

Subject Index

- AICC criterion, 363–368
- Aitken estimators, 37n3, 148, 179, 185, 196
- Almon lag, 419
- analysis of covariance (ANCOVA): *F* statistic and, 21, 23; homogeneity and, 17–26; Kuh and, 24–26; linear regression models and, 17–26, 35, 37; parameter constancy and, 193; parameter number and, 18; random-coefficient model and, 177, 179, 186; residual sum of squares (RSS) and, 19–21, 22t; time series and, 24–26; within-group estimates and, 19
- analysis of variance (ANOVA): fixed-coefficient model and, 182; linear regression models and, 17, 35; time and, 182
- arbitrary error structure, 69–75
- asymptotics: count data model and, 442–443; cross-sectionally dependent panel data and, 328, 333, 336–337, 340–345, 349; diagonal path limits and, 131; discrete data and, 233, 240, 242, 246n13, 249–250, 259, 266t, 271–273; duration model and, 434; dynamic models and, 81–86, 94, 96–99, 101, 103, 105–107, 111n18, 112–113, 115–121, 124, 126–135; dynamic systems and, 374–377, 381–382, 385–386, 388–392, 395–402; incomplete panel data and, 410, 414–415, 428–429; joint limits and, 131; multidimensional, 13, 469, 472; nonparametric panel data and, 462–463; normality and, 75–77, 82n2, 288; panel data advantages and, 9, 469; panel data issues and, 13, 472; panel quantile regression and, 447; sample truncation and, 283, 287–289, 295, 298–299, 305, 310, 313, 323, 326; sequential limits and, 130; simple regression and, 44, 47, 52, 55, 57–58, 65–68, 72–77; simulation methods and, 451–452; static simultaneous-equations models and, 136, 139, 143, 146–147, 150–152, 183n2; variable coefficient models and, 121, 174–178, 185–186, 193, 196, 201n16, 208, 223–225
- attrition: bias and, 292–296; Gary income-maintenance project and, 296–298; Hausman-Wise two-period model of, 295, 297–298; incomplete panel data and, 408; panel data issues and, 13, 469, 472–473; probability and, 292–296; sample selection and, 292–298, 300t, 312, 472–473
- augmented Dickey-Fuller (ADF) test, 389–390, 392, 395
- autocorrelation: cross-sectionally dependent panel data and, 331, 363; dynamic models and, 86, 94; heteroscedasticity and, 68–69; incomplete panel data and, 417n6; measurement errors and, 460; serially correlated errors and, 65–68; simple regression models and, 34, 64–69; variable coefficient models and, 214t, 217, 224

- autoregression: cross-sectionally
 dependent panel data and, 329–332,
 334, 336, 345, 363; discrete data and,
 251; dynamic models and, 82n2, 86,
 104, 118; dynamic systems and,
 369–378, 390; heterogeneity and,
 377–378; heteroscedastic
 autoregression (HAC) covariance
 matrix and, 331, 363; homogeneity
 and, 370–377; incomplete panel data
 and, 417n6, 418, 422, 425–426; panel
 vector models and, 370–378; sample
 selection and, 324; simple regression
 and, 66; simulation methods and, 450;
 variable coefficient models and, 187,
 207n18; vector autoregressive (VAR)
 models and, 369–378, 386, 393n7, 397
 autoregressive moving average (ARMA),
 187
 average treatment effect (ATE), 352–353

 Bank of America, 438
 baseline hazard function, 433
 Bayesian methods, xix; incomplete panel
 data and, 412, 415n5; mode estimators
 and, 174; panel data issues and, 471;
 variable coefficient models and, 174,
 198–201, 204–205, 208–212
 best linear unbiased estimators (BLUE):
 simple regression models and, 36,
 38–39, 41, 52, 60, 63; variable
 coefficient models and, 183–185, 195
 bias: adjusted estimators and, 270–273;
 attrition and, 292–296; best linear
 unbiased estimators (BLUE) and, 36,
 38–39, 41, 52, 60, 63, 183–185, 195;
 control groups and, 356;
 cross-sectionally dependent panel data
 and, 337, 340, 342, 344–346, 349, 354,
 356, 360; discrete data and, 230,
 242–243, 254–255, 264, 270–273,
 280; dynamic models and, 81–86, 97,
 99, 103–104, 108, 109t, 111–112,
 117–119, 123, 128, 133, 270–273;
 dynamic systems and, 381, 388–389,
 400–402; fixed-effects inference and,
 56, 467; homogeneity and, 24;
 incomplete panel data and, 412, 417,
 419; linear regression models and, 24,
 33, 36, 38, 41, 50–52, 55–58, 61;
 ordinary least squares (OLS)
 estimators and, 85–86, 97; panel data
 advantages and, 7–8, 464, 467–468;
 panel data issues and, 11–14, 471–472;
 panel quantile regression and, 447;
 probability and, 292–296; random
 effects and, 56, 85–86, 467; reducing,
 270, 467–468; sample truncation and,
 282, 290, 292–297, 312, 314; selection,
 14, 292–296, 312, 354, 360; simulation
 methods and, 450, 452, 455–457; state
 dependence and, 270–273; static
 simultaneous-equations models and,
 136–137, 143, 152; variable coefficient
 models and, 173–175, 178, 180, 183,
 184n10, 200, 210, 211t, 215, 220, 223
 bounding parameters, 274–276
 Box-Jenkins method, 67, 193, 363, 379
 British Household Panel Survey (BHPS),
 2
 Brownian motion, 134, 394, 396
 Bureau of the Census, 403–404

 cell-mean correction, 19, 27t–28t
 Center for Research in Security Prices
 (CRSP), 437
 central limit theory, 135
 Chamberlain-pi approach, 69–75
 chi-square distribution, 9, 233, 262n18,
 268t, 377, 391
 Cobb-Douglas production function, 32
 cointegrated panel models: common
 trends and, 379–380; estimation and,
 381–386; heterogeneity and, 383–386;
 homogeneity and, 381–383;
 maximum-likelihood estimators
 (MLE) and, 382–384;
 minimum-distance estimators (MDE)
 and, 382–383; properties of, 379–380
 cointegration tests: likelihood approach
 and, 395–397; residual-based, 394–395
 common correlated effects heterogeneous
 model (CCEMG), 350, 351t
 common correlated effects model
 (CCEP), 350, 351t
 common trends, 379–380
 Community Innovation Surveys (CIS), 3
 conditional inference, 48–56, 372, 470

- control groups: average difference and, 353; bias and, 356; confounding variables and, 353; cross-sectionally dependent panel data and, 353–357, 360–369; difference-in-difference method and, 360; frequency weight and, 357; mean difference and, 353; population sources and, 354; predicting counterfactuals and, 361–369; propensity score method and, 355–357, 360; sample selection and, 296; treatment groups and, 353–357, 360–361
- correlated random-coefficient models: conventional fixed-effects estimators and, 223–224; group mean estimators and, 223; identification with cross-sectionally dependent panel data and, 221–222; introduction to, 220; mean effects estimation and, 223–227; panel pooled maximum-likelihood estimators and, 224–226; semiparametric estimates and, 227
- count data model: asymptotics and, 442–443; density and, 442; dependent variables and, 444; exogenous variables and, 441; incidental parameters and, 443; individuals and, 441–443; infinity and, 442; log-likelihood function and, 441–443; maximum-likelihood estimators (MLE) and, 442–443; negative binomial distribution and, 442; Poisson process and, 439–440, 443–444; probability and, 438–439, 441t, 444; statistics and, 443
- counterfactuals: control group information and, 361–369; cross-sectionally dependent panel data and, 361–369, 469; panel data advantages and, 469; prediction of, 361–369
- covariance (CV) estimators: cross-sectionally dependent panel data and, 331; dynamic models and, 80–84, 92, 123, 132; fixed effects and, 47–56; heteroscedasticity and, 68–69; incomplete panel data and, 411; least-squares estimators and, 43; random effects and, 40–41; simple regression models and, 37–44, 47–57, 59–65, 67–69; static simultaneous-equations models and, 164
- Cowles Commission, 139
- Cramer-Rao bound, 57
- cross-sectionally dependent panel data, xxi; adjustment methods and, 354–359; AICC criterion and, 363–368; arbitrary labeling and, 327; asymptotics and, 328, 333, 336–337, 340–345, 349; autocorrelation and, 331, 363; autoregression and, 329–332, 334, 336, 345, 363; bias and, 337, 340, 342, 344–346, 349, 354, 356, 360; change inferences and, 5; common correlated effects heterogeneous model (CCEMG) model and, 350, 351t; common correlated effects model (CCEP) and, 350, 351t; control groups and, 353–357, 360–369; counterfactual prediction and, 361–369, 469; covariance (CV) estimators and, 331; degrees of freedom and, 345, 348–349; density and, 356; dependent variables and, 329, 348–350; difference-in-difference method and, 360–361; discrete-response models and, 230–235; dummy variable and, 343, 352; economic distance and, 331; efficiency and, 327; error-component model and, 334, 345; error terms and, 329, 336; example of, 350–351; exogenous variables and, 336; factor approach and, 327, 337–342; feasible generalized least-squares estimators (FGLS) and, 328, 335, 342; fixed constants (FE) and, 334–335; fixed effects and, 334, 340, 360; generalized method of moments (GMM) and, 341, 346, 348n8; group mean augmented approach and, 342–344; heterogeneity and, 350, 360; heteroscedasticity and, 331, 340–341, 363; homogeneity and, 350, 356; independence testing and, 344–351; individuals and, 327–331, 334–336, 339–340, 352–353, 357, 359–364; infinity and, 331, 333–334, 336, 363; instrumental

- cross-sectionally dependent panel data (*cont.*)
 variable (IV) estimators and, 333;
 issues of, 327–329; Lagrangians and, 344–345, 349; least-squares estimation and, 328–329, 333, 339–345, 364;
 linear model and, 344–348; local average treatment effect (LATE) and, 352n9; log-likelihood function and, 332–336; marginal treatment effect (MTE) and, 352n9; matching observables and, 355–357; matrices and, 327–331, 334, 336–340, 344, 350, 362; maximum-likelihood estimators (MLE) and, 354, 374–375, 383, 398, 400, 402; Monte Carlo studies and, 342, 346, 348, 350; neighbors and, 329–331, 333; nonparametric panel data and, 331, 355, 357, 359–368; normalization and, 329, 332, 337–338, 340; null hypotheses and, 344; omitted variables and, 327; ordinary least squares (OLS) estimation and, 364, 368; panel data issues and, 471–472; parametric models and, 331, 354, 357, 359–360; probability and, 339, 355, 357, 361; probit models and, 349; program evaluation and, 352–368; propensity score method and, 355–357, 360; random-coefficient models and, 221–222; random effects and, 335; regression discontinuity design and, 357–359; regression models and, 328–329, 339, 341, 350, 357–358; seemingly unrelated regression method (SUR) and, 328; simple regression models and, 328; spatial approach and, 329–337, 344; standard two-way effects models and, 327; statistics and, 327–328, 344–346, 348–350, 354–355, 364, 368; stochastics and, 347–348; SYR test and, 346–348; test of cross-sectional independence and, 344–351; time series and, 331, 339–340, 344–351, 362; time-specific variables and, 327, 331, 337; time-variant coefficients and, 180–186; Tobit models and, 348–349; treatment effects and, 352–368; variable coefficient models and, 170–186, 221–222; vector autoregressive (VAR) models and, 377–378
- cross-sectionally independent panel data, 350, 377; unit root tests and, 387–391
- cumulative distribution function: discrete data and, 245, 249, 253; duration model and, 430–431
- Current Population Survey and Social Security Administration (CPS-SSA), 323–324
- degrees of freedom: cross-sectionally dependent panel data and, 345, 348–349; dynamic models and, 105–107, 118; dynamic systems and, 386, 390, 396; homogeneity and, 18, 21, 23–25, 27t, 29t; incomplete panel data and, 414, 421, 428–429; linear regression models and, 18, 21, 23–25, 27t, 29t, 54–55, 57–58, 73, 77; panel data advantages and, 4, 464; panel data issues and, 470; sample truncation and, 314, 317; variable coefficient models and, 168, 174, 177–179, 186, 193, 209, 215, 223
- density: conditional, 9–10, 54–55, 177–179, 191, 209, 239, 274, 294, 356, 448–449, 452; count data model and, 442; cross-sectionally dependent panel data and, 356; discrete data and, 231–232, 239, 245–246, 259–260, 274; dynamic models and, 107; incomplete panel data and, 404; normal density function and, 231, 246, 259, 289, 293; panel data advantages and, 9–10; panel data issues and, 10; panel quantile regression and, 445; sample truncation and, 282–284, 289–291, 296, 298, 302, 305, 312, 326; simple regression and, 39, 54–56; simulation methods and, 448–452; variable coefficient models and, 177–179, 191, 205, 209, 216
- dependent variables: count data model and, 444; cross-sectionally dependent panel data and, 329, 348–350; discrete data and, 230, 233, 236, 250, 256, 259, 262, 270; dynamic models and, 80–81, 85–86, 97, 111–112, 115; dynamic systems and, 369, 376–377; incomplete panel data and, 412–414,

- 418; limited model and, 348–350; measurement errors and, 458; model of limited dependent variables and, 281; multilevel structures and, 453; nonparametric panel data and, 463; panel data advantages and, 467–468; panel data issues and, 14, 472; sample truncation and, 281–282, 284–285, 287, 290, 292, 295, 317, 325; simple regression and, 34, 39, 49t, 67; static simultaneous-equations models and, 136, 138, 144, 161, 163; variable coefficient models and, 175–176, 190, 215t, 216t
- difference-in-difference method, 360–361
- discrete data, xix; asymptotics and, 233, 240, 242, 246n13, 249–250, 259, 266t, 271–273; autoregression and, 251; bias and, 230, 242–243, 254–255, 264, 270–273, 280; bounding parameters and, 274–276; conditions for existence of consistent estimators and, 238–242; cumulative distribution function and, 245, 249, 253; density and, 231–232, 239, 245–246, 259–260, 274; dependent variables and, 230, 233, 236, 250, 256, 259, 262, 270; discrete-response models and, 230–235; distributed-lag models and, 263; dummy variable and, 239, 268; dynamic models and, 250–270; efficiency and, 233, 242, 245; equilibrium and, 252–254; error-component model and, 265; error terms and, 231, 235–236, 243–245, 251–252, 262–263; exogenous variables and, 242, 252, 254–255, 258, 265, 267, 270, 277, 471n1; fixed constants (FE) and, 251, 254, 270; fixed effects and, 236–243, 254–255, 256t, 270–272; Gaussian quadrature and, 245, 248; generalized method of moments (GMM) and, 246, 261n17; Hermite integration formula and, 245; heterogeneity and, 230, 235–246, 251–252, 261–271, 278; homogeneity and, 236, 253; incidental parameters and, 236–240, 244, 247–248, 271; independence of irrelevant alternatives and, 235; individuals and, 230–239, 242–243, 248–252, 254–255, 260–263, 265, 268–271, 277n21; infinity and, 238–240, 243, 246, 253–255, 259; initial conditions and, 252–255, 256t, 261; least-squares estimation and, 232–233, 239; linear-probability model and, 231–232, 238, 247; logit models and, 231–232, 234, 237–239, 241–242, 256, 259, 268, 271, 276–280, 471n1; log-likelihood function and, 237, 240–241, 243–244, 258, 263, 265, 266t, 272, 280; Markov process and, 251–253, 255, 256t, 265; matrices and, 232–233, 240–242, 244, 246, 250–255, 264, 266, 272; maximum-likelihood estimators (MLE) and, 233, 236–240, 245, 255, 263–264, 278; maximum score estimators and, 247–249; minimum-distance estimators and, 246; Monte Carlo studies and, 242, 254–255, 256t, 270, 273, 280; Newton-Raphson method and, 233, 280; normalization and, 235–236, 241, 246–250, 252, 270, 279; null hypotheses and, 255, 262n18; omitted variables and, 235, 243; parametric models and, 230–231, 235–250, 255; probability and, 231–232, 234–236, 238–257, 261–265, 268–275; probit models and, 231, 234, 236n4, 241–244, 254–255, 261n17, 264, 268t; random-coefficient models and, 236n4; random effects and, 242–246, 253–256, 261n17, 265, 268–270; regression models and, 232, 237, 239, 244, 252; root- N consistent estimators and, 249–250; semiparametric models and, 230, 235, 246–250, 255; state dependence and, 230, 252, 261–280; static models and, 230, 235–250, 255, 265–266; statistics and, 230, 233, 235–236, 239, 255, 261, 262n18, 265, 266t, 268t, 269–280; stochastics and, 251–254, 278; structural parameters and, 238–239, 242, 248, 254n16, 271, 278; Taylor series and, 273; time series and, 243, 257, 269–270; variance-components models and, 266; vectors and, 230–233, 247, 254n16

- discrete-response models, 230–235
- distance to default (DTD), 437
- distributed-lag models: common
 assumptions and, 419–420; discrete data and, 263; estimation and, 428–429; exogenous variables and, 421–425; incomplete panel data and, 16, 80n1, 418–429; lag coefficients and, 6, 418–429; panel data advantages and, 6; prior structure identification and, 421–425; short panels and, 418–429; testing and, 428–429
- dummy variable: cross-sectionally
 dependent panel data and, 343, 352; discrete data and, 239, 268; dynamic models and, 81, 110–111; incomplete panel data and, 410; least-squares estimation and, 34–39; nonparametric panel data and, 463; panel data advantages and, 5, 467; sample truncation and, 297; simple regression models and, 34–39, 48; static simultaneous-equations models and, 142; variable coefficient models and, 168
- duration model: asymptotics and, 434;
 baseline hazard function and, 433; cumulative distribution function and, 430–431; distance to default (DTD) and, 437; exit intensity and, 435–436; exogenous variables and, 433; failure time and, 433; hazard function and, 431–435; heterogeneity and, 433–434; individuals and, 430–435, 437; least-squares estimation and, 432–433; matrices and, 432–434; measurement errors and, 430; normalization and, 434; parametric models and, 434; probability and, 430–431, 433, 435, 438; regression models and, 432; statistics and, 430; survival function and, 431
- dynamic models: arbitrary serial
 correlations and, 121–122; asymptotics and, 81–86, 94, 96–99, 101, 103, 105–107, 111n18, 112–113, 115–121, 124, 126–135; autocorrelation and, 86, 94; autoregression and, 82n2, 86, 104, 118; bias and, 81–86, 97, 99, 103–104, 108, 109t, 111–112, 117–119, 123, 128, 133, 270–273; bounding parameters and, 274–276; censored, 317–324; conditional approach and, 255–261; covariance (CV) estimators and, 80–84, 92, 123, 132; density and, 107; dependent variables and, 80–81, 85–86, 97, 111–112, 115; diagonal path limits and, 131; discrete data and, 250–270; dummy variable and, 81, 110–111; efficiency and, 80, 103–104, 121, 128; endogenous variables and, 111; error-component model and, 85, 94, 96, 106, 108, 109t; error terms and, 81, 93, 107, 111, 118; examples of, 108–111, 264–270; exogenous variables and, 81–89, 93–94, 105, 107–108, 112, 121–122, 123n21; fixed constants (FE) and, 80, 88, 95, 123–124; fixed effects and, 80–83, 111–121, 132; generalized method of moments (GMM) and, 81, 89, 99–106, 112, 116–122, 125–128; general model and, 250–252; heterogeneity and, 111, 134, 261–264; homogeneity and, 92, 120–121; incidental parameters and, 81, 92, 97n12, 112, 120; independent variables and, 135; individuals and, 80–93, 97–98, 105, 108, 110–112, 117–129; infinity and, 81–83, 86, 91, 93–94, 97, 99, 111, 121, 124, 128, 130–132; initial conditions and, 81, 82n2, 85, 89–91, 98–99, 106–107, 117n20; instrumental variable (IV) estimators and, 81, 89, 98–99, 117, 125, 128; joint limits and, 131; least-squares estimation and, 81, 82n2, 85, 95–96, 104, 111, 115, 122–123, 133–134; log-likelihood function and, 106–107, 127–128; Markov process and, 251–253, 255, 256t, 265; matrices and, 94–97, 100–102, 104, 106–107, 109t, 112–113, 115–116, 126–130, 134; maximum-likelihood estimators (MLE) and, 81, 89–96, 99, 106–107, 117n20; mean square error and, 93, 103, 118, 120t; measurement errors and, 87; minimum-distance estimators (MDE) and, 95–96, 114–121,

- 129–130; Monte Carlo studies and, 84, 86, 94, 107, 117–118, 128; multicollinearity and, 91, 111; normalization and, 117; null hypotheses and, 106; omitted variables and, 97; ordinary least squares (OLS) estimation and, 85–86, 97, 99, 110–111; orthogonality and, 100, 105, 112, 125; probability and, 82n2, 85, 123, 131–132; random-coefficient models and, 206–212; random effects and, 80–81, 84–108, 109t, 120–121; regression models and, 84, 97, 111, 130, 133–135; sample selection and, 324–326; sequential limits and, 130; spatial approach and, 336–337; state dependence and, 261–264; static models and, 80–82, 100, 112; statistics and, 82n2, 84, 86n5, 105–108, 117, 121, 124, 130; stochastics and, 82n2, 87–88, 92, 94–95, 104, 108; Taylor series and, 129; time series and, 81, 83, 91, 108, 110, 119, 124, 130, 133–135; time-specific variables and, 80–81, 122–129; Tobit models and, 324–326; transformed likelihood approach and, 112–115; variance-components models and, 107; vectors and, 80, 87, 93, 94n9, 97, 100, 112, 121, 124, 131
- dynamic systems: asymptotics and, 374–377, 381–382, 385–386, 388–392, 395–402; autoregression and, 369–378, 390; bias and, 381, 388–389, 400–402; change inferences and, 5; cointegrated panel models and, 379–386; cointegrating system and, 383–386; cointegration tests and, 394–397; common trends and, 379–380; degrees of freedom and, 386, 390, 396; dependent variables and, 369, 376–377; endogenous variables and, 369; equilibrium and, 380, 393n7; error terms and, 397–399; exogenous variables and, 369; fixed constants (FE) and, 372, 400–401; fixed effects and, 372, 382; generalized method of moments (GMM) and, 373–374, 377, 382, 401–402; heterogeneity and, 370, 377–378, 383–386, 390–392, 395–396; heteroscedasticity and, 382n5, 387–388; homogeneity and, 370–377, 386, 389–390, 395–396, 399; incidental parameters and, 372, 375; individuals and, 369–373, 377, 380–383, 386–390, 393–399, 402; infinity and, 392, 400–402; instrumental variable (IV) estimators and, 373, 401–402; joint dependent variables and, 369; Lagrangians and, 391; least-squares estimation and, 377–378, 381, 387–389, 394–395; likelihood approach and, 386, 395–396, 398–401; log-likelihood function and, 384, 399–400; matrices and, 370–385, 396–402; maximum-likelihood estimators (MLE) and, 386, 395–396, 398–401; minimum distance estimators (MDE) and, 375–377, 382; Monte Carlo studies and, 377, 382, 389–390, 394–395, 402; nonparametric panel data and, 390; normalization and, 380, 382, 385; null hypotheses and, 385–387, 390, 392; orthogonality and, 373, 401; parametric models and, 390; pooling and, 383, 389; probability and, 372, 394; random-coefficient models and, 392; random effects and, 372, 399; regression models and, 377–378, 382, 384, 386–387, 389–392, 395; simultaneous equations models and, 397–402; statistics and, 369, 377, 385–397; time series and, 16, 369–372, 377–379, 383, 386–387, 390, 392–395; time-specific variables and, 393; unit root tests and, 386–394; vector autoregressive (VAR) models and, 369–378, 380, 386, 393n7, 397; vectors and, 369–386, 393, 396–399
- efficiency: cross-sectionally dependent panel data and, 327; discrete data and, 233, 242, 245; dynamic models and, 80, 103–104, 121, 128; generalized least-squares estimators and, 147; panel data advantages and, 4, 8; panel data issues and, 470, 473; simple

efficiency (*cont.*)

regression and, 32–33, 44, 50, 52, 54–55, 75n25; simulation methods and, 452; static simultaneous-equations models and, 136, 140, 143, 153; variable coefficient models and, 197, 224

eigenvectors, 148, 151, 334n4, 338–340

endogenous variables: dynamic models and, 111; dynamic systems and, 369; sample truncation and, 296; simple regression and, 73; static simultaneous-equations models and, 137, 151, 155, 159

English Longitudinal Study of Aging (ELSA), 4

equations: analysis of covariance

(ANCOVA), 18–21, 23; Cobb-Douglas production function, 32; count data model, 439–444; cross-sectionally dependent panel data, 328–350, 352–363; discrete data, 230–235, 237–255, 257–263, 267, 269, 271–279; distribution-lag model, 6; duration model, 430–438; dynamic models, 80, 82–110, 112–116, 118, 121–134; dynamic simultaneous, 397–402; dynamic systems, 370–402; homogeneity, 17–21, 23, 25t; incomplete panel data, 404–411, 413–416, 418–429; least-square estimation, 14; least-squares dummy variable, 34–39; linear regression models, 11, 17–21, 23, 25t, 32, 34–47, 50–55, 58–79; measurement errors, 455–460; multilevel structures, 453–455; nonparametric panel data, 461–463; panel quantile regression, 445–447; sample truncation, 281–283, 285–295, 298–299, 301–302, 304–307, 309–312, 317, 321–326; simple regression model, 6–7, 17–21, 23, 25t, 32, 34–37, 50–55, 58–79; simulation methods, 448–452; slope coefficients, 15; static simultaneous-equations models, 136–166; Tobit model, 9; variable coefficient models, 168–202, 205–209, 212–213, 217–218, 222–229

equilibrium: discrete data and, 252–254; dynamic systems and, 380, 393n7; incomplete panel data and, 413

error-component model: cross-sectionally dependent panel data and, 334, 345; discrete data and, 265; dynamic models and, 85, 94, 96, 106, 108, 109t; incomplete panel data and, 404; multilevel structures and, 430, 453, 455; nonparametric panel data and, 461; sample truncation and, 292; simple regression models and, 39n5, 40, 64, 75; static simultaneous-equations models and, 139, 143–144, 147, 151–153; variable coefficient models and, 168n1, 174, 198, 200, 201n16

error-component two-stage least-squares estimators (EC2SLS), 147–148, 152, 154

error sum of squares (ESS), 219t

error terms: cross-sectionally dependent panel data and, 329, 336; discrete data and, 231, 235–236, 243–245, 251–252, 262–263; dynamic models and, 81, 93, 107, 111, 118; dynamic systems and, 397–399; homogeneity and, 18; incomplete panel data and, 404, 411, 414, 416, 420; linear regression models and, 18, 35, 50, 59, 63, 65–67, 69; mean square error and, 47; panel data advantages and, 6, 467; panel data issues and, 11, 14; sample truncation and, 281–282, 284–285, 287, 290, 292, 298, 302, 313–314, 317, 325; static simultaneous-equations models and, 139, 144, 152; variable coefficient models and, 183–185, 206. *See also* bias

Euclidean norm, 132, 247

Euclidean space, 330

European Community Household Panel (ECHP), 3

Eurostat, 2–3

exit intensity, 435–436

exogenous variables: count data model and, 441; cross-sectionally dependent panel data and, 336; discrete data and, 242, 252, 254–255, 258, 265, 267, 270,

- 277; distributed lag models and, 421–425; duration model and, 433; dynamic models and, 81–89, 93–94, 105, 107–108, 112, 121–122, 123n21; dynamic systems and, 369; homogeneity and, 17–18; incomplete panel data and, 418, 421–425; linear regression models and, 17–18, 34–35, 53; nonparametric panel data and, 461; panel data advantages and, 6, 467; panel data issues and, 11, 14, 471n1; prior structure identification and, 421–425; sample truncation and, 281, 287, 325; static simultaneous-equations models and, 137, 144, 153, 155, 161; variable coefficient models and, 169, 177, 187, 193–196, 198, 206
- factor approach, 327, 337–342
- failure time, 433
- feasible general least-squares estimators (FGLS), 44, 65, 127–128, 225–226, 328, 335, 342
- fixed-coefficient models: BLUEs and, 183; complete heterogeneity and, 170–171; heterogeneity and, 170–172; mixed fixed- and random-coefficient model and, 196–206; random-coefficient models and, 223–224; variable coefficient models and, 170–172, 177–178, 182–183, 196–206, 216–217
- fixed constants (FE): cross-sectionally dependent panel data and, 334–335; discrete data and, 251, 254, 270; dynamic models and, 80, 88, 95, 123–124; dynamic systems and, 372, 400–401; incomplete panel data and, 407; linear regression models and, 24, 33, 38–39, 41, 50, 59, 62, 66; nonparametric panel data and, 461; panel data issues and, 13; simple regression models and, 33, 38–39, 41, 50, 59, 62, 66; variable coefficient models and, 170, 193, 210, 212, 223
- fixed-effects inference, 56, 467
- fixed-effects models: censored regression and, 306–311; conditional inference and, 48–56; conditions for existence of consistent estimators and, 238–242; cross-sectionally dependent panel data and, 334, 340, 360; discrete data and, 236–243, 254–255, 256t, 270–272; dynamic models and, 80–83, 111–121, 132; dynamic systems and, 372, 382; generalized method of moments (GMM) and, 116–119; incomplete panel data and, 408; individual correlations and, 52–56; linear regression models and, 34–39, 43–44, 47–59, 67; maximum-likelihood estimators (MLE) and, 236–238; minimum distance estimators (MDE) and, 114–121, 129–130; misspecification tests and, 56–58; Mundlak's formulation and, 50–54, 56; pairwise trimmed least-squares estimators and, 299–311; panel data advantages and, 467; panel data issues and, 10–11, 13, 470; panel quantile regression and, 447; random effects and, 47–56; sample truncation and, 299–314, 315t; simple regression models and, 47–56; specification issues and, 119–121; static simultaneous-equations models and, 138n2, 142; transformed likelihood approach and, 112–115; truncated regression and, 301–306; unconditional (marginal) inference and, 48–56; variable coefficient models and, 182, 223–224, 227
- Frisch-Waugh FGLS approach, 342
- Frobenius norm, 171
- F* statistic, 21, 23, 214t, 215t
- fuzzy regression discontinuity (FRD), 357–358
- Gary income-maintenance project, 296–298
- Gaussian quadrature, 245, 248
- generalized least-squares (GLS) estimators: cross-sectionally dependent panel data and, 328, 332, 335–336, 342; dynamic models and, 89, 96–97, 104, 106, 110t, 111, 120, 124, 126–128; incomplete panel data

- generalized least-squares (GLS) (*cont.*)
 and, 405–408; multilevel structures
 and, 454; sample truncation and,
 295, 297; simple regression and,
 41–44, 47n8, 52–68, 75; static
 simultaneous-equations models and,
 142–144, 151–152, 162; variable
 coefficient models and, 171–175, 178,
 184–185, 190, 195–196, 200–201,
 225–226
- generalized method of moments (GMM):
 cross-sectionally dependent panel data
 and, 341, 346, 348n8; discrete data
 and, 246, 261n17; dynamic models
 and, 81, 89, 99–106, 112, 116–122,
 125–128; dynamic systems and,
 373–374, 377, 382, 401–402;
 fixed-effects models and, 116–119;
 incomplete panel data and, 407;
 maximum-likelihood estimators
 (MLE) and, 116–119; measurement
 errors and, 460; sample truncation and,
 323–326; simple regression models
 and, 70, 75n26; simulation methods
 and, 451–452; vector autoregressive
 (VAR) models and, 373–374
- German Social Economics Panel
 (GSOEP), 2
- Gibbs sampler, 209–210
- global vector autoregressive (GVAR)
 models, 378, 386
- group mean augmented approach,
 342–344
- Grunfeld investment function, 168,
 175
- Hausman type test statistic, 57–58, 105,
 121, 408
- Hausman-Wise (HW) model, 295,
 297–298
- hazard function, 431–435
- Health and Retirement Study (HRS), 3
- Heckman two-step estimators, 238–244,
 288, 299
- Hermite integration formula, 245
- heterogeneity, 16; autoregression and,
 377–378; cointegrating system and,
 383–386; common correlated effects
 heterogeneous model (CCEMG) and,
 350, 351t; complete, 170–171;
 cross-sectionally dependent panel data
 and, 350, 360; discrete data and, 230,
 235–246, 251–252, 261–271, 278;
 duration model and, 433–434; dynamic
 models and, 111, 134; dynamic
 systems and, 370, 377–378, 383–386,
 390–392, 395–396; fixed-coefficient
 models and, 170–171; fixed-effects
 models and, 236–242; group, 171–172;
 homogeneity and, 20–24, 26n4;
 intercepts and, 11, 20–23; linear
 regression models and, 31, 50, 53–54,
 56; panel data advantages and, 5–6, 8,
 464–465, 468; panel data issues and,
 10–13, 469–470; parametric approach
 and, 235–246; random-effects models
 and, 242–246; sample truncation and,
 298; simulation methods and, 448;
 state dependence and, 261–264; static
 models and, 235–246; static
 simultaneous-equations models and,
 136; time and, 10–13; unobserved,
 10–15, 31, 111, 136, 167–169, 202,
 252, 270–271, 278, 298, 360, 434, 448,
 465, 469–470; unobserved across
 individuals and over time and, 10–13;
 variable coefficient models and,
 167–171, 178–180, 186, 196–197,
 202, 204, 212, 214t, 215, 217–219;
 variable-intercept models and, 15,
 31–32; vector autoregressive (VAR)
 models and, 377–378
- heteroscedastic autoregression (HAC)
 covariance matrix, 331, 363
- heteroscedasticity: autocorrelation and,
 68–69; covariance (CV) estimators
 and, 68–69; cross-sectionally
 dependent panel data and, 331,
 340–341, 363; dynamic systems and,
 382n5, 387–388; homogeneity and, 24;
 linear regression models and, 24, 34,
 39n5, 64–70, 73n22; sample truncation
 and, 284, 313; serially correlated errors
 and, 65–68; simple regression models
 and, 34, 39n5, 64–70, 73n22; static
 simultaneous-equations models and,
 145, 147, 149; variable coefficient
 models and, 170, 176, 179, 184–185,
 224
- Hildreth-Houck estimators, 184n10

- homogeneity: autoregression and, 370–377; bias and, 24; cointegrated panel models and, 381–383; common correlated effects model (CCEP) and, 350, 351t; cross-sectionally dependent panel data and, 350, 356; degrees of freedom and, 18, 21, 23–25, 27t, 29t; discrete data and, 236, 253; dynamic models and, 92, 120–121; dynamic systems and, 370–377, 386, 389–390, 395–396, 399; error terms and, 18; exogenous variables and, 17–18; fixed constants (FE) and, 24; *F* statistic and, 21, 23; heterogeneity and, 20–24, 26n4; heteroscedasticity and, 24; incomplete panel data and, 409; individuals and, 17–19, 22t, 25–26; least-squares estimation and, 17, 19–20, 24; linear regression model tests and, 17–30; nonparametric panel data and, 461; null hypotheses and, 24; panel data advantages and, 4, 8, 465, 468; panel data issues and, 11; probability and, 17; residual sum of squares (RSS) and, 19–21, 22t; simple regression and, 31–32; slope and, 11, 20–24, 26; statistics and, 21, 23–24, 26; time series and, 24–26; variable coefficient models and, 177–179, 202, 213, 215t, 217; vector autoregressive (VAR) models and, 370–377; within-group estimators and, 19
- idempotent (covariance) transformation matrix, 37, 40, 77, 141
- identity matrix, 36, 141–143, 148, 380, 385
- importance sampling, 450
- incidental parameters: count data model and, 443; discrete data and, 236–240, 244, 247–248, 271; dynamic models and, 81, 92, 97n12, 112, 120; dynamic systems and, 372, 375; linear regression models and, 55–56, 65; multidimensional statistics and, 13; panel data issues and, 11, 13, 470–471; sample truncation and, 302, 312
- income-schooling model, 136–137, 154, 466
- incomplete panel data: asymptotics and, 410, 414–415, 428–429; attrition and, 408; autocorrelation and, 417n6; autoregression and, 417n6, 418, 422, 425–426; Bayesian methods and, 412, 415n5; bias and, 412, 417, 419; covariance (CV) estimators and, 411; degrees of freedom and, 414, 421, 428–429; density and, 404; dependent variables and, 412–414, 418; distributed-lag models and, 16, 80n1, 418–429; dummy variable and, 410; equilibrium and, 413; error-component model and, 404; error terms and, 404, 411, 414, 416, 420; exogenous variables and, 418, 421–425; fixed constants (FE) and, 407; fixed effects and, 408; generalized method of moments (GMM) and, 407; homogeneity and, 409; independent variables and, 413–414; individuals and, 403–414, 417–420; infinity and, 409, 420; initial conditions and, 407, 426; instrumental variable (IV) estimators and, 425; lag coefficients and, 418–429; least-squares estimation and, 405, 415; matrices and, 405, 408, 410, 413–415, 421–422, 426–428; maximum-likelihood estimators (MLE) and, 406–407, 412–417; mean square error and, 410, 420; minimum-distance estimators and, 428; null hypotheses and, 414, 428; omitted variables and, 412–413, 417, 419; pooling of single cross-sectional data and, 411–418; probability and, 403; pseudopanel and, 16, 408–411; randomly missing data and, 403–408; regression models and, 412–413, 416, 423, 426–427; repeated cross-sectional data and, 408–411; rotating data and, 403–408; single time series data and, 411–418; statistics and, 404, 408–410, 415–416, 429; stochastics and, 421–422; time series and, 402–403, 405, 407, 411–419; vectors and, 404–405, 407, 409, 413–414, 420–422, 427–428
- independence of irrelevant alternatives, 235

- independence tests: example of, 350–351;
limited dependent-variable model and,
348–350; linear model and, 344–348
- independent variables: dynamic models
and, 135; incomplete panel data and,
413–414
- individuals, 1–3, 15; count data model
and, 441–443; cross-sectionally
dependent panel data and, 327–331,
334–336, 339–340, 352–353, 357,
359–364; discrete data and, 230–239,
242–243, 248–252, 254–255,
260–263, 265, 268–271, 277n21;
duration model and, 430–435, 437;
dynamic models and, 80–93, 97–98,
105, 108, 110–112, 117–129; dynamic
systems and, 369–374, 377, 380–383,
386–390, 393–399, 402; homogeneity
and, 17–19, 22t, 25–26; incomplete
panel data and, 403–414, 417–420;
linear regression models and, 17–19,
22t, 25–26, 31–40, 44, 48–70, 73;
measurement errors and, 455–459;
multilevel structures and, 453;
nonparametric panel data and, 462;
panel data advantages and, 4–10,
464–469; panel data issues and, 10–14,
469–473; panel quantile regression
and, 447; sample truncation and, 290,
292, 295–301, 311–312, 317–318, 325;
static simultaneous-equations models
and, 136–138, 144–145, 149–153;
unobserved heterogeneity and, 10–13;
variable coefficient models and,
167–180, 184–186, 193, 197–201, 204,
207–208, 214t, 215, 218, 220, 223, 227
- infinity: count data model and, 442;
cross-sectionally dependent panel data
and, 331, 333–334, 336, 363; discrete
data and, 238–240, 243, 246, 253–255,
259; dynamic models and, 81–83, 86,
91, 93–94, 97, 99, 111, 121, 124, 128,
130–132; dynamic systems and, 392,
400–402; incomplete panel data and,
409, 420; measurement errors and,
456; sample truncation and, 299, 323;
simple regression and, 38, 41, 47, 52,
58, 60–61, 63, 65, 67, 69–71; static
simultaneous-equations models and,
138n2, 142, 145, 149; variable
coefficient models and, 174, 176–178,
185, 196, 209
- initial conditions: discrete data and,
252–255, 256t, 261; dynamic models
and, 81, 82n2, 85, 89–91, 98–99,
106–107, 117n20, 252–255, 256t, 261;
incomplete panel data and, 407, 426;
maximum-likelihood estimators
(MLE) and, 106
- instrumental variable (IV) estimators:
cross-sectionally dependent panel data
and, 333; dynamic models and, 81, 89,
98–99, 117, 125, 128; dynamic
systems and, 373, 401–402;
incomplete panel data and, 425;
measurement errors and, 456; panel
data advantages and, 468; sample
truncation and, 290–291, 314; static
simultaneous-equations models and,
149, 155–159; variable coefficient
models and, 172n3, 208, 221–223
- Investing in Children and their Societies
(ICS), 3
- investment function, 24, 168, 175
- investment ratio, 8
- jackknife estimators, 271
- Jacobian matrices, 54, 154–155, 422,
427
- joint dependent variables: dynamic
systems and, 369; panel data
advantages and, 468; sample
selection and, 295; static
simultaneous-equations models and,
138, 144, 161, 163. *See also*
endogenous variables
- joint generalized least-squares
estimators, 140–144
- joint probability, 239, 252–253, 288, 295,
307
- Kalman filter, 188–191
- kernel estimates: cross-sectionally
dependent panel data and, 358;
discrete data and, 259, 277; dynamic
systems and, 389; nonparametric panel
data and, 461; sample truncation and,
288–290, 312–313, 325–326; simple

- regression and, 69; variable coefficient models and, 227
- kernel weighted generalized method of moments (KGMM), 325–326
- Koyck lag, 419, 426
- Kronecker product, 59n15, 61, 124, 141n5, 385, 454
- labor, 1, 3; dynamic models and, 230, 235–236, 250, 264–266; homogeneity and, 32, 33t, 34t; incomplete panel data and, 404; panel data and, 4–5, 7; sample truncation and, 287, 296–297; variable coefficient models and, 179–180
- lag coefficients: incomplete panel data and, 418–429; panel data advantages and, 6
- Lagrangians: cross-sectionally dependent panel data and, 344–345, 349; dynamic systems and, 390–391; multiplier tests and, 162n14, 176–177, 185, 192, 345, 349, 390–391; variable coefficient models and, 162n14, 176–177, 185, 192
- Lasso (Least Absolute Shrinkage and Selection Operator), 171
- least absolute deviation (LAD)
 - estimation: censored data and, 306–311; Honoré and, 299; panel quantile regression and, 446;
 - regression models and, 301–311;
 - sample truncation and, 287, 299–311;
 - truncated regression and, 301–306
- least-squares dummy variable (LSDV), 34–39, 43, 48, 82, 97, 100, 110t, 137, 239n10
- least-squares estimators: covariance (CV)
 - estimators and, 43; cross-sectionally dependent panel data and, 328–329, 333, 339–345, 364; discrete data and, 232–233, 239; dummy variable approach and, 34–39; duration model and, 432–433; dynamic models and, 81, 82n2, 85, 95–96, 104, 111, 115, 122–123, 133–134; dynamic systems and, 377–378, 381, 387–389, 394–395; efficiency and, 147; error-component two-stage (EC2SLS), 147–148, 152, 154; generalized, 37n3, 41–44, 66, 81, 96–97, 140–144, 147, 162, 171, 295, 300t, 378, 438, 454, 463; generalized (GLS), 41–44, 47n8, 52–68 (*see also* generalized least-squares (GLS) estimators); homogeneity and, 17, 19–20, 24; incomplete panel data and, 405, 415; joint general, 140–144; linear regression models and, 17, 19–20, 24, 32, 36–38, 41, 44, 50, 61–67, 71, 74–75; measurement errors and, 455–456; multilevel structures and, 454; OLS, 14 (*see also* ordinary least squares (OLS) estimators); pairwise trimmed, 299–311; panel data advantages and, 7, 9, 461, 463, 469; panel data issues and, 11, 14; penalized, 171; pooled, 11, 17, 210, 224–227, 328, 389; random effects and, 96–106; residual sum of squares (RSS) and, 19–21, 22t, 172; sample truncation and, 282–287, 290, 295, 299, 300t, 311, 313–314; simulation methods and, 451; static simultaneous-equations models and, 136–137, 139–151, 153, 162, 164; three-stage (3SLS), 74–75, 95–96, 122, 149–152; two-stage (2SLS), 104, 145, 147–148, 152, 154, 333; variable coefficient models and, 168, 171, 173–176, 184–185, 192, 195, 208, 210, 225–227; vector autoregressive (VAR) models and, 374–375
- Lehman Brothers, 438
- limited dependent-variable model, 348–350
- limited information principle, 145, 147, 149, 151, 398, 400, 402
- linear-probability model, 231–232, 238, 247
- linear regression models: analysis of covariance (ANCOVA) and, 17–26, 35, 37; analysis of variance (ANOVA) and, 17, 35; arbitrary error structure and, 69–75; asymptotics and, 44, 47, 52, 55, 57–58, 65–68, 72–77; autocorrelation and, 34, 64–69; basic assumptions of, 31; best linear unbiased estimators (BLUE) and, 36, 38–39, 41, 52, 60, 63;

linear regression models (*cont.*)

bias and, 24, 33, 36, 38, 41, 50–52, 55–58, 61; Chamberlain approach and, 69–75; Cobb-Douglas production function and, 32; conditional inference and, 48–56; consistency and, 75–77; covariance (CV) estimators and, 37–38, 41, 43–44, 47, 52, 54, 57, 59–65, 68–69; degrees of freedom and, 18, 21, 23–25, 27t, 29t, 54–55, 57–58, 73, 77; density and, 39, 54–56; dependent variables and, 34, 39, 49t, 67; dummy variable and, 34–39, 48; efficiency and, 32–33, 44, 50, 52, 54–55, 75n25; endogenous variables and, 73; error-component model and, 39n5, 40, 64, 75; error terms and, 18, 35, 50, 59, 63, 65–67, 69; exogenous variables and, 17–18, 34–35, 53; fixed constants (FE) and, 24, 33, 38–39, 41, 50, 59, 62, 66; fixed-effects models and, 34–39, 43–44, 47–59, 67; generalized method of moments (GMM) and, 70, 75n26; heterogeneity and, 31, 50, 53–54, 56; heteroscedasticity and, 24, 34, 39n5, 64–70, 73n22; homogeneity tests and, 17–30; incidental parameters and, 55–56, 65; individuals and, 17–19, 22t, 25–26, 31–40, 44, 48–70, 73; individual-specific variables and, 58–61; individual/time effects and, 61–64; least-squares estimation and, 17, 19–20, 24, 32, 36–38, 41, 44, 50, 61–67, 71, 74–75; matrices and, 36–44, 47, 52, 54, 57, 59, 62–63, 65–70, 72–77; maximum-likelihood estimators (MLE) and, 45–47; mean square error and, 47n8, 71; minimum-distance estimators and, 72–77; misspecification tests and, 56–58; Monte Carlo studies and, 47n8; multicollinearity and, 59; Mundlak's formulation and, 50–54, 56; normalization and, 74; null hypotheses and, 57–58; omitted variables and, 31–35, 39, 48, 65; ordinary least squares (OLS) estimation and, 36–37, 43, 59–61, 63; parametric models and,

55, 74; probability and, 47, 58, 75–77; random effects and, 33, 39–58; regression discontinuity design and, 357–359; static models and, 52, 55; statistics and, 21, 23–24, 26, 55, 58; stochastics and, 33, 35; structural parameters and, 55; Taylor series and, 77; three-component model and, 39, 77–79; time series and, 24–26, 36, 67, 70, 73; time-specific variables and, 32–34, 58–64; unconditional (marginal) inference and, 48–56; variance-components models and, 39–47, 52, 66; vectors and, 34–36, 39–40, 58, 61, 70–71, 73, 75–79; within-group estimators and, 37, 43–44, 54

liquidity: homogeneity and, 26; variable coefficient models and, 169, 212–217
local average treatment effect (LATE), 352n9

logit models: discrete data and, 231–232, 234, 237–239, 241–242, 256, 259, 268, 271, 276–280, 471n1; panel data issues and, 471n1; pooled, 268–269

log-likelihood function: count data model and, 441–443; cross-sectionally dependent panel data and, 332–336; discrete data and, 237, 240–241, 243–244, 258, 263, 265, 266t, 272, 280; dynamic models and, 106–107, 127–128; dynamic systems and, 384, 399–400; sample truncation and, 295; simulation methods and, 451; static simultaneous-equations models and, 159–161; variable coefficient models and, 176n7, 191, 205

managerial-differences variable, 152
Manheim Innovation Panel (MIP), 3
Manheim Innovation Panel-Service Sector (MIP-S), 3

marginal treatment effect (MTE), 352n9

Markov Chain Monte Carlo method,

209–210, 251–253, 255, 256t, 265
matrices: asymptotic covariance, 74–75, 101, 115–116, 126, 128–130, 224, 240, 250, 272, 283, 305, 310, 313, 323, 336, 375–376, 434, 451; cross-sectionally

- dependent panel data and, 327–331, 334, 336–340, 344, 350, 362; definite, 100, 106; discrete data and, 232–233, 240–242, 244, 246, 250–255, 264, 266, 272; duration model and, 432–434; dynamic models and, 94–97, 100–102, 104, 106–107, 109t, 112–113, 115–116, 126–130, 134; dynamic systems and, 370–385, 396–402; heteroscedastic autoregression (HAC) covariance, 331, 363; idempotent (covariance) transformation, 37, 40, 77, 141; identity, 36, 141–143, 148, 380, 385; incomplete panel data and, 405, 408, 410, 413–415, 421–422, 426–428; information, 177, 240–241, 242n11, 255, 266, 283, 471; Jacobian, 54, 154–155, 422, 427; measurement errors and, 457–459; multilevel structures and, 453–455; nonpositive semidefinite, 116; orthogonal, 165; panel data issues and, 471; partitioned, 52, 142; positive definite, 289, 323, 328, 362, 451; positive semidefinite, 43, 116, 246n13, 377; sample truncation and, 283, 288–289, 305, 310, 313, 323, 325; simple regression and, 36–44, 47, 52, 54, 57, 59, 62–63, 65–70, 72–77; simulation methods and, 450–451; sparse, 330, 333; static simultaneous-equations models and, 138–155, 158–160, 165; stochastic, 325; transformation, 37, 40, 44, 59, 62, 67, 334n4, 459; variable coefficient models and, 170–175, 177, 182–184, 187–195, 197, 201–203, 206–209, 219t, 223–227; variance-covariance, 38, 40, 47, 54n11, 57, 62–77, 95–96, 107, 139–140, 146–147, 150–151, 154–155, 173, 183–184, 194–195, 201, 219t, 242n11, 244, 246n13, 251, 283, 376–377, 405, 410, 414–415, 428, 453
- maximum-likelihood estimators (MLE):
 cointegrated panel models and, 382–384; count data model and, 442–443; cross-sectionally dependent panel data and, 354, 374–375, 383, 398, 400, 402; discrete data and, 233, 236–240, 245, 255, 263–264, 278; dynamic models and, 81, 89–96, 99, 106–107, 117n20; dynamic systems and, 386, 395–396, 398–401; fixed-effects models and, 116–119, 236–238; generalized method of moments (GMM) and, 116–119; hazard function and, 431–435; incomplete panel data and, 406–407, 412–417; initial conditions and, 106; limited information, 117n20, 400, 402; linear regression models and, 45–47; log-likelihood function and, 106–107, 127–128, 159–161, 176n7, 191, 205, 237, 240–241, 243–244, 258, 263, 265, 266t, 272, 280, 295, 332–336, 384, 399–400, 441–443, 451; Monte Carlo studies and, 94; multilevel structures and, 455; panel data advantages and, 9, 469; panel limited information (PLIML), 400–402; pooling and, 413–415; quasi, 124, 335–337, 401; random-coefficient models and, 224–226; sample truncation and, 283, 294, 297, 300t, 312; simulated (SMLE), 451–452; spatial dynamic models and, 336–337; spatial error model and, 334–335; spatial lag model and, 333; static simultaneous-equations models and, 152, 155, 159–162; time series and, 413–415; transformed, 112–115, 374–375; triangular system and, 159–162; variable coefficient models and, 176–177, 184, 188, 191–192
- maximum score estimators, 247–249, 256, 259–260, 312
- mean square error: dynamic models and, 93, 103, 118, 120t; incomplete panel data and, 410, 420; root (RMSE), 118–119, 120t, 128, 203t, 204t; simple regression models and, 47n8, 71; variable coefficient models and, 190, 201n16, 203, 204t
- measurement errors, 16; arbitrary error structure and, 69–75; autocorrelation and, 460; Chamberlain approach and, 69–75; correlation and, 456–460; dependent variables and, 458; duration

measurement errors (*cont.*)

model and, 430; dynamic models and, 87; generalized method of moments (GMM) and, 460; individuals and, 455–459; infinity and, 456; instrumental variable (IV) estimators and, 456; least squares and, 455–456; matrices and, 457–459; mean square error and, 47 (*see also* mean square error); misspecification tests and, 56–58; ordinary least squares (OLS) estimation and, 455; orthogonality and, 459; panel data advantages and, 9, 467–468; probability and, 456; regression models and, 456, 460; static simultaneous-equations models and, 153; vectors and, 379–386, 396, 458–460

Merrill Lynch, 438

minimum-distance estimators (MDE):

cointegrated panel models and, 382–383; discrete data and, 246; dynamic models and, 95–96, 114–121, 129–130; dynamic systems and, 375–377; fixed-effects models and, 114–121, 129–130; incomplete panel data and, 428; limited-information, 147; simple regression models and, 72–77; static simultaneous-equations models and, 145, 147, 149–151; vector autoregressive (VAR) models and, 375–377

missing at random (MAR) model, 297–298

misspecification tests, 56–58

mixed fixed- and random-coefficient

model: Bayes solution and, 198–201; formulation of, 196–198; individual parameter estimates and, 201–202; model selection and, 204–206; pooled parameter estimates and, 201–202; prediction comparison and, 202–204

model of limited dependent variables, 281

Modigliani-Miller theory, 212

Monte Carlo studies: cross-sectionally dependent panel data and, 342, 346, 348, 350; discrete data and, 242, 254–255, 256t, 270, 273, 280; dynamic

models and, 84, 86, 94, 107, 117–118, 128; dynamic systems and, 377, 382, 389–390, 394–395, 402; Gibbs sampler and, 209–210; importance sampling and, 450; Markov Chain, 209–210, 251–253, 255, 256t, 265; maximum-likelihood estimators (MLE) and, 94; panel quantile regression and, 447; simple regression models and, 47n8; simulation methods and, 450; variable coefficient models and, 206, 209–210, 212, 227

multicollinearity: dynamic models and, 91, 111; panel data advantages and, 6, 464; simple regression and, 59; variable coefficient models and, 201, 213–215, 223, 226

multilevel structures: dependent variables and, 453; error-component model and, 430, 453, 455; individuals and, 453; least-squares estimation and, 454; matrices and, 453–455; maximum-likelihood estimators (MLE) and, 455; multiway error components model and, 453; vectors and, 453

Mundlak-Chamberlain approach, 172n3

Mundlak's formulation, 50–54, 56

National Data Collection Units (NDU), 2
National Longitudinal Surveys (NLS), 1–2, 13

negative binomial distribution, 442

neighbors, 329–331, 333

New Cronos, 3

Newey-West heteroscedasticity-autocorrelation consistent formula, 224

Newton-Raphson iterative procedure, 46, 94, 114, 233, 280, 283

non-government organizations (NGOs), 3
nonparametric panel data: asymptotics and, 462–463; counterfactuals prediction and, 361–363; cross-sectionally dependent panel data and, 331, 355, 357, 359–368; dependent variables and, 463; difference-in-difference method and, 360–361; dummy variable and, 463;

- dynamic systems and, 390;
- error-component model and, 461;
- exogenous variables and, 461; fixed constants (FE) and, 461; homogeneity and, 461; individuals and, 462; normalization and, 461; parametric models and, 461; sample truncation and, 288, 298, 326; time series and, 462; vectors and, 463
- Nordica, 267
- normalization: cross-sectionally dependent panel data and, 329, 332, 337–338, 340; discrete data and, 235–236, 241, 246–250, 252, 270, 279; duration model and, 434; dynamic models and, 117; dynamic systems and, 380, 382, 385; nonparametric panel data and, 461; sample truncation and, 287, 293; simple regression and, 74; static simultaneous-equations models and, 154–155, 161, 162n14, 164; variable coefficient models and, 199
- null hypotheses: cross-sectionally dependent panel data and, 344; discrete data and, 255, 262n18; dynamic models and, 106; dynamic systems and, 385–387, 390, 392; homogeneity and, 24; incomplete panel data and, 414, 428; simple regression and, 57–58; variable coefficient models and, 176–177, 186, 192–193, 212, 214
- omitted variables: average vs. individual behavior and, 235; covariations of, 412–413; cross-sectionally dependent panel data and, 327; discrete data and, 235, 243; dynamic models and, 97; incomplete panel data and, 412–413, 417, 419; linear regression models and, 31–35, 39, 48, 65; panel data advantages and, 6, 8, 466–467; static simultaneous-equations models and, 136, 152–153; time series and, 412–413; variable coefficient models and, 167, 198
- ordinary least squares (OLS) estimators: asymptotics and, 97; bias and, 85–86, 97; cross-sectionally dependent panel data and, 364, 368; dynamic models and, 85–86, 97, 99, 110–111; linear regression models and, 36–37, 43, 59–61, 63; measurement errors and, 455; random effects and, 85–86; sample truncation and, 316t; two-step GLS estimator and, 111n18; variable coefficient models and, 211t
- Organisation for Economic Co-operation and Development (OECD), 3, 364
- orthogonality: cross-sectionally dependent panel data and, 355; dynamic models and, 100, 105, 112, 125; dynamic systems and, 373, 401; measurement errors and, 459; panel data issues and, 471; sample selection and, 322–323
- panel analysis of nonstationarity in idiosyncratic and common components (PANIC), 398n8
- panel data: accuracy and, 4; capacity and, 4; cross-sectionally dependent panel data and, 327–368 (*see also* cross-sectionally dependent panel data); incidental parameters and, 470–471; increasing availability of, xvii; issues with, 10–14, 469–473; omitted variables and, 6, 8, 31–35 (*see also* omitted variables); statistics and, 3 (*see also* statistics); treatment effects and, 359–368
- panel data advantages: aggregation levels and, 468–469; asymptotics and, 9, 469; bias and, 7–8, 464, 467–468; computation simplification and, 469; degrees of freedom and, 4, 464; density and, 9–10; dependent variables and, 467–468; dummy variable and, 5; efficiency and, 4, 8; error terms and, 6, 467; exogenous variables and, 6, 467; fixed effects and, 467; homogeneity and, 4, 8, 465, 468; identification/discrimination of competing hypotheses and, 465–467; impact of observables selection and, 469; individuals and, 4–10, 464–469; instrumental variable (IV) estimators

- panel data advantages (*cont.*)
 and, 468; joint dependent variables and, 468; least-squares estimation and, 7, 9, 461, 463, 469; maximum-likelihood estimators (MLE) and, 9, 469; measurement errors and, 9, 467, 467–468; multicollinearity and, 6, 464; parametric models and, 467; prediction accuracy and, 468–469; random effects and, 467; regression models and, 6–8, 467–468; specification problem and, 467; statistics and, 467, 469; time series and, 4, 6–9, 464–469; time-specific variables and, 467–468; vectors and, 6
- panel data issues: asymptotics and, 13, 472; attrition and, 13, 469, 472–473; Bayesian methods and, 471; bias and, 11–14, 471–472; cross-sectionally dependent panel data and, 471–472; degrees of freedom and, 470; density and, 10; dependent variables and, 14, 472; efficiency and, 470, 473; error terms and, 11, 14; exogenous variables and, 11, 14; fixed constants (FE) and, 13; fixed effects and, 10–11, 13, 470; homogeneity and, 11; incidental parameters and, 11, 13; individuals and, 10–14, 469–473; least-squares estimation and, 11, 14; logit models and, 471n1; matrices and, 471; multidimensional asymptotics and, 472; orthogonality and, 471; parametric models and, 10; probability and, 470; random effects and, 10, 470–471; regression models and, 11, 14; sample attrition and, 13–14, 469, 472–473; state dependence and, 13; statistics and, 471–473; structural parameters and, 10, 471; time series and, 13, 469–473; unobserved heterogeneity and, 469–471; vectors and, 10
- panel least variance ratio estimators (PLVAR), 402
- panel limited information maximum-likelihood estimators (PLIML), 400–402
- panel quantile regression, xvii;
 asymptotics and, 447; bias and, 447; density and, 445; fixed effects and, 447; individuals and, 447; probability and, 445; vectors and, 446
- Panel Study of Income Dynamics (PSID), 1–2
- panel vector autoregressive (PVAR)
 models: dynamic systems and, 370–378, 380, 382, 395–396; heterogenous, 377–378; homogenous, 370–377; likelihood approach and, 395–396
- parametric models: cross-sectionally dependent panel data and, 331, 354, 357, 359–360; discrete data and, 230–231, 235–250, 255; duration model and, 434; dynamic systems and, 390; nonparametric panel data and, 461–462; panel data advantages and, 467; panel data issues and, 10; sample truncation and, 288–291, 298–299, 311–313, 326; simple regression and, 55, 74; variable coefficient models and, 227
- Penn-World tables, 130
- Poisson process, 439–440, 443–444
- pooled regression models, 11, 19–20, 390
- pooling: dynamic systems and, 383, 389; homogeneity and, 18n1, 24; incomplete panel data and, 16, 411–418; panel data advantages and, 8, 464; panel data issues and, 11; panel quantile regression and, 447; time series and, 411–418; variable coefficient models and, 169, 197, 203, 215, 217
- predicted error sum of squares (PES), 219t
- Primary School Deworming Project (PDSP), 3
- probability: attrition and, 292–296; conditional, 239–241, 252, 256, 262–263, 295, 431, 433; count data model and, 438–439, 441t, 444; cross-sectionally dependent panel data and, 339, 355, 357, 361; discrete data and, 231–232, 234–236, 238–257, 261–265, 268–275; duration model

- and, 430–431, 433, 435, 438; dynamic models and, 82n2, 85, 123, 131–132; dynamic systems and, 372, 394; homogeneity and, 17; incomplete panel data and, 403; joint, 239, 252–253, 288, 295, 307; measurement errors and, 456; panel data advantages and, 5; panel data issues and, 10, 470; panel quantile regression and, 445; sample truncation and, 284, 288–297, 302, 307, 321, 325; selection bias and, 292–296; simple regression and, 47, 58, 75–77; simulation methods and, 448; static simultaneous-equations models and, 137, 148; variable coefficient models and, 169, 198–199, 205, 209
- probit models: cross-sectionally dependent panel data and, 349; discrete data and, 231, 234, 236n4, 241–244, 254–255, 261n17, 264, 268t; sample truncation and, 281; simulation methods and, 449
- propensity score method, 227, 355–357, 360
- pseudopanel, xix, 16, 408–411
- quasi maximum-likelihood estimators (MLE), 124, 335–337, 401
- random-coefficient models: analysis of covariance (ANCOVA) and, 177, 179, 186; Bayes solution and, 198–201; correlated, 220–227; cross-sectionally dependent panel data and, 221–222; description of, 172–173; discrete data and, 236n4; dynamic, 206–212, 392; estimation and, 173–175; example for, 179–180; fixed coefficients and, 178–179, 201–206, 223–224; Grunfeld investment function and, 175; maximum-likelihood estimators (MLE) and, 224–226; mixed fixed- and random-coefficient model and, 196–206; parameter reduction and, 169; predicting individual coefficients and, 175; sample truncation and, 298n5; simple regression and, 70; simulation methods and, 448; Swamy formulation and, 178, 180; testing for coefficient variation and, 175–178; variable coefficient models and, 169–170, 172–180, 183–186, 196–212, 215–227
- random-effects inference, 56, 467
- random effects models: covariance (CV) estimators and, 40–41; cross-sectionally dependent panel data and, 335; discrete data and, 242–246, 253–256, 261n17, 265, 268–270; dynamic models and, 80–81, 84–108, 109t, 120–121; dynamic systems and, 372, 399; estimation of, 89–106; estimation of variance-components models and, 39–47; fixed effects and, 47–56; generalized least-squares estimation and, 37n3, 41–44, 66; individual correlations and, 52–56; initial conditions testing and, 106–107; instrumental-variable estimators and, 98–99; least-squares estimators and, 96–106; linear regression models and, 33, 39–58; maximum-likelihood estimators (MLE) and, 45–47, 89–96; misspecification tests and, 56–58; model formulation and, 86–89; Mundlak's formulation and, 50–54, 56; OLS estimators bias and, 85–86; panel data advantages and, 467; panel data issues and, 10, 470–471; sample truncation and, 299, 314–317; simple regression models and, 47–56; simulation methods and, 107–108, 448; specification issues and, 119–121; unconditional (marginal) inference and, 48–56; variable coefficient models and, 215; variance-components models and, 39–47
- randomly missing data, 403–408
- regression discontinuity (RD) design, 357–359
- regression models: augmented Dickey-Fuller (ADF), 389–390, 392; cell-mean corrected, 19, 27t–28t; censored, 306–311; cross-sectionally dependent panel data and, 328–329, 339, 341, 350, 357–358; discrete data and, 232, 237, 239, 244, 252; duration

regression models (*cont.*)

model and, 432; dynamic models and, 84, 97, 111, 130, 133–135; dynamic systems and, 377–378, 382, 384, 386–387, 389–392, 395; incomplete panel data and, 412–413, 416, 423, 426–427; least-squares estimators and, 7 (*see also* least-squares estimators); linear, 15 (*see also* linear regression models); measurement errors and, 456, 460; OLS, 85–86 (*see also* ordinary least squares (OLS) estimators); panel data advantages and, 6–8, 467–468; panel data issues and, 11, 14; panel quantile, 16, 445–447; pooled, 11, 19–20, 390; residual sum of squares (RSS) and, 19–21, 22t, 172; sample truncation and, 281, 285, 289–290, 296, 299, 306, 309, 311, 313, 324n10, 326; seemingly unrelated regression method (SUR) and, 140n4, 143, 170–171, 197, 328, 377–378, 384, 386; static, 84; static simultaneous-equations models and, 140n4, 143, 146; truncated, 301–306; *T*-variate, 70; variable coefficient models and, 167–176, 185, 187, 189, 192–193, 196–197, 202t, 208, 213, 214t–216t, 220, 225–226

repeated cross-sectional data, 408–411

research and development (R&D), 3

Research Center for Rural Development, 2

residual sum of squares (RSS), 19–21, 22t, 172

return-to-normality model, 187

root mean square error (RMSE), 118–119, 120t, 128, 203t, 204t

rotating data, 403–408

sample selection, xix; attrition and, 13–14, 292–298, 300t, 312, 469, 472–473; autoregression and, 324; control groups and, 296; dynamic models and, 324–326; endogenous issues and, 287–288; Hausman-Wise two-period model and, 295, 297–298; Heckman two-step estimators and, 238–244, 288, 299; housing

expenditure example and, 313–317; joint dependent variables and, 295; latent response function and, 281; missing at random (MAR) model and, 297–298; nonrandomly missing data and, 292–298; orthogonality and, 322–323; Robinson approach and, 289, 291; self selection and, 292; semiparametric two-step estimators and, 311–313; single index, 290; Tobit models and, 298–299, 324–326

sample truncation: asymptotics and, 283, 287–289, 295, 298–299, 305, 310, 313, 323, 326; bias and, 282, 290, 292–297, 312, 314; censored data and, 281–287, 298–301, 306–311, 317–318, 323–324; censored regression and, 306–311; conditional expectation and, 282; data points and, 281–284; degrees of freedom and, 314, 317; density and, 282–284, 289–291, 296, 298, 302, 305, 312, 326; dependent variables and, 281–282, 284–285, 287, 290, 292, 295, 317, 325; dummy variable and, 297; endogenous issues and, 287–288; endogenous variables and, 296; error-component model and, 292; error terms and, 281–282, 284–285, 287, 290, 292, 298, 302, 313–314, 317, 325; exogenous variables and, 281, 287, 325; fixed effects and, 299–314, 315; generalized method of moments (GMM) and, 323–326; Heckman two-step estimators and, 238–244, 288, 299; heterogeneity and, 298; heteroscedasticity and, 284, 313; housing expenditure example and, 313–317; incidental parameters and, 302, 312; individuals and, 290, 292, 295–301, 311–312, 317–318, 325; infinity and, 299, 323; instrumental variable (IV) estimators and, 290–291, 314; latent response function and, 281; least absolute deviation (LAD) estimators and, 287, 299–311; least-squares estimation and, 282–287, 290, 295, 299, 300t, 311, 313–314; log-likelihood function and, 295; matrices and, 283, 288–289, 305, 310,

- 313, 323, 325; maximum-likelihood estimators (MLE) and, 283, 294, 297, 300t, 312; model of limited dependent variables and, 281; nonparametric panel data and, 288, 298, 326; nonrandomly missing data and, 292–298; normalization and, 287, 293; ordinary least squares (OLS) estimation and, 316t; parametric models and, 288–291, 298–299, 311–313, 326; probability and, 284, 288–297, 302, 307, 321, 325; probit models and, 281; random-coefficient models and, 298n5; random effects and, 299, 314–317; regression models and, 281, 285, 289–290, 296, 299, 306, 309, 311, 313, 324n10, 326; Robinson approach and, 289, 291; semiparametric models and, 288–291, 311–313; static models and, 317; statistics and, 281, 292, 297, 314, 317, 323; stochastics and, 287, 325; structural models and, 292, 297, 300t; structural parameters and, 293, 295, 297; Tobit models and, 281, 288, 298–299, 317–326; truncated regression and, 301–306; unimodality and, 286–287; variable-intercept models and, 311; variance-components models and, 295; vectors and, 281, 287, 289–290, 293, 306, 310, 313–314, 324–325
- seemingly unrelated regression method (SUR), 140n4, 143, 170–171, 197, 328, 377–378, 384, 386
- semiparametric models: discrete data and, 230, 235, 246–250, 255; duration model and, 434; maximum score estimators and, 247–249; nonparametric panel data and, 461; panel data issues and, 471; root- N consistent estimators and, 249–250; sample truncation and, 288–291, 311–313; static models and, 246–250; variable coefficient models and, 227
- sequential limit theory, 130–131
- sharp regression discontinuity (SRD), 357–358
- simple regression models: Aitken estimators and, 37n3; arbitrary error structure and, 69–75; asymptotics and, 44, 47, 52, 55, 57–58, 65–68, 72–77; autocorrelation and, 34, 64–69; autoregression and, 66; basic assumptions of, 31; best linear unbiased estimators (BLUE) and, 36, 38–39, 41, 52, 60, 63; Chamberlain approach and, 69–75; Cobb-Douglas production function and, 32; conditional inference and, 48–56; consistency and, 75–77; covariance (CV) estimators and, 37, 40–41, 67–68; cross-sectionally dependent panel data and, 328; density and, 39, 54–56; dependent variables and, 34, 39, 49t, 67; dummy variable and, 34–39, 48; dynamic models and, 80–135 (*see also* dynamic models); efficiency and, 32–33, 44, 50, 52, 54–55, 75n25; endogenous variables and, 73; error-component model and, 39n5, 40, 64, 75; fixed constants (FE) and, 33, 38–39, 41, 50, 59, 62, 66; fixed-effects models and, 34–39, 43–44, 47–59, 67; generalized least-squares estimation and, 37n3, 41–44, 66; generalized method of moments (GMM) and, 70, 75n26; heteroscedasticity and, 34, 39n5, 64–70, 73n22; homogeneity and, 31–32; individual correlations and, 52–56; individual-specific variables and, 58–64; individual/time effects and, 61–64; infinity and, 38, 41, 47, 52, 58, 60–61, 63, 65, 67, 69–71; matrices and, 36–44, 47, 52, 54, 57, 59, 62–63, 65–70, 72–77; maximum likelihood estimation and, 45–47; mean square error and, 47n8, 71; minimum-distance estimators and, 72–77; misspecification tests and, 56–58; Monte Carlo studies and, 47n8; Mundlak's formulation and, 50–54, 56; multicollinearity and, 59; normalization and, 74; null hypotheses and, 57–58; panel data advantages and, 6; parametric models and, 55, 74;

- simple regression models (*cont.*)
 - probability and, 47, 58, 75–77;
 - random-coefficient models and, 70;
 - random effects models and, 33, 33, 39–58; serially correlated errors and, 65–68; static models and, 52, 55; stochastics and, 33, 35;
 - three-component model and, 39, 77–79; time effects and, 61–64;
 - time-specific variables and, 32–34, 58–64; unconditional (marginal) inference and, 48–56; variable coefficient models and, 173;
 - variance-components models and, 39–47, 52, 66; vectors and, 34–36, 39–40, 58, 61, 70–71, 73, 75–79;
 - within-group estimators and, 37, 43–44, 54
- simulated generalized method of moments (SGMM) estimators, 451–452
- simulated maximum-likelihood estimators (SMLE), 451–452
- simulated method of moments (SMM) estimators and, 451–452; Tobit models and, 448–449, 451; vectors and, 451
- simulation methods: asymptotics and, 451–452; autoregression and, 450; bias and, 450, 452, 455–457; density and, 448–452; efficiency and, 452; generalized method of moments (GMM) and, 451–452; heterogeneity and, 448; importance sampling and, 450; least-squares estimation and, 451; log-likelihood function and, 451; matrices and, 450–451; maximum-likelihood estimators (MLE) and, 451; Monte Carlo studies and, 450; probability and, 448; probit models and, 449; random-coefficient models and, 448; random effects and, 107–108, 448
- Social Economic Panel (PSELL) (Luxembourg), 2
- Social Science Citation Index*, xix
- Socio-Economic Panel (SEP), 2
- sparse elements, 330, 333
- spatial approach: cross-sectionally dependent panel data and, 329–335, 337, 344; dynamic models and, 336–337; economic distance and, 331; error model and, 332–335; independence testing and, 344–351; individual-specific effects and, 334–336; lag model and, 333, 335–336; neighbors and, 329–331, 330, 333; sparse elements and, 330; SYR test and, 346–348
- spatial autoregressive form, 329–330
- spatial lag operator, 329
- spatial moving average, 329
- specification problem, 467
- state dependence: approximate method and, 276–280; bias-adjusted estimators and, 270–273; bounding parameters and, 274–276; discrete data and, 230, 252, 261–280; heterogeneity and, 261–264; panel data issues and, 13
- static models, 15; discrete data and, 230, 235–250, 255, 265–266; dynamic models and, 80–82, 100, 112; heterogeneity and, 235–246; linear, 52, 55, 80–81, 100, 138n2, 239n10; maximum score estimators and, 247–249; parametric, 235–246; root-*N* consistent estimators and, 249–250; sample truncation and, 317; semiparametric, 230, 246–250; simple regression and, 52, 55
- static simultaneous-equations models: Aitken estimators and, 148; asymptotics and, 136, 139, 143, 146–147, 150–152, 183n2; bias and, 136–137, 143, 152; covariance (CV) estimators and, 164; dependent variables and, 136, 138, 144, 161, 163; dummy variable and, 142; efficiency and, 136, 140, 143, 153; endogenous variables and, 137, 151, 155, 159; error-component model and, 139, 143–144, 147, 151–153; error terms and, 139, 144, 152; estimation of structural equations and, 144–152; exogenous variables and, 137, 144, 153, 155, 161; fixed effects and, 138n2, 142; heterogeneity and, 136; heteroscedasticity and, 145, 147, 149; identification and, 153–155; income-schooling model and, 136–137, 154, 466; individuals and,

- 136–138, 144–145, 149–153; infinity and, 138n2, 142, 145, 149; instrumental variable (IV) estimators and, 149, 155–159; joint dependent variables and, 138, 144, 161, 163; least-squares estimation and, 136–137, 139–151, 153, 162, 164; log-likelihood function and, 159–161; matrices and, 138–155, 158–160, 165; maximum-likelihood estimators (MLE) and, 152, 155, 159–162; measurement errors and, 153; minimum-distance estimators and, 145, 147, 149–151; normalization and, 154–155, 161, 162n14, 164; omitted variables and, 136, 152–153; probability and, 137, 148; regression models and, 140n4, 143, 146; structural models and, 139, 144–152; structural parameters and, 152; time series and, 138; time-specific variables and, 138; variance-components models and, 144, 149, 152–153; vectors and, 138–141, 143–144, 148, 151, 154, 160–161, 162n14, 165, 327–329, 334n4, 336–340, 343, 356–357, 362
- Statistical Office of the European Communities, 2
- statistics: Bureau of Labor Statistics and, 1; chi-square distribution and, 9, 233, 262n18, 268t, 377, 391; count data model and, 443; cross-sectionally dependent panel data and, 327–328, 344–346, 348–350, 354–355, 364, 368; discrete data and, 230, 233, 235–236, 239, 255, 261, 262n18, 265, 266t, 268t, 269, 270–280; duration model and, 430; dynamic models and, 82n2, 84, 86n5, 105–108, 117, 121, 124, 130; dynamic systems and, 369, 377, 385–397; European Community Household Panel (ECHP) and, 3; formal level of, 24; foundational theorems of, 10; F statistic and, 21, 23, 214t, 215t; Hausman type test, 57–58, 105, 121, 408; homogeneity and, 21, 23–24, 26; incidental parameters and, 11 (*see also* incidental parameters); incomplete panel data and, 404, 408–410, 415–416, 429; inference and, 9, 117, 173, 236, 327, 369, 397, 430, 469, 473; Lagrangian multiplier tests and, 162n14, 176–177, 185, 192, 345, 349, 391; least-squares estimators and, 82n2 (*see also* least-squares estimators); linear regression models and, 21, 23–24, 26, 55, 58; MLE and, 9 (*see also* maximum-likelihood estimators (MLE)); multidimensional, 13; panel data advantages and, 467, 469; panel data issues and, 471–473; random effects and, 10 (*see also* random effects models); regression models and, 24 (*see also* regression models); sample truncation and, 281, 292, 297, 314, 317, 323; specification problem and, 467; structural parameters and, 10 (*see also* structural parameters); test interpretation and, 24; t -statistic and, 84, 124, 202t, 368, 388–390, 394, 410; unobserved heterogeneity and, 10; variable coefficient models and, 173, 176–179, 184, 193, 202t, 204, 214, 215t, 217–218; Wald type tests and, 9, 377, 385–386
- stochastics: cross-sectionally dependent panel data and, 347–348; discrete data and, 251–254, 278; dynamic models and, 82n2, 87–88, 92, 94–95, 104, 108; incomplete panel data and, 421–422; sample truncation and, 287, 325; simple regression and, 33, 35; variable coefficient models and, 169, 193, 195, 197
- structural models: estimation of complete system and, 149–152; estimation of single equation in, 144–149; sample truncation and, 292, 297, 300t; static simultaneous-equations models and, 139, 144–152; triangular system and, 152–164
- structural parameters: discrete data and, 238–239, 242, 248, 254n16, 271, 278; linear regression models and, 55; panel data issues and, 10, 471; sample truncation and, 293, 295, 297; static simultaneous-equations models and, 152

- Survey of Health, Aging and Retirement in Europe (SHARE), 4
- Survey of Income and Program Participation, 404
- survival function, 431
- symmetry: cross-sectionally dependent panel data and, 328–329, 332; discrete data and, 232, 249; dynamic systems and, 390; sample truncation and, 284–291, 302, 304, 307, 318, 321–323; simple regression and, 77; static simultaneous-equations models and, 141, 155, 164; variable coefficient models and, 212, 224
- Taylor series, 77, 129, 273
- three-stage least-squares (3SLS) estimators, 74–75, 95–96, 122, 149–152
- time-evolving coefficients: Kalman filter predictions and, 188–191; maximum-likelihood estimators (MLE) and, 191–192; model of, 186–188; parameter constancy tests and, 192–193; variable coefficient models and, 186–193
- time series: analysis of covariance (ANCOVA) and, 24–26; cross-sectionally dependent panel data and, 331, 339–340, 344–351, 362; discrete data and, 243, 257, 269–270; duration model and, 430–438; Durbin-Watson/Box-Pierce tests and, 345; dynamic models and, 81, 83, 91, 108, 110, 119, 124, 130, 133–135; dynamic systems and, 16, 369–372, 377–379, 383, 386–387, 390, 392–395; homogeneity and, 24–26; incomplete panel data and, 402–403, 405, 407, 411–419; independence test and, 344–351; linear regression models and, 24–26, 36, 67, 70, 73; maximum-likelihood estimators (MLE) and, 413–415; nonparametric panel data and, 462; panel data advantages and, 4, 6–9, 464–469; panel data issues and, 13, 469–473; pooling and, 411–418; static simultaneous-equations models and, 138; variable coefficient models and, 170–171, 184, 193–194, 201, 205, 207, 218–219, 223, 227
- time-specific variables: cross-sectionally dependent panel data and, 327, 331, 337; dynamic models and, 80–81, 122–129; dynamic systems and, 393; panel data advantages and, 467–468; simple regression models and, 32–34, 58–64; static simultaneous-equations models and, 138; variable coefficient models and, 167
- time-variant coefficients, 180–186
- Tobin's q , 213, 217
- Tobit models: cross-sectionally dependent panel data and, 348–349; dynamic, 317–326; panel data advantages and, 9; random individual effects and, 298–299; sample selection and, 298–299, 324–326; sample truncation and, 281, 288, 298–299, 317–324; simulation methods and, 448–449, 451; type II, 287, 298–299
- transformed likelihood approach, 112–115
- treatment effects: adjustment methods and, 354–359; counterfactuals prediction and, 361–363; cross-sectionally dependent panel data and, 352–368; definition of, 352–354; difference-in-difference method and, 360–361; example of, 363–368; panel data approach and, 359–368; regression discontinuity design and, 357–359
- treatment groups, 353–357, 360–361
- treatment on the treated (TT) effect, 352–353
- triangular system: estimation and, 155–162; example of, 162–164; identification and, 153–155; maximum-likelihood estimators (MLE) and, 159–162; static simultaneous-equations models and, 152–164
- t -statistic, 84, 124, 202t, 368, 388–390, 394, 410
- two-stage least-squares estimators (2SLS), 104, 145, 147–148, 152, 154, 333

- unconditional inference, 48–56, 178
- unit root tests: augmented Dickey-Fuller (ADF) and, 389–390, 392;
 - cross-sectionally correlated data and, 392–394; cross-sectionally independent data and, 387–392;
 - dynamic systems and, 386–394;
 - Lagrangian multiplier (LM) and, 391;
 - Sargan-Bharvaga (SB) test statistic and, 394
- U.S. Department of Labor, 1
- variable coefficient models: aggregate vs. disaggregate analysis and, 217–220;
 - Aitken estimators and, 179, 185, 196;
 - asymptotics and, 121, 174–178, 185–186, 193, 196, 201n16, 208, 223–225; autocorrelation and, 214t, 217, 224; autoregression and, 187, 207n18; Bayesian methods and, 174, 198–201, 204–205, 208–212; best linear unbiased estimators (BLUE) and, 183–185, 195; bias and, 173–175, 178, 180, 183, 184n10, 200, 210, 211t, 215, 220, 223; combination of two normal distributions and, 228–229; cross-sectionally dependent panel data and, 170–186, 221–222; degrees of freedom and, 168, 174, 177–179, 186, 193, 209, 215, 223; density and, 177–179, 191, 205, 209, 216; dependent variables and, 175–176, 190, 215t, 216t; dummy variable and, 168; dynamic, 206–212; efficiency and, 197, 224; error-component model and, 168n1, 174, 198, 200, 201n16; error terms and, 183–185, 206; exogenous variables and, 169, 177, 187, 193–196, 198, 206; firm investment expenditure and, 212–217; fixed-coefficient models and, 170–172, 177–178, 182–183, 196–206, 216–217; fixed constants (FE) and, 170, 193, 210, 212, 223; fixed effects and, 182, 223–224, 227; Frobenius norm and, 171; Gibbs sampler and, 209–210; Grunfeld investment function and, 175; heterogeneity and, 167–171, 178–180, 186, 196–197, 202, 204, 212, 214t, 215, 217–219; heteroscedasticity and, 170, 176, 179, 184–185, 224; Hildreth-Houck estimators and, 184n10; homogeneity and, 177–179, 202, 213, 215t, 217; individuals and, 167–180, 184–186, 193, 197–201, 204, 207–208, 214t, 215, 218, 220, 223, 227; infinity and, 174, 176–178, 185, 196, 209; instrumental variable (IV) estimators and, 172n3, 208, 221–223; Kalman filter and, 188–191; Lagrangians and, 162n14, 176–177, 185, 192; least-squares estimation and, 168, 171, 173–176, 184–185, 192, 195, 208, 210, 225–227; liquidity and, 169, 212–217; log-likelihood function and, 176n7, 191, 205; matrices and, 170–175, 177, 182–184, 187–195, 197, 201–203, 206–209, 219t, 223–227; maximum-likelihood estimators (MLE) and, 176–177, 184, 188, 191–192; mean square error and, 190, 201n16, 203, 204t; mixed fixed- and random- coefficient model and, 196–206; Monte Carlo studies and, 206, 209–210, 212, 227; multicollinearity and, 201, 213–215, 223, 226; normalization and, 199; null hypotheses and, 176–177, 186, 192–193, 212, 214; omitted variables and, 167, 198; ordinary least squares (OLS) estimation and, 211t; parameter variation assumptions and, 169; parametric models and, 227; parsimonious regression and, 167; pooling and, 169, 197, 203, 215, 217; probability and, 169, 198–199, 205, 209; random-coefficient models and, 169–170, 172–180, 183–186, 196–212, 215–227, 220–227; random effects and, 215; regression models and, 167–176, 185, 187, 189, 192–193, 196–197, 202t, 208, 213, 214t–216t, 220, 225–226; simple regression models and, 173 (*see also* simple regression models); statistics and, 173, 176–179, 184, 193, 202t, 204, 214, 215t, 217–218; stochastics and, 169, 193, 195, 197; time-evolving

- variable coefficient models (*cont.*)
 coefficients and, 186–193; time series and, 170–171, 184, 193–194, 201, 205, 207, 218–219, 223, 227; time-specific variables and, 167; time-variant coefficients and, 180–186; Tobin's q and, 213, 217; variable-intercept models and, 167–169, 178, 180, 198, 214, 215t, 217; variance-components models and, 184, 208; vectors and, 168–171, 177–179, 184, 186–187, 191–194, 196–198, 203, 206, 209, 222, 225–226
- variable-intercept models: assumption of, 31–32; heterogeneity and, 15, 31–32; sample truncation and, 311; variable coefficient models and, 167–169, 178, 180, 198, 214, 215t, 217
- variance-components models: discrete data and, 266; dynamic models and, 107; random effects and, 39–47; sample truncation and, 295; simple regression models and, 39–47, 52, 66; static simultaneous-equations models and, 144, 149, 152–153; variable coefficient models and, 184, 208
- vector autoregressive (VAR) models:
 cross-sectionally dependent panel data and, 377–378; cross-sectionally independent data and, 377; dynamic systems and, 369–378, 380, 386, 393n7, 397–402; general method of moments (GMM) estimation and, 373–374; global, 378, 386; heterogeneity and, 377–378; homogeneity and, 370–377; maximum-likelihood estimators (MLE) and, 374–375; minimum-distance estimators (MDE) and, 375–377; model formulation and, 370–372; MonteCarlo studies and, 377; simultaneous equations and, 397–402
- vectors, 15; autoregressive models and, 379–388; cointegrated models and, 379–386; cross-sectionally dependent panel data and, 327–329, 334n4, 336–340, 343, 356–357, 362; discrete data and, 230–233, 247, 254n16; dynamic models and, 80, 87, 93, 94n9, 97, 100, 112, 121, 124, 131; dynamic systems and, 369–386, 393, 396–399; eigenvectors, 148, 151, 334n4, 338–340; error correction and, 379–386, 396; homogeneity and, 17–18; incomplete panel data and, 404–405, 407, 409, 413–414, 420–422, 427–428; measurement errors and, 458–460; multilevel structures and, 453; nonparametric panel data and, 463; panel data advantages and, 6; panel data issues and, 10; panel quantile regression and, 446; sample truncation and, 281, 287, 289–290, 293, 306, 310, 313–314, 324–325; simple regression and, 34–36, 39–40, 58, 61, 70–71, 73, 75–79; simulation methods and, 451; static simultaneous-equations models and, 138–141, 143–144, 148, 151, 154, 160–161, 162n14, 165; variable coefficient models and, 168–171, 177–179, 184, 186–187, 191–194, 196–198, 203, 206, 209, 222, 225–226
- Wald type tests, 9, 377, 385–386
- within-group estimators: homogeneity and, 19; linear regression models and, 37, 43–44, 54
- World Bank, 3
- Yoplait, 267