalized, 56
- hierarchical, 100–102, 125, 130, 288
- imputation, 89–92, 124–125
- jittered, 124
- mirror-match, 93, 125, 129
- model-based, 349, 433, 434
- nested, *see* double
- nonparametric, 22
- parametric, 15–21, 261, 333, 334, 339, 344, 347, 373, 378, 379, 416, 528, 534
- population, 94, 125, 129
- post-blackened, 397, 399, 433
- post-simulation balance, 441–445, 486, 488, 495
- quantile, 18–21, 36, 69, 441, 442, 448–450, 453–456, 457–463, 468, 490
- recycling, 463–466, 486, 492, 496
- robustness, 264
- shrunk smoothed, 79, 81, 127
- simulation size, 17–21, 34–37, 69, 155–156, 178–180, 183, 185, 202, 226, 246, 248
- smoothed, 79–81, 124, 127, 168, 169, 310, 418, 431, 531
- spectral, 412–415, 427, 430
- stationary, 398–408, 427, 428–429, 433
- stratified, 89, 90, 306, 340, 344, 365, 371, 457, 494, 531
- superpopulation, 94, 125, 129
- symmetrized, 78, 122, 169, 471, 485
- tile, 424–426, 428, 432
- tilted, 166–167, 452–456, 459, 462, 546–547
- weighted, 60, 514, 516
- weird, 86–87, 124, 128, 132
- wild, 272–273, 316, 319, 538
- bootstrap diagnostics, 113–120, 125
  - bias function, 108, 110, 464–465
  - jackknife-after-bootstrap, 113–118, 532
  - linearity, 118–120
  - variance function, 107–111, 464–465
- bootstrap frequencies, 22–23, 66, 76, 110–111, 438–445, 464, 526, 527
- bootstrap likelihood, 507–509, 515, 517, 518
- bootstrap recycling, 463–466, 487, 492, 497, 508
- bootstrap test, *see* significance test
- Box-Cox transformation, 118
- brambles data example, 422
- Breslow estimator, 350
- calcium uptake data example, 355, 441, 442
- capability index example, 248, 253, 497
- carbon monoxide data, 67
- cats data example, 321
- caveolae data example, 416, 425
- CD4 data example, 68, 134, 190, 251, 252, 254
- cement data example, 277
- censboot, 532, 541
- censored data, 82–87, 124, 128, 131, 160, 346–353, 514, 532, 541
- changepoint model, 241
- Channing House data example, 131
- choice of estimator, 120–123, 125, 134
- choice of predictor, 301–305
- choice of test statistic, 173, 180, 184, 187
- circular data, 126, 517, 520
- city population data example, 6, 13, 22, 30, 49, 52, 53, 54, 66, 95, 108, 110, 113, 118, 201, 238, 249, 440, 447, 464, 473, 490, 492, 513
- Claridge data example, 157, 158, 496
- cloth data example, 382
- coal-mining data example, 435
- collinearity, 276–278
- complementary set partitions, 552, 554
- complete enumeration, 27, 60, 438, 440, 486
- conditional inference, 43, 138, 145, 238–243, 247, 251
- confidence band, 375, 417, 420, 435
- confidence interval
  - $ABC$ , 214–220, 231, 246, 511, 536
  - $BC_a$ , 203–213, 246, 249, 336–337, 383, 536
  - basic bootstrap, 28–29, 194–195, 199, 213–214, 337, 365, 374, 383, 435
  - coefficient, 191
  - comparison of methods, 211–214, 230–233, 246, 336–338
  - conditional, 238–243, 247, 251
  - double bootstrap, 223–230, 250, 254, 374, 469
  - normal approximation, 14, 194, 198, 337, 374, 383, 435
  - percentile method, 202–203, 213–214, 336–337, 352, 383
  - profile likelihood, 196, 346
  - studentized bootstrap, 29–31, 95, 125, 194–196, 199, 212, 227–228, 231, 233, 246, 248, 250, 336–337, 391, 449, 454, 483–485
  - test inversion, 220–223, 246
- confidence limits, 193
- confidence region, 192, 231–237, 504–506
- consistency, 13
- contingency table, 177, 183, 184, 342
- control, 545
- control methods, 446–450, 486
  - bias estimation, 446–448, 496
  - efficiency, 447, 448, 450, 462
  - importance resampling weight, 456

- linear approximation, 446, 486, 495
- quantile estimation, 446–450, 461–463, 486, 495–496
- saddlepoint approximation, 449
- variance estimation, 446–448, 495
- Cornish-Fisher expansion, 40, 211, 449
- correlation estimate, 48, 61, 63, 68, 69, 80, 90–92, 108, 115–116, 134, 138, 157, 158, 247, 251, 254, 266, 475, 493
- correlogram, 386, 389
  - partial, 386, 389
- coverage process, 428
- cross-validation, 153, 292–295, 296–301, 303, 305–307, 316, 320, 321, 324, 360–361, 365, 377, 381
- K*-fold, 294–295, 316, 320, 324, 360–361, 381
- cumulant-generating function, 66, 466, 467, 472, 479, 551–553
  - approximate, 476–478, 482, 492
  - paired comparison test, 492
- cumulants, 551–553
  - approximate, 476
  - generalized, 552
- cumulative hazard function, 82, 83, 86, 350
- Darwin data example, 186, 188, 471, 481, 498
- defensive mixture distribution, 457–459, 462, 464, 486, 496
- delivery suite data example, 300
- delta method, 45–46, 195, 227, 233, 419, 432, *see also* nonparametric delta method
- density estimate, *see* kernel density estimate
- deviance, 330–331, 332, 335, 367–369, 370, 373, 378, 382
- deviance residuals, *see* regression residuals
- diagnostics, *see* bootstrap diagnostics
- difference of means, *see* average, comparison of two
- directional data, 126, 234, 505, 515, 517, 520
- dirty data, 44
- discreteness effects, 26–27, 61
- dispersion parameter, 327, 328, 331, 339, *see also* overdispersion
- distribution
  - F*, 331, 368
  - t*, 81, 331, 484
  - Bernoulli, 376, 378, 381, 474, 475
  - beta, 187, 248, 377
  - beta-binomial, 338, 377
  - binomial, 86, 128, 327, 333, 338, 377
  - bivariate normal, 63, 80, 91, 108, 128
  - Cauchy, 42, 81
  - chi-squared, 139, 142, 163, 233, 234, 237, 303, 330, 335, 368, 373, 378, 382, 484, 500, 501, 503, 504, 505, 506
  - defensive mixture, *see* defensive mixture distribution
  - Dirichlet, 513, 518
  - double exponential, 516
  - empirical, *see* empirical distribution function, empirical exponential family
  - exponential, 4, 81, 82, 130, 132, 176, 188, 197, 203, 205, 224, 249, 328, 334, 336, 430, 491, 503, 521
  - exponential family, 504–507, 516
  - gamma, 5, 131, 149, 207, 216, 230, 233, 247, 328, 332, 334, 376, 503, 512, 513, 521
  - geometric, 398, 428
  - hypergeometric, 444, 487
  - least-favourable, 206, 209
  - lognormal, 66, 149, 336
  - multinomial, 66, 111, 129, 443, 446, 452, 468, 473, 491, 492, 493, 501, 502, 517, 519
  - multivariate normal, 445, 552
  - negative binomial, 337, 344, 345, 371
  - normal, 10, 150, 152, 154, 208, 244, 327, 485, 488, 489, 518, 551
  - Poisson, 327, 332, 333, 337, 342, 344, 345, 370, 378, 382, 383, 416, 419, 431, 473, 474, 493, 516
  - posterior, *see* posterior distribution
  - prior, *see* prior distribution
  - slash, 485
  - tilted, *see* exponential tilting
  - Weibull, 346, 379
- dogs data example, 187
- Downs' syndrome data example, 371
- ducks data example, 134
- Edgeworth expansion, 39–41, 60, 408, 476–477
- EEF.profile, 550
- eigenvalue example, 64, 134, 252, 278, 445, 447
- eigenvector, 505
- EL.profile, 550
- empinf, 530
- empirical Bayes, 125
- empirical distribution function, 11–12, 60–61, 128, 501, 508
  - as model, 108
  - marginal, 267
  - missing data, 89–91
  - residuals, 77, 181, 261
  - several, 71, 75
  - smoothed, 79–81, 127, 169, 227, 228
  - symmetrized, 78, 122, 165, 169, 228, 251
  - tilted, 166–167, 183, 209–210, 452–456, 459, 504
- empirical exponential family
  - likelihood, 504–506, 515, 516, 520
- empirical influence values, 46–47, 49, 51–53, 54, 63, 64, 65, 75, 209, 210, 452, 461, 462, 476, 517
- generalized linear models, 376
- linear regression, 260, 275, 317
- numerical approximation of, 47, 51–53, 76
- several samples, 75, 127, 210
  - see also* influence values
- empirical likelihood, 500–504, 509, 512, 514–515, 516, 517, 519, 520
- empirical likelihood ratio statistic, 501, 503, 506, 515
- envelope test, *see* graphical test

- equal marginal distributions example, 78
- error rate, 137, 153, 174, 175
- estimating function, 50, 63, 105, 250, 318, 329, 470–471, 478, 483, 504, 505, 514, 516
- excess error, 292, 296
- exchangeability, 143, 145
- expansion
  - Cornish–Fisher, 40, 211, 449
  - cubic, 475–478
  - Edgeworth, 39–41, 60, 411, 476–478, 487
  - linear, 47, 51, 69, 75, 76, 118, 443, 446, 468
  - notation, 39
  - quadratic, 50, 66, 76, 443
  - Taylor series, 45, 46
- experimental design
  - relation to resampling, 58, 439, 486
- exponential mean example, 15, 17, 19, 30, 61, 176, 250, 510
- exponential quantile plot, 5, 188
- exponential tilting, 166–167, 183, 209–210, 452–454, 456–458, 461–463, 492, 495, 504, 517, 535, 546, 547
- exp.tilt, 535
- factorial experiment, 320, 322
- finite population sampling, 92–100, 125, 128, 129, 130, 474
- fir seedlings data, 142
- Fisher information, 193, 206, 349, 516
- Fourier frequencies, 387
- Fourier transform, 387
  - empirical, 388, 408, 430
  - fast, 388
  - inverse, 387
- frequency array, 23, 52, 443
- frequency smoothing, 110, 456, 462, 463, 464–465, 496, 508
- Frets' heads data example, 115, 447
- gamma model, 5, 25, 62, 131, 149, 207, 216, 233, 247, 376
- generalized additive model, 366–371, 375, 382, 383
- generalized likelihood ratio, 139
- generalized linear model, 327–346, 368, 369, 374, 376–377, 378, 381–384, 516
  - comparison of resampling schemes for, 336–338
- graphical test, 150–154, 183, 188, 416, 422
- gravity data example, 72, 121, 131, 150, 152, 154, 162, 163, 166, 171, 172, 454, 457, 494, 519
- Greenwood's formula, 83, 128
- half-sample methods, 57–59, 125
- handedness data example, 157, 158, 496
- hat matrix, 258, 275, 278, 318, 330
- hazard function, 82, 146–147, 221–222, 350
- heads data example, *see* Frets' heads data example
- heart disease data example, 378
- heteroscedasticity, 259–260, 264, 269, 270–271, 307, 318, 319, 323, 341, 363, 365
- hierarchical data, 100–102, 125, 130, 251–253, 287–289, 374
- Huber M-estimate, *see* robust M-estimate example
- hypergeometric distribution, 487
- hypothesis test, *see* significance test
- implied likelihood, 511–512, 515, 518
- imp.moments, 546
- importance resampling, 450–466, 486, 491, 497
  - balanced, 460–463
    - algorithm, 491
    - efficiency, 461, 462
  - efficiency, 452, 458, 461, 462, 486
  - improved estimators, 456–460
  - iterated bootstrap confidence intervals, 486
  - quantile estimation, 453–456, 457, 495
  - ratio estimator, 456, 459, 464, 486, 490
  - raw estimator, 459, 464, 486
  - regression, 486
  - regression estimator, 457, 459, 464, 486, 491
  - tail probability estimate, 452, 455
  - time series, 486
  - weights, 451, 455, 456–457, 458, 464
- importance sampling, 450–452, 489
  - efficiency, 452, 456, 459, 460, 462, 489
  - identity, 116, 451, 463
  - misapplication, 453
  - quantile estimate, 489, 490
  - ratio estimator, 490
  - raw estimator, 451
  - regression estimator, 491
  - tail probability estimate, 453
  - weight, 451
- imp.prob, 546
- imp.quantile, 546
- imputation, 88, 90
- imp.weights, 546
- incomplete data, 43–44, 88–92
- index notation, 551–553
- infinitesimal jackknife, *see* nonparametric delta method
- influence functions, 46–50, 60, 63–64
  - chain rule, 48
  - correlation, 48
  - covariance, 316, 319
  - eigenvalue, 64
  - estimating equation, 50, 63
  - least squares estimates, 260, 317
  - M-estimation, 318
  - mean, 47, 316
  - moments, 48, 63
  - multiple samples, 74–76, 126
  - quantile, 48
  - ratio of means, 49, 65, 126
  - regression, 260, 317, 319
  - studentized statistic, 63
  - trimmed mean, 64
  - two-sample *t* statistic, 454
  - variance, 64
  - weighted mean, 126
- information distance, 165–166

- integration
  - number-theoretic methods, 486
- interaction example, 322
- interpolation of quantiles, 195
- Islay data example, 520
- isotonic regression example, 371
- iterative weighted least squares, 329
- jackknife, 50–51, 59, 64, 65, 76, 115
  - delete-*m*, 56, 60, 493
  - for least squares estimates, 317
  - for sample surveys, 125
  - infiniteesimal, *see* nonparametric delta method
  - multi-sample, 76
- jack.after.boot, 532
- jackknife-after-bootstrap, 113–118, 125, 133, 134, 135, 308, 313, 322, 325, 369
  - parametric model, 116–118, 130
- Jacobian, 470, 479
- K-function, 416, 424
- Kaplan-Meier estimate, *see* product-limit estimate
- kernel density estimate, 19–20, 79, 124, 127, 168–170, 189, 226–230, 251, 413, 469, 507, 511, 514
- kernel intensity estimate, 419–421, 431, 435
- kernel smoothing, 110, 363, 364, 375
- kriging, 428
- Kronecker delta symbol, 412, 443, 553
- Lagrange multiplier, 165–166, 502, 504, 515, 516
- Laplace's method, 479, 481
- laterite data example, 234, 505
- Latin hypercube sampling, 486
- Latin square design, 489
- least squares estimates, 258, 275, 392
  - penalized, 364
  - weighted, 271, 278, 329
- length-biased data, 514
- leukaemia data example, 328, 334, 367
- leverage, 258, 271, 275, 278, 330, 370, 377
- likelihood, 137
  - adjusted, 500, 512, 515
  - based on confidence sets, 509–512
  - bootstrap, 507–509
  - combination of, 500, 519
  - definition, 499
  - dual, 515
  - empirical, 500–506
  - implied, 511–512
  - multinomial-based, 165–166, 186, 500–509
  - parametric, 347, 499–500
  - partial, 350, 507
  - pivot-based, 510–511, 512, 515
  - profile, 62, 206, 248, 347, 501, 515, 519
  - quasi, 332, 344
- likelihood ratio statistic, 62, 137, 138, 139, 148, 196, 234, 247, 330, 347, 368, 373, 380, 499–501
- signed, 196
- linear.approx, 530
- linear approximation, *see* nonparametric delta method
- linear predictor, 327, 366
  - residuals, 331
- linearity diagnostics, 118–120, 125
- link function, 327, 332, 367
- location-scale model, 77, 126
- logistic regression example, 141, 146, 338, 359, 361, 371, 376, 378, 381, 474
- logit, 338, 372
- loglinear model, 177, 184, 342, 369
- lognormal model, 66, 149
- log rank test, 160
- long-range dependence, 408, 410, 426
- low birth weights data example, 361
- lowess, 363, 369
- lunch
  - nonexistence of free, 437
- lynx data example, 432
- M-estimate, 311–313, 316, 318, 471, 483, 515
- maize data example, 181
- mammals data example, 257, 262, 265, 324
- Markov chain, 144, 429
- Markov chain Monte Carlo, 143–147, 183, 184, 385, 428
- matched-pair data example, 186, 187, 188, 471, 481, 492, 498
- maximum likelihood estimate
  - bias-corrected, 377
  - generalized linear model, 329
  - nonparametric, 165–166, 186, 209, 501, 516
- mean, *see* average
- mean polar axis example, 234, 505
- median, *see* sample median
- median absolute deviation, 311
- median survival time example, 86, 124
- melanoma data example, 352
- misclassification error, 358–362, 375, 378, 381
- misclassification rate, 359
- missing data, 88–92, 125, 128
- mixed continuous-discrete distribution example, 78
- mode estimator, 124
- model selection, 301–307, 316, 375, 393, 427, 432
- model-based resampling, 389–396, 427, 433
- modified sample size, 93
- moment-generating function, 551, 552
- Monte Carlo test, 140–147, 151–154, 183, 184
- motoneurone firing, 418
- motorcycle impact data example, 363, 365
- moving average process, 386
- multiple imputation, 89–91, 125, 128
- multiplicative bias, 62
- multiplicative model, 77, 126, 328, 335
- negative binomial model, 337, 344
- Nelson-Aalen estimator, 83, 86, 128
- nested bootstrap, *see* double bootstrap
- nested data, *see* hierarchical data



neurophysiological data example, 418, 428

Nile data example, 241

nitrofen data example, 383

nodal involvement data example, 381

nonlinear regression, 353–358

nonlinear time series, 393–396, 401, 410, 426

nonparametric delta method, 46–50, 75

balanced bootstrap, 443–444

cubic approximation, 475–478

linear approximation, 47, 51, 52, 60, 69, 76, 118, 126, 127, 205, 261, 443, 454, 468, 487, 488, 490, 492

control variate, 446

importance resampling, 452

tilted, 490

quadratic approximation, 50, 79, 212, 215, 443, 487, 490

variance approximation, 47, 50, 63, 64, 75, 76, 108, 120, 199, 260, 261, 265, 275, 312, 318, 319, 376, 477, 478, 483

nonparametric maximum likelihood, 165–166, 186, 209, 501

nonparametric regression, 362–373, 375, 382, 383

normal prediction limit, 244

normal quantile plot test, 150

notation, 9–10

nuclear power data example, 286, 298, 304, 323

null distribution, 137

null hypothesis, 136

one-way model example, 208, 276, 319, 320

outliers, 27, 307–308, 363

overdispersion, 327, 332, 338–339, 343–344, 370, 382

test for, 142

paired comparison, *see* matched-pair data

parameter transformation, *see* transformation of statistic

partial autocorrelation, 386

partial correlation example, 115

periodogram, 387–389, 408, 430

resampling, 412–415, 427, 430

permutation test, 141, 146, 156–160, 173, 183, 185–186, 266, 279, 422, 486, 492

for regression slope, 266, 378

saddlepoint approximation, 475, 487

PET film data example, 346, 379

phase scrambling, 408–412, 427, 430, 435

pivot, 29, 31, 33, 510–511, *see also* studentized statistic

point process, 415–426, 427–428

poisons data example, 322

Poisson process, 416–422, 425, 428, 431–432, 435

Poisson regression example, 342, 369, 378, 382, 383

posterior distribution, 499, 510, 513, 515, 520

power notation, 551–553

prediction error, 244, 375, 378

K-fold cross-validation estimate, 293–295, 298–301, 316, 320, 324, 358–362, 381

0.632 estimator, 298, 316, 324, 358–362, 381

adjusted cross-validation estimate, 295, 298–301, 316, 324, 358–362

aggregate, 290–301, 320, 321, 324, 358–362

apparent, 292, 298–301, 320, 324, 381

bootstrap estimate, 295–301, 316, 324, 358–362, 381

comparison of estimators, 300–301

cross-validation estimate, 292–293, 298–301, 320, 324, 358–362, 381

generalized linear model, 340–346

leave-one-out bootstrap estimate, 297, 321

time series, 393–396, 401, 427

prediction limits, 243–245, 251, 284–289, 340–346, 369–371

## Subject index

prediction rule, 290, 358, 359

prior distribution, 499, 510, 513

product factorial moments, 487

product-limit estimator, 82–83, 87, 124, 128, 350, 351, 352, 515

profile likelihood, 62, 206, 248, 347, 501, 515, 519

proportional hazards model, 146, 160, 221, 350–353, 374

P-value, 137, 138, 141, 148, 158, 161, 437

adjusted, 175–180, 183, 187

importance sampling, 452, 454, 459

quadratic approximation, *see* nonparametric delta method

quantile estimator, 18–21, 48, 80, 86, 124, 253, 352

quartzite data example, 520

quasi-likelihood, 332, 344

random effects model, *see* hierarchical data

random walk model, 391

randomization test, 183, 492, 498

randomized block design, 489

ratio

in finite population sampling, 98

stratified sampling for, 98

ratio estimate

in finite population sampling, 95

ratio example, 6, 13, 22, 30, 49, 52, 53, 54, 62, 66, 98, 108, 110, 113, 118, 126, 127, 165, 178, 186, 201, 217, 238, 249, 439, 447, 464, 473, 490, 513

recycling, *see* bootstrap recycling

regression

$L_1$ , 124, 311, 312, 316, 325

case deletion, 317, 377

case resampling, 264–266, 269, 275, 277, 279, 312, 333, 355, 364

convex, 372

design, 260, 261, 263, 264, 276, 277, 305

generalized additive, 366–371, 375, 382, 383

- generalized linear, 327–346, 374, 376, 377, 378, 381, 382, 383
- isotonic, 371
- least trimmed squares, 308, 311, 313, 325
- linear, 256–325, 434
- local, 363, 367, 375
- logistic, 141, 146, 338, 371, 376, 378, 381, 474
- loglinear, 342, 369, 383
- M-estimation, 311–313, 316, 318
- many covariates with, 275–277
- model-based resampling, 261–264, 267, 270–272, 275, 276, 279, 280, 312, 333–335, 346–351, 364–365
- multiple, 273–307
- no intercept, 263, 317
- nonconstant variance, 270–273
- nonlinear, 353–358, 375, 441, 442
- nonparametric, 362–373, 375, 427
- Poisson, 337, 342, 378, 382, 383, 473, 504, 516
- prediction, 284–301, 315, 316, 323, 324, 340–346, 369
- repeated design points in, 263
- resampling moments, 262
- residuals, *see* residuals
- resistant, 308
- robust, 307–314, 315, 316, 318, 325
- significance tests, 266–270, 279–284, 322, 325, 367, 371, 382, 383
- straight-line, 257–273, 308, 317, 322, 391, 449, 461, 489
- survival data, 346–353
- weighted least squares, 271–272, 278–279, 329
- regression estimate
  - in finite population sampling, 95
- remission data example, 378
- repeated measures, *see* hierarchical data
- resampling, *see* bootstrap
- residuals
  - deviance, 332, 333, 334, 345, 376
  - in multiple imputations, 89–91
  - inhomogeneous, 338–340, 344
  - linear predictor, 331, 333, 376
  - modified, 77, 259, 270, 272, 275, 279, 312, 318, 331, 355, 365
  - nonlinear regression, 355, 375
  - nonstandard, 349
  - raw, 258, 275, 278, 317, 319
  - Pearson, 331, 333, 334, 342, 370, 376, 382
  - standardized, 259, 331, 332, 333, 376
  - time series, 390, 392
- returns data example, 269, 272, 449, 461
- Richardson extrapolation, 487, 494
- Rio Negro data example, 388, 398, 403, 410, 427
- robustness, 3, 14, 264, 318
- robust M-estimate example, 471, 483
- robust regression example, 308, 309, 313, 318, 325
- rock data example, 281, 287
- rough statistics, 41–43
- saddle, 547
- saddle.distn, 547
- saddlepoint approximation, 466–485, 486, 487, 492, 493, 498, 508, 509, 517, 547
  - accuracy, 467, 477, 487
  - conditional, 472–475, 487, 493
  - density function, 467, 470
  - distribution function, 467, 468, 470, 486–487
  - double, 473–475
  - equation, 467, 473, 479
  - estimating function, 470–472
  - integration approach, 478–485
  - linear statistic for, 468–469, 517
  - Lugannani-Rice formula, 467
  - marginal, 473, 475–485, 487, 493
  - permutation distribution, 475, 486, 487
  - quantile estimate, 449, 468, 480, 483
  - randomization distribution, 492, 498
- salinity data example, 309, 311, 324
- sample average, *see* average
- sample maximum example, 39, 56, 247
- sample median, 41, 61, 65, 80, 121, 181, 518
- sample variance, 61, 62, 64, 104, 208, 432, 488
- sampling
  - stratified, *see* stratified sampling
  - without replacement, 92
- sampling fraction, 92–93
- sandwich variance estimate, 63, 275, 318, 376
- second-order accuracy, 39–41, 211–214, 246
- semiparametric model, 77–78, 123
- sensitivity analysis, 113
- separate families example, 148
- sequential spatial inhibition process, 425
- several samples, 71–76, 123, 126, 127, 130, 131, 133, 163, 208, 210–211, 217–220, 253
- shrinkage estimate, 102, 130
- significance probability, *see* P-value
- significance test
  - adaptive, 173–174, 184, 187, 188
  - conditional, 138, 173–174
  - confidence interval, 220–223
  - critical region, 137
  - double bootstrap, 175–180, 183, 186, 187
  - error rate, 137, 175–176
  - generalized linear regression, 330–331, 367–369, 378, 382
  - graphical, 150–154, 188, 416, 422, 428
  - linear regression, 266–270, 279–284, 317, 322, 392
  - Monte Carlo, 140–147, 151–154
  - multiple, 174–175, 184
  - nonparametric bootstrap, 161–175, 267–270
  - nonparametric regression, 367, 371, 382, 383
  - parametric bootstrap, 148–149
  - permutation, 141, 146, 156–160, 173, 183, 185, 188, 266, 317, 378, 475, 486

pivot, 138–139, 268–269, 280, 284, 392, 454, 486

power, 155–156, 180–184

P-value, 137, 138, 141, 148, 158, 161, 175–176

randomization, 183, 185, 186, 492, 498

separate families, 148, 378

sequential, 182

spatial data, 416, 421, 422, 428

studentized, *see* pivot

time series, 392, 396, 403, 410

simulated data example, 306

simulation error, 34–37, 62

simulation outlier, 73

simulation size, 17–21, 34–37, 69, 155–156, 178–180, 183, 185, 202, 226, 246, 248

size of test, 137

`smooth.f`, 533

smooth estimates of  $F$ , 79–81

spatial association example, 421, 428

spatial clustering example, 416

spatial data, 124, 416, 421–426, 428

spatial epidemiology, 421, 428

species abundance example, 169, 228

spectral density estimation example, 413

spectral resampling, *see* periodogram resampling

spectrum, 387, 408

spherical data example, 126, 234, 505

spline smoother, 352, 364, 365, 367, 368, 371, 468,

standardized residuals, *see* residuals, standardized

stationarity, 385–387, 391, 398, 416

statistical error, 31–34

statistical function, 12–14, 46, 60, 75

Stirling's approximation, 61, 155

straight-line regression, *see* regression, straight-line

stratified resampling, 71, 89, 90, 306, 340, 344, 365, 371, 457, 494

stratified sampling, 97–100

Strauss process, 417, 425

studentized statistic, 29, 53, 119, 139, 171–173, 223, 249, 268, 280–281, 284, 286, 313, 315, 324, 325, 326, 330, 477, 481, 483, 513

subsampling, 55–59

balanced, 125

in model selection, 303–304

spatial, 424–426

sugar cane data example, 338

summation convention, 552

sunspot data example, 393, 401, 435

survival data

nonparametric, 82–87, 124, 128, 131, 132, 350–353, 374–375

parametric, 346–350, 379

survival probability, 86, 132, 160, 352, 515

survival proportion data example, 308, 322

survivor function, 82, 160, 350, 351, 352, 455

symmetric distribution example, 78, 169, 228, 251, 470, 471, 485

tau particle data example, 133, 495

test, *see* significance test

tile resampling, 424–426, 427, 428, 432

`tilt.boot`, 547

tilted distribution, *see* exponential tilting

time series, 385–415, 426–427, 428–431, 514

econometric, 427

nonlinear, 396, 410, 426

toroidal shifts, 423

traffic data, 253

## Subject index

training set, 292

transformation of statistic

empirical, 112, 113, 118, 125, 201

for confidence interval, 195, 200, 233

linearizing, 118–120

variance stabilizing, 32, 63, 108, 109, 111–113, 125, 195, 201, 227, 246, 252, 394, 419, 432

trend test in time series example, 403, 410

trimmed average example, 64, 121, 130, 133, 189

`tsboot`, 544

tuna data example, 169, 228, 469

two-way model example, 338, 342, 369

two-way table, 177, 184

unimodality test, 168, 169, 189

unit root test, 391, 427

urine data example, 359

variable selection, 301–307, 316, 375

variance approximations, *see* nonparametric delta method

variance estimate, *see* sample variance

variance function, 327–330, 332, 336, 337, 338, 339, 344, 367

estimation of, 107–113, 465

variance stabilization, 32, 63, 108, 109, 111–113, 125, 195, 201, 227, 246, 419, 432

variation of properties of  $T$ , 107–113

`var.linear`, 530

weighted average example, 72, 126, 131

weighted least squares, 270–272, 278–279, 329–330, 377

white noise, 386

Wilcoxon test, 181

wool prices data example, 391