

Author Index

- Abramson, M. A. 234
 Adjabi, S. 21
 Ahamada, I. xvi
 Ahmad, I. A. 97, 142
 Ai, C. 269, 284
 Aitchison, J. xv, xvii, 12, 17, 19, 131
 Aitken, C. G. G. xv, xvii, 12, 17, 19, 131
 Aldrich, J. H. 158
 Altonji, J. G. 194
 Audet, C. 234
 Azzalini, A. xvi

 Bai, J. 105
 Baker, E. R. 82
 Bashtannyk, D. M. 149
 Bassett, G. 154, 155
 Bauwens, L. 138
 Becker, G. S. 199
 Belaire-Franch, J. 105
 Bera, A. 105
 Beresteanu, A. 245
 Berry, D. A. 5, 22, 27
 Blomqvist, N. 140
 Blundell, R. 285, 289
 Boneva, L. I. 111
 Bos, L. 245
 Bosq, D. xvi
 Bouezmarni, T. 111
 Bowman, A. W. xvi, 73, 82
 Box, G. E. P. 147
 Brown, L. D. 311
 Buja, A. 295

 Cai, T. T. 311
 Cai, Z. 295
 Calonico, S. 124
 Calvo, B. 111
 Cameron, A. C. 147
 Cantoni, E. 220
 Carrasco, M. 283–285
 Carroll, R. J. xvi, 248, 269
 Cattaneo, M. D. 124
 Centorrino, S. 284, 285
 Chao, M. T. 246
 Chen, L.-H. 310, 311, 313
 Chen, S. X. 111, 117
 Chen, T. 285
 Chen, X. 138, 239, 284, 285, 289
 Cheng, M.-Y. 84, 310, 311, 313
 Chernozhukov, V. 156
 Chesher, A. 284
 Chu, C. I. 131
 Chu, C.-Y. 21
 Čížek, P. 220
 Cleveland, W. S. 220
 Cline, D. B. H. 111
 Cohen, M. 285
 Connors, A. F. 181, 182, 184
 Copas, J. B. 111
 Corradi, V. 172, 173
 Couture, G. 234
 Cowling, A. 111
 Craven, P. 222, 246
 Cressie, N. A. C. 247
 Croissant, Y. 270
 Crum, W. L. 104

- Daouia, A. 248
 Darolles, S. 283, 284
 Davis, L. 328
 Dawson, N. V. 181, 182, 184
 de Boor, C. 195
 Dehejia, R. H. 184
 Delaigle, A. 248
 Delgado, M. A. 239
 Dennis Jr., J. E. 234
 Denuit, M. 141
 Devroye, L. xv
 Diebold, F. X. 173, 174
 Diggle, P. 115
 Doksum, K. 223, 274
 Du, P. 245–247
 Duin, R. P. W. 74, 97, 149
 Duraiswami, R. 328

 Efron, B. 103, 173, 174
 Elgammal, A. 328
 Engle, R. F. 309
 Epanechnikov, V. A. 68

 Fan, J. xvi, 206, 220, 227, 294,
 309–311, 313
 Fan, Y. 138, 142, 239, 283, 284
 Faraway, J. J. 74
 Farrell, M. H. 124
 Fermanian, J.-D. 138, 139
 Fernández-Val, I. 156
 Fève, F. 285
 Fix, E. xv, 52, 56
 Flachaire, E. xvi
 Flanery, B. P. 119
 Florens, J.-P. 283–285
 Foster, P. J. 111
 Fox, J. 229
 Fredholm, E. I. 281
 Freyberger, J. 283
 Fridman, V. M. 282
 Fryer, M. J. 111
 Fu, T. T. 294, 295
 Fubini, G. 60
 Funke, B. 21

 Galichon, A. 156
 Gallant, A. R. 195, 245
 Gao, Q. 292
 Gasser, T. 111, 228, 246
 Geary, R. C. 49
 Geisser, S. 74
 Gencay, R. 142
 Gifford, J. 245
 Gijbels, I. xvi, 227, 245
 Gilli, M. 119
 Gini, C. 140
 Golan, A. 89
 Granger, C. W. 94, 105, 106, 108,
 109
 Gray, A. 328
 Greene, W. H. 270
 Greengard, L. 328
 Györfi, L. xv

 Hadamard, J. 277
 Hahn, J. 180
 Hall, P. G. xviii, 82, 97, 111, 148,
 149, 151, 152, 160, 163, 221, 228,
 232–234, 240, 242, 245–249, 264,
 269, 284, 297, 305
 Hansen, B. xvi
 Härdle, W. 253, 297
 Harfouche, L. 21
 Hart, J. D. xvi, 111, 238
 Hartley, R. V. L. 90
 Hastie, T. 294, 295, 301
 Hausman, J. 159
 Hayfield, T. xvi, xviii, 257, 343
 Heckman, J. J. 184
 Henderson, D. J. xvi, 21, 226, 269
 Hirano, K. 180
 Hodges, J. L. xv, 52, 56, 68
 Hoerl, A. E. 280
 Hong, Y. M. 97
 Horowitz, J. L. xvi, 253, 276,
 283–285
 Hosmer, D. W. 161
 Hristache, M. 253
 Hsiao, C. 253, 254

- Huang, C. J. 294, 295
 Huang, H. 245–247
 Huber, P. J. 220
 Hurvich, C. M. 222, 260, 270
 Hyndman, R. J. 149, 244

 Ichimura, H. 184, 297, 301
 Ichino, A. 179
 Igarashi, G. 111
 Imbens, G. W. 180
 Inoue, A. 173

 Jhun, M. 74
 Jiang, J. 220
 Joe, H. 109
 Johannes, J. 285
 Jones, M. C. xvi, 73, 111, 115, 311
 Juditsky, A. 253

 Kakizawa, Y. 111
 Karunamunia, R. J. 111
 Kendall, D. 111
 Kendall, M. G. 140
 Kennard, R. W. 280
 Keynes, J. M. 104
 Khaled, M. A. 138
 Khandakar, Y. 244
 Kiefer, N. M. xviii, 19, 232
 Kilian, L. 173
 Klein, R. W. 298, 307
 Koch, S. F. 161
 Koenker, R. 154, 155
 Kristensen, D. 285, 289
 Kronmal, R. A. 181, 182
 Kullback, S. 74, 97

 Landweber, L. 282
 Laurent, S. 138
 Laurent, T. 248
 Lavergne, P. 239
 Le Digabel, S. 234
 Lechner, M. 179
 Lehmann, E. L. 68, 140
 Lemeshow, S. 161
 Lemieux, T. 265

 Leung, D. 219, 220
 Levine, M. 311
 Li, C. 88, 135, 137, 159
 Li, D. 294, 295
 Li, H. 88, 135, 137
 Li, K. 157
 Li, Q. xvi, xix, 17, 22, 61, 87, 96, 97,
 134, 137, 139, 142, 148, 149,
 151–153, 157, 160, 163, 180, 181,
 221, 226, 232, 238–240, 253, 254,
 269, 283, 294, 295, 301
 Lin, D. Y. 181, 182
 Lin, J. 153
 Lin, J. L. 94, 109
 Lin, X. 269
 Lindgren, B. W. 5, 22, 27
 Linton, O. B. 292
 Liu, L. 292
 Liu, R. 88, 139
 Loader, C. R. 73, 75, 123
 Lozano, J. A. 111

 Maasoumi, E. 94, 105, 106, 108, 109,
 142
 Mammen, E. 142, 253
 Mammitzsch, V. 111
 Manteiga, W. G. 239
 Mariano, R. S. 173, 174
 Maringer, D. 119
 Maronna, A. 220
 Marron, J. S. 111, 131
 Martin, R. D. 220
 Maslow, A. 193
 Masry, E. 229, 240
 Matzkin, R. L. 194, 245
 McCracken, M. W. 173
 McFadden, D. 159
 Medeiros, M. C. 172
 Millo, G. 270
 Mitchell, W. C. 104
 Moore, A. W. 328
 Mora, J. 159
 Moro-Egido, A. I. 159
 Morozov, V. A. 282

- Müller, H.-G. 111
 Müller, M. xvi
 Murphy, K. M. 265
 Murtazashvili, I. 294
 Müller, H.-G. 111
- Nadaraya, E. A. 77, 206, 226
 Nelsen, R. B. 84, 137–139, 157
 Nelson, F. D. 158
 Newey, W. K. 283, 285
 Ng, S. 105
 Nie, Z. 234, 249, 257
 Noh, H. 247, 248
- Otsu, T. 155, 156
 Ouyang, D. 17, 240, 295
- Pagan, A. xvi, 349
 Parmeter, C. F. xvi, 21, 173, 226, 245–247, 269
 Parzen, E. 56
 Patton, A. 105, 174
 Pearson, K. 51
 Peiro, A. 105
 Peng, L. 310, 311, 313
 Perez, A. 111
 Perez-Quiros, G. 105
 Phillips, P. C. B. 61
 Polansky, A. M. 82
 Politis, D. N. xvi, 105, 174
 Pouzo, D. 284
 Powell, J. L. 283, 285
 Prakasa Rao, B. L. S. xv, xviii
 Premaratne, G. 105
 Press, W. H. 119
 Priestley, M. B. 246
 Prvan, T. 82
 Psaty, B. M. 181, 182
- Qu, Z. 156
- R Core Team xvi
 Racine, J. S. xvi, xviii, xix, 17, 19, 22, 61, 87, 88, 94, 96, 97, 105, 106, 108, 109, 134, 135, 137, 139, 142, 148, 149, 151–153, 157, 159, 160, 163, 172, 173, 180, 181, 221, 227, 232–234, 238, 240, 242, 245–247, 249, 253, 254, 257, 264, 269, 283, 284, 292, 295, 305, 328, 343
- Ramsey, J. B. 196, 197, 255, 351
 Read, T. R. C. 247
 Rech, G. 172
 Renault, E. 283–285
 Rényi, A. 94
 Ridder, G. 180
 Rilstone, P. 226
 Ripley, B. D. 160, 162
 Robinson, P. M. 42, 61, 97, 109, 239, 291, 292, 301, 307
 Rodriguez-Poo, J. M. 269
 Rolin, J.-M. 111
 Romano, J. P. 105
 Rombouts, J. V. K. 111, 138
 Ronchetti, E. 220
 Rosen, A. M. 284
 Rosenbaum, P. 180
 Rosenblatt, M. 56
 Rubin, D. 180
 Rudemo, M. 73
 Ruppert, D. xvi, 111, 221, 228
- Samarov, A. 223, 274
 Santafe, G. 111
 Scaillet, O. 111, 138, 139, 141
 Schumann, E. 119
 Scott, D. W. xvi, 112, 220, 327
 Seifert, B. 228
 Shannon, C. E. 89
 Shapiro, S. S. 51, 349
 Shaw, P. 285
 Sheather, S. J. 73, 221, 327
 Shen, X. 173
 Silverman, B. W. xvi, 69, 98, 103, 328
 Simonoff, J. S. xvi, 4, 222, 260, 270
 Skaug, H. J. 109
 Smith, M. S. 138
 Soberon, A. 269

- Spady, R. H. 298, 307
 Spearman, C. 140
 Sperlich, S. xvi
 Speroff, T. 181, 182, 184
 Spokoiny, V. G. 253
 Statistics South Africa 161
 Stefanov, I. 111
 Stein, C. xviii, 18
 Stone, C. J. 74, 220
 Strain, J. 328
 Stute, W. 296
 Su, L. 223, 269, 284, 294, 311
 Sun, J. 123
 Sun, S. 84
 Sun, Y. 240, 269, 295
 Swanson, N. R. 172, 173

 Teräsvirta, T. 172
 Teukolsky, S. A. 119
 Tibshirani, R. 294, 295, 301
 Tikhonov, A. N. 280
 Timmermann, A. 105
 Titterington, D. M. 228
 Tjøstheim, D. 109
 Todd, P. 184
 Tonelli, L. 60
 Trivedi, P. K. 138, 147
 Tsai, C. L. 222, 260, 270
 Tschernig, R. 232
 Tsukahara, H. 138
 Tsybakov, A. B. xvi
 Tsyrennikov, V. 138
 Turlach, B. A. 257

 Ullah, A. xvi, 142, 223, 225, 226, 269, 284, 294, 311, 349

 van Belle, G. 142
 van Bellegem, S. 285
 van Ryzin, J. 20
 Vanhems, A. 285
 Venables, W. N. 160, 162
 Vetterling, W. T. 119
 Vinod, R. 225

 Vuong, Q. 239

 Wahba, G. 195, 222, 246
 Wahba, S. 184
 Wand, M. P. xvi, 221, 228
 Wang, F. T. 220
 Wang, L. 311
 Wang, M. C. 20
 Wang, N. 269
 Wang, Q. 61
 Wang, S. 301
 Wang, Y. 195
 Wasserman, L. xvi
 Watson, G. S. xv, 206, 226
 Wehrly, T. E. 111
 Weingessel, A. 257
 Weisberg, S. 229
 Welch, F. 265
 Werwatz, A. xvi
 West, K. D. 173
 White, H. L. 11, 18, 70, 97, 105, 173, 174
 Wikipedia 233
 Wilk, M. B. 51, 349
 Winter-Ebmer, R. 179
 Wooldridge, J. M. 132, 180, 181
 Wu, W. 138

 Xie, Y. xix

 Yan, K. X. 22
 Yang, L. 88, 139, 232
 Yang, S.-S. 84
 Yao, Q. W. xvi, 309–311, 313
 Yao, S. 226
 Yatchew, A. xvi, 245
 Ye, J. 173
 Yi, Y. 138
 Yohai, V. J. 220
 Yoon, J. 156
 Young, G. A. 103
 Yu, K. 311

 Zhang, S. 111
 Zhang, W. 294

396

AUTHOR INDEX

Zhang, Y. Y. 269

Zimmer, D. 138

Zhu, L.-X. 296

Zougab, N. 21

Subject Index

A

Aitchison and Aitken kernel
estimator, 15, 17, 20, 42, 133

Analytic functions, 232

Applied nonparametric density
estimation, 349–351

Applied nonparametric regression,
351–352

Assessment of model performance,
see Model performance
assessment

Asymptotic normality
for local constant kernel
regression, 219, 226
in discrete and cumulative
probability functions, 18
in smooth kernel density
function estimation, 69–70

AT&T, Inc., 323

Average treatment effects and
propensity score matching,
179–184

Axiom systems, entropy and, 94–95

B

Bandwidth
as smoothing parameter, 11
for local constant kernel
regression, 220–222
IMSE-optimal
for continuous density
functions, 66–67
for smooth kernel density
function estimation, 67

for smooth kernel distribution
function estimation, 80–81
kernel function and, 218–219
in smooth kernel conditional
cumulative distribution
function estimation, 153
information-theoretic selector
for, 222
joint determination of
polynomial degree and
bandwidth, 249–252
least squares cross-validation of,
149
likelihood cross-validation of,
149–150
multivariate, 87–88
selection of, 71–75

Bell Laboratories, 323

Bhattacharya-Matusita-Hellinger
entropy, 94

Bias
boundary, 206
kernel functions to reduce, 75–77
pointwise, 211–214, 225, 229

Bias-corrected confidence bands,
124–127

Bias-variance trade-off, 15–16

Big and small O notation, 317–319

Binary choice models, 158–162

Binary Y (Klein and Spady's
method), 298–300

Binning methods, in computational
considerations, 327

- Bootstrap
 for bandwidth selection, 74
 for continuous density and cumulative distribution functions, 103–104
 for counterfactual predictions, 166–170
 smoothed, 170–171
- Boundary bias, 206
- Bounded domains and boundary corrections
 custom boundary kernel function for, 114–118
 data-reflection approach, 111–113
 overview, 111
 transformation methods for, 113–114
- British Family Expenditure survey, 285
- Bulleted and numbered lists, R package software for, 336–337
- C**
- Categorical variables
 ordered, 3, 19–22
 unordered, 3, 12–16
- Cauchy distribution, 74
- Central limit theorem (CLT)
 Liapounov, 18, 22, 27, 134, 219, 226, 232
 Lindeberg-Levy, 11, 25
- Chambers, John, 323
- Chi-square (χ^2) goodness-of-fit procedure, 6
- Coefficient of determination for nonparametric kernel regression, 222–223
- Computational considerations, 327–331
 binning methods, 327
 kernel estimation in R package, 328–331
 multiple and tree-based methods, 328
 parallelism, 328
 transforms, 328
- Conditional mean function
 estimation, *see also* Semiparametric conditional mean functions estimation
 confidence bands and nonparametric estimation, 263–264
 consistent nonparametric test for correct parametric specification, 253–256
 fixed-effects panel data models, 269–271
 joint determination of polynomial degree and bandwidth, 249–252
 kernel regression is weighted least squares estimation, 248–249
 local constant kernel regression asymptotic normality, 219
 bandwidth selection, 220–222
 coefficient of determination for nonparametric, 222–223
 estimator properties, 208–217
 IMSE-optimal bandwidth and kernel function, 218–219
 local constant marginal effects, 223–226
 outlier-resistant, 219–220
 overview, 206–208
- local polynomial kernel regression and shrinkage, 232–235
- model performance assessment, 264–269
- multivariate application of local linear regression, 260–263
- multivariate local polynomial extension, 229–232

- multivariate mixed-data
 - marginal effects, 235–236
 - overview, 193–195
 - parametric
 - counterfactual experiments and, 199–205
 - interpretation of, 197–199
 - overview, 195–197
 - shape constrained kernel
 - regression, 245–248, 257–260
 - time series kernel regression, 240–245
 - Conditional mean function
 - estimation with endogenous predictors, 275–287
 - Engel curve estimation, 285
 - ill-posed inverse problems and identification, 276–280
 - nonparametric instrumental regression, 281–285
 - nonparametric instrumental regression with a linear DGP, 285–287
 - overview, 275–276
 - parametric instrumental regression, 280–281
- Conditional moment functions, 189–191
- Conditional probability density and cumulative distribution functions, 147–184
- average treatment effects and propensity score matching, 179–184
 - binary choice and multinomial choice models, 158–162
 - conditional quantile function estimation, 154–157
 - counterfactual predictions, 166–170
 - joint density modeling, 162–165
 - model performance assessment, 172–179
 - overview, 147–148
 - smooth kernel conditional
 - cumulative distribution function estimation, 152–153
 - smooth kernel conditional density function estimation, 148–150
 - smoothed bootstrap, 170–171
- Conditional quantile function estimation, 154–157
- Conditional variance function estimation, 309–312
- local linear, 309–311
 - overview, 309
 - simulated illustration of, 311–312
- Confidence bands
- for conditional mean function estimation, 263–264
 - in continuous density and cumulative distribution functions, 123–127
- Consistency, entropy and, 95–96
- Consistent nonparametric inference, 354–357
- Consistent nonparametric test for parametric specification, 253–256
- Continuous density and cumulative distribution functions, 49–127
- entropy, 89
 - axiom systems and, 94–95
 - inferences, robustness, consistency and, 94
 - joint and conditional, 93
 - kernel estimation and, 96–97
 - metricness and, 94
 - relative, 91
 - multivariate extension for, 85–89
 - mutual information, 93–94
 - nonsmooth density function estimation, 51–55
 - overview, 49–50

- parametric density function
 - estimation, 50–51
 - R package np
 - bounded domains and
 - boundary corrections in, 111–118
 - confidence bands and
 - nonparametric estimation in, 123–127
 - nonlinear optimization and
 - multi-starting in, 118–123
 - overview, 97–103
 - smoothed bootstrap for, 103
 - testing equality of univariate densities in, 106–108
 - testing nonlinear pairwise
 - independence in, 108–109
 - testing nonlinear serial
 - independence in, 109–110
 - testing univariate asymmetry
 - in, 104–106
 - Continuous random variables, 3
 - Continuous Y (Ichimura’s method)
 - Continuous Y (Ichimura’s method)
 - model performance assessment for, 301–306
 - Continuous Y (Ichimura’s method)
 - overview, 297
 - Convergence, rate of
 - IMSE-optimal bandwidth and, 66–67
 - SMSE-optimal smoothing
 - parameter and, 16–17
 - Convergent power series, analytic
 - functions locally given by, 233
 - Copula function
 - contour function for, 143–144
 - smooth kernel, 137–139
 - Counterfactual experiments
 - bootstrapping, 166–170
 - for parametric conditional mean
 - function estimation, 199–205
 - Covariates, irrelevant, 150–151
 - Cross entropy, 91
 - Cross-validation, in bandwidth
 - selection, 73–74
 - Cumulative distribution function
 - estimation, *see also*
 - Conditional probability density and cumulative distribution functions;
 - Continuous density and cumulative distribution functions;
 - Mixed-data probability density and cumulative distribution functions
 - Cumulative probability functions
 - nonsmooth, 22–25
 - smooth kernel, 25–27
- D**
- Data generating process (DGP), 4, 285–287
 - Data reflection, 111–113
 - Demographic and Health Survey, 19
 - Density functions, *see* Conditional probability density and cumulative distribution functions; Continuous density and cumulative distribution functions; Mixed-data probability density and cumulative distribution functions
 - Dependence, copulae and, 139–141
 - Design matrices, ill-posedness and, 279–280
 - DGP (Data generating process), 4, 285–287
 - Direct plug-in method for kernel estimates, 221
 - Discrete choice models,
 - nonparametric, 360–362
 - Discrete random variables, 3–4, 9

- Distribution functions, *see*
 Conditional probability density and cumulative distribution functions;
 Continuous density and cumulative distribution functions; Mixed-data probability density and cumulative distribution functions
- Divergence, Kullback-Leibler, 91, 97
 Donald Knuth, 325
- E**
- Efficiency of kernel function, 68–69
 Empirical cumulative distribution function (ECDF), 23–25, 82
 Endogenous predictors, *see*
 Conditional mean function estimation with endogenous predictors
- Engel curve estimation, 285
- Entropy
 axiom systems and, 94–95
 inferences, robustness, consistency and, 95–96
 joint and conditional, 93
 kernel estimation and, 96–97
 metricness and, 94
 relative, 91
- Epanechnikov kernel function, 21, 68, 139
- Equality
 testing for in mixed-data multivariate densities, 142–143
 testing for in univariate densities, 106–108
- Estimator properties for local constant kernel regression, 208–217
- Expected value of discrete random variable, 9
- F**
- Fast Fourier transform, 97–98
 Fixed-effects panel data models, 269–271
 Fourier Flexible Form (FFF) estimator, 245
 Free Software Foundation's GNU General Public License, 324
 Frequency estimator, 8
 Fundamental theorem of calculus, 53
- G**
- GARCH models, 138
 Gaussian (normal) quantile function, 82–83
 Gaussian kernel function, 57, 139
 Generalized cross-validation (GCV) for local constant kernel regression, 222
 Git revision control system, 325–326
- H**
- Histogram density, 51
 Human capital, theory of, 199
- I**
- Ichimura's method (continuous Y) model performance assessment for, 301–306
 overview, 296
- Ill-posed inverse problems and identification, 276–277
- IMSE-optimal bandwidth
 for continuous density functions, 66–67
 for smooth kernel density function estimation, 66–67
 for smooth kernel distribution function estimation, 80–81
 kernel function and, 67–69, 218
- Independence
 co-monotonicity and, 140
 nonlinear pairwise, 108–109
 nonlinear serial, 109–110

- Inferences, entropy and, 95–96
 Information entropy, 89
 Information functions
 mutual information, 93–94
 statistical mechanics and, 89–91
 Inverse cumulative distribution
 function, 82, 138
 Inverse problems in conditional mean
 function estimation with
 endogenous predictors,
 276–277
 Irrelevant covariates, 150–151
- J**
 Joint and conditional entropy, 93
 Joint density modeling, 162–165
 Joint determination of polynomial
 degree and bandwidth,
 249–252
- K**
 Kernel carpentry, 114–118
 Kernel functions, *see also* Smooth
 kernel density function
 estimation; Smooth kernel
 probability function
 estimation, *see also* Smooth
 kernel density function
 estimation; Smooth kernel
 probability function
 estimation
 bias-reducing, 75–77
 boundary, 114–118
 entropy and, 96–97
 ill-posedness and, 277–279
 IMSE-optimal, 67–69, 218–219
 in R package software, 328–331
 marginal, 86
 smooth conditional cumulative
 distribution, 152–153
 smooth conditional density,
 148–150
 smooth cumulative distribution,
 77–82
 smooth cumulative probability,
 25–27
- Kernel regression, *see also* Local
 constant kernel regression
 local polynomial, shrinkage and,
 232–235
 shape constrained, 245–248,
 257–260
 time series, 240–245
 weighted least squares
 estimation in, 248–249
 Klein and Spady's method (binary
 Y), 298–300
 Kullback-Leibler divergence, 91, 97
- L**
 Least squares cross-validation of
 bandwidth, 73, 149, 221
 Least squares estimation, 248–249
 Liapounov central limit theorem
 (CLT), 18, 22, 134, 219, 226,
 232
 Likelihood cross-validation of
 bandwidth, 74, 149–150
 Lindeberg-Levy central limit
 theorem (CLT), 11, 25
 Local constant kernel regression
 asymptotic normality, 219
 bandwidth selection, 220–222
 coefficient of determination for,
 222–223
 estimator properties, 208–217
 IMSE-optimal bandwidth and
 kernel function, 218–219
 marginal effects, 223–226
 outlier-resistant, 219–220
 overview, 206–208
 Local linear conditional variance
 function estimation, 309–311
 Local linear regression, multivariate
 application of, 260–263
 Local minima, 120–123
 Local polynomial extension
 multivariate, 229–232

- Nadaraya-Watson estimator and, 206
- Local polynomial kernel regression and shrinkage, 232–235
- Locally weighted regression (The Multivariate Local Polynomial Extension), 220
- Lowess (locally weighted regression), 220
- M**
- macOS, 323
- Magnitude and probability, large and small orders of, 317–321
- Marginal effects function
description of, 194
in multivariate mixed-data, 235–236
local constant, 223–226
- Marginal kernel functions, 86
- Mathematical typesetting, 337–338
- Mean square error (MSE) criterion, 10, 15–19
- Metricness, entropy and, 94
- Mixed-data multivariate marginal effects, 235–236
- Mixed-data probability density and cumulative distribution functions, 131–144
copula function contour generation, 143–144
multivariate extension for, 135–137
overview, 131–132
smooth kernel copula function estimation with, 137–139
smooth mixed-data kernel density and cumulative distribution function estimation, 132–133
testing equality of mixed-data multivariate densities, 142–143
- Model performance assessment
for continuous Y (Ichimura's method), 301–306
in conditional mean function estimation, 264–269
maximizing expected true gain in, 176–179
out-of-sample predictive, 173–176
parametric versus nonparametric, 172–173
- Mohr, Franz, 324
- Moment-based inferential procedures, 95
- Monte Carlo comparison of probability function estimation
correct parametric specification, 35–38
discussion, 41–43
incorrect parametric specification, 38–41
overview, 34–35
- MSE (mean square error) criterion, 10, 15–19
- Multi-starting in continuous density and cumulative distribution functions, 118–123
- Multinomial choice models, 158–162
- Multiplicative bias-corrected discrete support kernel function, 21
- Multipole and tree-based methods, for computations, 328
- Multivariate application of local linear regression, 260–263
- Multivariate densities, mixed-data, 142–143
- Multivariate extension
for continuous density and cumulative distribution functions, 85–89
for mixed-data probability density and cumulative distribution functions,

- 135–137
 - for probability function estimation, 27–29
- Multivariate local polynomial extension, 229–232
- Multivariate mixed-data marginal effects, 235–236
- Mutual information, 93–94
- N**
- Nadaraya-Watson estimator, 206
- Naïve density estimator, 52–55
- Naïve linear model, testing
 - specifications of, 254–256
- New York Times, 324
- Non-nested model comparison, 357–359
- Nonlinear optimization in continuous density and cumulative distribution functions, 118–123
- Nonlinear pairwise independence in continuous density and cumulative distribution functions, 108–109
- Nonlinear serial independence in continuous density and cumulative distribution functions, 109–110
- Nonparametric density estimation, applied, 349–351
- Nonparametric discrete choice models, 360–362
- Nonparametric estimation
 - for parametric specification, 253–256
 - in conditional mean function estimation, 263–264
 - in continuous density and cumulative distribution functions, 123–127
- Nonparametric inference, consistent, 354–357
- Nonparametric instrumental regression, 281–285
- Nonparametric kernel-smoothed approach, *see also* Smooth kernel probability function estimation
- Nonparametric nonsmooth frequency estimator, 8
- Nonparametric regression
 - applied, 351–352
 - shape constrained, 362–366
- Nonsmooth cumulative probability functions, estimation of, 22–25
- Nonsmooth density function estimation, 51–55
- Nonsmooth probability functions, estimation of, 8–11
- Normality, asymptotic
 - for local constant kernel regression, 219, 226
 - in discrete and cumulative probability functions, 18
 - in smooth kernel density function estimation, 69–70
- npksum function in R software, 348–349, 352–354
- npudens in R software
 - applied nonparametric density estimation, 349–351
 - npksum function, 348–349
 - overview, 346–348
- Numbered lists, R package software for, 336–337
- O**
- O* notation, big and small, 317–321
- Optimal smoothing parameter, 16–17
- Ordered categorical variables, smooth kernel probability functions and, 19–22
- Outlier-resistant local constant kernel regression, 219–220

P

- Parallelism, in computational considerations, 328
- Parametric binary choice models, 158–159
- Parametric conditional mean function estimation
counterfactual experiments and, 199–205
interpretation of, 197–199
overview, 195–197
- Parametric conditional quantile function estimation, 154–156
- Parametric density function estimation, 50–51
- Parametric instrumental regression, 280–281
- Parametric multinomial choice models, 158–159
- Parametric probability function estimation, 5–8
- Partially linear model for semiparametric conditional mean function estimation, 291–294, 300–301
- PDF (probability density function), 49–50
- Pearson, Karl, 51
- Performance assessment of models, *see* Model performance assessment
- Plots, R package software for, 335–336
- Pointwise bias, 211–214, 225, 229
- Pointwise variance, 214–216, 225, 229
- Polynomial degree
joint determination of bandwidth and, 249–252
multivariate local, 229–232
- Polynomial kernel regression, local, 232–235
- Predictor relevance, testing for, 236–239
- Printing documents, R package software for, 338–339
- Probability and magnitude, large and small orders of, 317–321
- Probability density function (PDF), 49–50
- Probability functions, estimating, *see also* Conditional probability density and cumulative distribution functions; Mixed-data probability density and cumulative distribution functions
- Monte Carlo comparison of correct parametric specification, 35–38
discussion, 41–43
incorrect parametric specification, 38–41
overview, 34–35
- multivariate extension for, 27–29
- nonsmooth, 8–11
- nonsmooth cumulative, 22–25
- overview, 3–5
- parametric, 5–8
- smooth kernel
asymptotic normality, 18
ordered categorical variables and, 11, 19–22
shrinkage and, 18–19
SMSE-optimal smoothing parameter, 16–17
unordered categorical variables and, 12–16
smooth kernel cumulative, 25–27
- Product kernel functions, 27–29, 86
- Propensity score matching, 179–184

Q

- Quantile function estimation, smooth kernel, 82–85
- Quantile functions, conditional, 154–157

R

R package software

- applied nonparametric density estimation, 349–351
- applied nonparametric regression, 351–352
- conditional variance function estimation in, 311–312
- consistent nonparametric inference, 354–357
- continuous density and cumulative distribution functions in
- bounded domains and boundary corrections in, 111–118
- confidence bands and nonparametric estimation in, 123–127
- nonlinear optimization and multi-starting in, 118–123
- overview, 97–103
- smoothed bootstrap for, 103
- testing equality of univariate densities in, 106–108
- testing nonlinear pairwise independence in, 108–109
- testing nonlinear serial independence in, 109–110
- testing univariate asymmetry in, 104–106
- getting started, 343–346
- installation of, 323–324
- kernel estimation in, 328–331
- mixed-data multivariate density equality testing with, 142–143
- multivariate copulae estimation from, 141
- multivariate local polynomial estimation in, 234–235
- non-nested model comparison, 357–359

nonparametric discrete choice models, 360–362

nonparametric instrumental regression in, 283–284

npksum function, 348–349

overview, 343

parametric linear fixed-effects model in, 270–271

probability function estimation in, 29–34

semiparametric models, 359–360

shape constrained nonparametric regression, 362–366

R package software, markdown for assignments in, 333–341

bulleted and numbered lists, 336–337

description of, 333–334

document creation, 338

document printing, 338–339

mathematical typesetting, 337–338

plots, 335–336

R markdown documents created in RStudio, 334

R markdown documents with R results, 334

R, RStudio, \TeX , and Git, 333

tables, 337

troubleshooting, 339–341

URL data read by R, 334

verbatim, 337

Random denominators, 209–211

Regression, *see* Conditional mean function estimation; Conditional mean function estimation with endogenous predictors

Relative entropy, 91

Ridge regression, 280

Robinson's partially linear model for semiparametric conditional mean function estimation,

- 291–294, 300–301
- Robustness, entropy and, 95–96
- Rosenblatt-Parzen kernel density estimator
- confidence bands for, 123–127
 - description of, 56
 - eruptions data estimates from, 82
 - mechanics of, 56–57
 - mixed-data, 132
 - properties of, 58–66
- RStudio Desktop, 325
- S**
- Score matching, propensity, 179–184
- Second conditional moment about the conditional mean or variance, 309
- Semiparametric conditional mean function estimation, *see also* See also Conditional mean function estimation
- Ichimura’s method (continuous Y), 297–298
 - Klein and Spady’s method (binary Y), 298–300
 - model performance assessment for continuous Y , 301–306
 - overview, 291
 - semiparametric single index models for, 296
 - varying coefficient models for, 294–296
- Semiparametric models, 359–360
- Shannon’s entropy, 90–91, 94, 109
- Shape constrained kernel regression, 245–248, 257–260
- Shape constrained nonparametric regression, 362–366
- Shrinkage
- local polynomial kernel regression and, 232–235
 - smooth kernel probability functions and, 18–19
- Silverman’s rule of thumb, 98
- Single index models, semiparametric, 296
- Singular design matrices, ill-posedness and, 279–280
- Sklar’s theorem, 138
- Smooth kernel binary choice and multinomial choice models, 159–162
- Smooth kernel conditional cumulative distribution function estimation, 152–153
- Smooth kernel conditional density function estimation, 148–150
- Smooth kernel conditional quantile function estimation, 157
- Smooth kernel copula function estimation, 137–139
- Smooth kernel cumulative distribution function estimation, 77–82
- Smooth kernel cumulative probability function estimation, 25–27
- Smooth kernel density function estimation
- asymptotic normality, 69–70
 - bandwidth selection, 71–75
 - IMSE-optimal bandwidth and rate of convergence, 66–67
 - IMSE-optimal kernel function, 67–69
 - overview, 56
 - Rosenblatt-Parzen kernel density estimator, 58–66
- Smooth kernel probability function estimation
- asymptotic normality, 18
 - ordered categorical variables and, 19–22
 - overview, 11–12
 - shrinkage and, 18–19
 - SMSE-optimal smoothing parameter, 16–17

- unordered categorical variables and, 12–16
- Smooth kernel quantile function estimation, 82–85
- Smooth mixed-data kernel density and cumulative distribution function estimation, 132–133
- Smoothed bootstrap, 170–171
- Smoothing parameters, *see also* Smooth kernel probability function estimation
- SMSE-optimal smoothing parameter, 16–17, 34
- Stanford University, 325
- Statistical mechanics, 89
- Stein effect, 18, 34
- Summed MSE (SMSE)-optimal smoothing parameter, 16–17, 34, 39

- T**
- Tables, R package software for, 337
- Tail dependence, 140–141
- TeX typesetting system, 325, 337–338
- Time series kernel regression, 240–245
- Transformation methods, for boundaries, 113–114
- Transforms, in computational consideration, 328
- Treatment effects and propensity score matching, average, 179–184
- Tree-based methods, for computations, 328

- U**
- U.S. Current Population Survey, 132, 199
- Univariate asymmetry in continuous density and cumulative distribution functions, 104–106
- Univariate densities, equality of, 106–108
- UNIX platforms, 324
- Unordered Aitchison and Aitken kernel estimator, 15
- Unordered categorical variables, smooth kernel probability functions and, 12–16
- URL data read by R package software, 334

- V**
- Variance
 - conditional variance function estimation, 309–312
 - pointwise, 214–216, 225, 229
- Varying coefficient models for semiparametric conditional mean function estimation, 294–296

- W**
- Weighted least squares estimation in kernel regression, 248–249
- Windows platforms, 324

- Y**
- Yellowstone National Park, 51