

# Subject Index

- Anderson-Rubin test, 547
- Anticipation, 138–139, 202–203, 236–237, 285, 471–472, 603–607, 646
- Asset prices, 201–203, 209, 224, 226, 230–232, 435, 532–542, 544, 603–605
- Asymmetric responses, 638, 648–658
- Asymmetric VAR models, 73–74
- Asymptotic inference
  - fractionally integrated processes, 49, 98–99, 292–293, 388–389
  - integrated processes, 75–108, 369–377
  - local-to-unity asymptotics, 97–98, 322–323, 337–385, 387–389
  - robust inference in levels, 41–43, 107–108, 373–377, 381–387
  - sieve approximations, 43–46
  - stationary processes, 19–72, 334–369
- Atheoretical VAR models, 212, 220
- Bayes factor, 144
- Bayesian posterior inference
  - credible sets, 143, 396–397, 406–409
  - estimation, 142–143, 163, 186, 265–268
  - framework, 140–145
  - impulse response inference
    - joint, 406–409
    - pointwise, 394–397, 420
  - median response function, 409, 442–447
  - model averaging, 145
  - posterior odds ratio, 143–144
  - unit roots and cointegration in, 158–159, 397–398
- Bayesian posterior simulation
  - acceptance sampling, 146–147
  - direct sampling, 145–146
- Gibbs sampling, 149
- importance sampling, 147
- Markov Chain Monte Carlo sampling, 147–148
- Metropolis-Hastings sampling, 148–149
- Bayesian priors
  - conjugate, 150
  - diffuse, 154, 395
  - flat, 153
  - Gaussian for given  $\Sigma_u$ , 151–155
  - Haar, 452–454
  - hyperparameters, 150–151
  - independent Gaussian-inverse Wishart, 166–169
  - Litterman, 155–162
  - Minnesota, 155–162
  - natural conjugate, 150
  - natural conjugate Gaussian-inverse Wishart, 162–166
  - on structural model, 265–268, 454
  - sum-of-coefficients, 158–159
  - uniform, 151, 440
  - uninformative, 154
- Beveridge-Nelson decomposition, 23, 80
- Blaschke matrix, 593, 597
- Bonferroni method, 384–385, 399–400, 438, 537–538
- Bootstrap inference
  - bias-adjusted estimators, 363–365
  - bias estimate, 365
  - confidence interval
    - Efron's percentile interval, 357–360
    - equal-tailed percentile-t interval, 360–362
  - finite-sample accuracy, 368–369

- Bootstrap inference (*cont.*)
  - Hall's percentile interval, 362–363
  - symmetric percentile-t interval, 362
  - critical values of a test statistic, 411–412
  - impulse response inference
    - joint, 400–406
    - pointwise, 340–369
  - in overidentified models, 406–418
  - invalidity, 366, 376
  - pitfalls, 365–368
  - prediction, 410–411
  - standard error estimate, 357
- Bootstrap simulation methods
  - blocks-of-blocks bootstrap, 351–353
  - bootstrapping tuples of data, 347–348
  - grid bootstrap, 382–384
  - naïve block bootstrap, 348–351
  - residual-based bootstrap
    - block, 353–357
    - iid, 341–345
    - wild, 345–357
- Brownian motion, 83, 101, 381
- Censored variables, 650–658
- Cholesky decomposition, 219–221, 271, 275
- Cointegration
  - common-trends representation, 79–80
  - definition, 75–77
  - implications for VAR model, 77–82
  - matrix, 78
  - near-cointegrated process, 98, 374, 384–385
  - rank, 78
  - rank tests, 100–104
  - vector, 76–77
- Companion matrix, 25
- Counterfactuals, 121–123, 131–139, 191, 208
- Cowles Commission, 171, 187
- Delta method inference
  - bootstrap standard errors, 357
  - closed-form solutions for variance, 335–336
  - parametric VAR models, 336–338
  - sieve autoregressions, 338–339
- Distributed-lag model, 205–206
- Drift, 21
- Dynamic stochastic general equilibrium model
  - calibration, 184–185
  - estimation, 185–186
  - forecasting, 190
  - VAR representation, 177–183
- Dynamic simultaneous equations model
  - final-form representation, 172
  - identifying restrictions, 174–176
  - reduced-form representation, 172
  - structural representation, 172
- Endogeneity, 172, 177–178, 204–207, 541
- Exogeneity
  - definition, 74, 171–172, 175, 193, 199–201, 543
  - strict, 200
  - tests of, 203–204
- Exogenous shocks
  - data-based counterfactuals, 208
  - narrative approach, 205–208
  - news shocks, 209–210
  - shocks to expectations, 210–211
  - structural VAR shocks, 211–215
- External instruments, 542–548
- Factor models
  - approximate, 555, 557, 560
  - dynamic, 555–560
  - generalized dynamic, 560–562
  - selecting the number of factors, 562–564
  - static, 551–555
  - structural change, 565
- Factors
  - oblique, 551
  - primitive, 558–559
- Forecast scenarios, 123–131
- Forward-looking behavior, 182, 201–203, 594–595, 602–607
- Fractional differencing, 23, 98–99, 292–293, 388–389
- Frequentist inference, 149–141, 143–145
- Fundamentality
  - definition, 592–594
  - tests of, 593, 598, 601
- Fundamental process, 593
- Fundamental shock, 590
- Futures prices, 210–211, 532–542, 548, 598, 605, 607
- GARCH process, 24, 69, 92, 346, 492, 517–524, 528
- Generalized impulse response, 617–618
- Generalized orthogonal (GO) GARCH model, 518
- Granger causality
  - bootstrap critical values, 411–412

- forward-looking asset prices, 201–203
- in higher-dimensional processes, 50
- in the presence of unit roots and cointegration, 49, 85
- tests, 48–50, 196–204
- Granger representation, 80–82, 273, 292–293
- Graph-theoretic approach, 238–239
- High-frequency data, 29–30, 210–211, 223–224, 532–542
- Historical decompositions
  - bar charts, 121–122
  - counterfactuals, 122–123
  - definition, 116–117
  - extensions to integrated series, 120–121
  - time series plots, 117–120
  - transients, 117–119
- Identification
  - data-based identification, 238–239, 491–492
  - exact identification, 174
  - order condition, 218
  - overidentification, 174, 253
  - partial identification, 174, 228, 430–432
  - point identification, 174
  - problem of, 174, 212–213
  - rank condition, 218
  - set identification, 174
  - underidentification, 174
- Identification based on
  - external instruments, 542–548
  - heteroskedasticity, 491–526
  - high-frequency futures prices, 532–542
  - long-run restrictions, 269–296
  - non-Gaussianity, 526–531
    - independent shocks, 526–528
    - uncorrelated shocks, 528–530
  - short-run restrictions, 216–240
  - sign restrictions, 421–490
- Identifying restrictions
  - exclusion restrictions, 218, 222–224
  - long-run restrictions, 269–278
  - short-run restrictions, 216–219
  - sign restrictions, 294–295, 421–436
  - sources of, 221–224, 421–424
- Idiosyncratic component, 551
- Impulse responses, 110–113
  - cumulated, 212
  - forecast error, 111
  - generalized, 617–618
  - long-run, 269–278
  - nonlinear, 614–619
  - reduced-form, 111
  - structural, 110–113
  - transformations, 112
- Inference in sign-identified models
  - agnostic Bayesian priors, 462–463
  - conventional Bayesian priors, 440–442
  - explicit Bayesian priors, 453–461
  - frequentist approaches, 438–439
  - other non-Bayesian approaches, 463–464
  - penalty function approaches, 448–451
  - robust Bayesian priors, 461–462
  - using historical information, 451–452
- Instrumental variables
  - external instruments, 542–548
  - structural VAR(0) model, 258–259
  - structural VAR(p) model, 259–262, 307–310
  - weak instruments, 211, 323, 548
- Joint inference, 391–392, 398–411, 445–446, 483–488
- Kalman filter, 560, 633
- Kurtosis, 67–68
- Kuznets cycle, 661
- Lag augmentation, 42–43, 49–50, 96, 376, 378, 381
- Lag operator, 21
- Lag-order selection
  - Bayesian approach, 144, 169
  - conservative approach, 63–65
  - consistency, 58–59
  - finite-sample properties, 59–60
  - information criteria
    - Akaike information criterion, 54–57
    - Hannan-Quinn criterion, 54–57
    - Schwarz information criterion, 54–57
  - practical considerations, 61–66
  - recursive MSPE rankings, 57–58
  - sequential tests
    - LM test, 53–54
    - LR test, 51–52
    - Portmanteau test, 52–53
    - Wald test, 52
- Large-dimensional structural VAR models
  - Bayesian VAR models, 579–584
  - factor-augmented (FA) structural VAR models, 565–571

- Large-dimensional structural VAR models (*cont.*)
  - global VAR models, 586–587
  - panel VAR models, 584–585
  - spatial models, 587
  - structural dynamic factor models, 571–577
- LASSO approach, 588–589
- Levels VAR models with integrated variables, 95–99
  - estimation, 95–96
  - fractional integration, 98–99
  - local-to-unity asymptotics, 97–98
  - sieve estimation, 96–97
- Loading matrix, 78, 552, 569
- Local projections, 389–393
- Long memory, 23, 42
- Long-run restrictions
  - ability to recover DSGE model responses, 323–333
  - combining short- and long-run restrictions, 287–292, 310–320
  - estimation subject to, 299–320
  - general framework, 272–278
  - practical limitations, 320–323
  - theoretical limitations, 292–296
  - traditional framework, 269–272
- Loss function, 60, 142, 145, 184, 265–266, 399, 409, 447, 449, 458–459, 489–490
- Lucas critique, 137–138, 172, 183, 191–192, 232, 625
- Marginal likelihood, 144, 150–151, 189
- Marginal processes, 28–29, 180, 599
- Markov switching, 623–626
- Martingale difference sequence, 24, 44, 46–47, 257, 601, 640, 645
- Martingale sequence, 24
- Measurement error, 30, 179, 565
- Model diagnostics
  - nonnormality, 67–68, 104
  - residual ARCH, 68–69, 104
  - residual autocorrelation, 67, 104
  - time invariance, 69–72, 104–105
- Moore–Penrose inverse, 336
- Moving average
  - fundamental, 592–601
  - nonfundamental, 592–601
  - representation, 26–27, 111
- Multiplier
  - dynamic, 45, 590
  - impact, 3, 7, 109–111, 217–219
  - long-run, 272–274, 321, 387–386
- Near unit roots, 97, 108, 158–159
- Nonfundamentality, 592–594
- Nonfundamental process, 593
- Nonfundamental shock, 592
- Nonlinear VAR models
  - GARCH-in-mean, 636–640
  - Markov switching, 505–511, 528–530, 622–630
  - noncausal VAR model, 645–648
  - nonparametric VAR model, 640–645
  - thresholds and smooth transitions, 619–622
  - time-varying coefficients, 630–636
- Normalization, 78, 83, 88, 216–219, 245–246, 267, 295, 414, 427, 506, 536–537, 545, 552
- Order of integration, 22
- Ornstein–Uhlenbeck process, 381
- Orthogonal factor, 551
- Orthogonalization, 219–221
- Orthogonal matrix, 313–315, 425, 327
- Overidentified structural models
  - estimation, 253–254, 258, 266, 319, 420
  - inference, 416–420
  - testing, 254, 418
- Penalty functions, 448–452
- Policy counterfactuals, 136–139, 191–192, 231–232
- Post-model selection inference, 61–63, 106
- Predeterminedness, 199–200
- Prediction
  - conditional expectation, 46, 210, 594, 615
  - prediction intervals, 47, 410–411
  - prediction mean squared error, 46–48, 114–116
  - predictive density, 127–128, 410–411, 643
- Price puzzle, 230, 538, 578
- Principal components, 229, 554, 561, 578, 601
- Projection method, 381, 438
- Proxy VAR model, 544
- QR decomposition, 427
- Quasi-maximum likelihood estimator, 40

- Random walk, 20–21, 80, 83
- Rational expectations, 176, 183–184, 194
- Real business cycle model, 109, 178–179, 221, 278–280, 283, 296, 323–324
- Reduced-form autoregressive representation, 25
- Reduced-form estimation
  - VAR model
    - bias-corrected least squares, 35–38
    - generalized least squares, 34–35
    - least squares, 31–34
    - levels VAR models with integrated variables, 41–43
    - maximum likelihood estimation, 38–40
  - VECM
    - generalized least squares, 84
    - least squares, 83, 95–96
    - least squares with known cointegrating matrix, 84–85
    - maximum likelihood with known cointegrating matrix, 90–95
    - maximum likelihood with known cointegrating rank, 85–90
- Reduced-form moving average representation, 26–27
- Risk, 129–130
- Romer dummies, 205–208
- Roots, 21–22, 25–28, 45–46
- Rotation matrix
  - generation of, 426–428
  - Givens rotation matrix, 426
  - Householder transformation, 427–428
- Seasonality
  - combining seasonal specifications, 668
  - deterministic, 663
  - periodical, 666–667
  - seasonal differencing, 664–665
  - seasonal dummies, 663
  - seasonal filters, 667–668
  - seasonal integration, 664–666
  - seasonal lags, 664
  - seasonal unit roots, 665
  - stationary, 664
  - stochastic, 664–666
  - time-varying, 667
- Semistructural VAR model, 228–234, 464–465
- Shocks to
  - aggregate demand, 113, 224–226, 269, 289–290, 310, 416, 465, 473, 528, 543
  - aggregate supply, 224, 237, 269, 288, 290, 310, 465, 473
  - demand, 113, 213, 224, 269, 421–424, 466
  - efficiency, 179
  - energy price, 227
  - exchange rate, real and nominal, 284
  - expected productivity, 284, 472, 606
  - financial market expectations, 210
  - fiscal policy, 177, 207–208, 236, 471, 544, 594, 603
  - flow demand, 433, 470, 483
  - flow supply, 433, 470, 483
  - IS curve, 237, 288–289
  - labor supply, 289
  - LM curve, 289
  - markup, 468
  - measurement error, 179, 468
  - monetary policy, 205, 224, 228–234, 290, 310, 404–405, 465, 467–468, 473, 485, 502, 523, 532–535, 538–539, 577–579, 607, 621, 629, 635
  - money demand, 224, 237, 251, 288, 473
  - money supply, 177, 224, 237, 251, 288, 473
  - news, 209, 285–286, 543–544, 606
  - oil market-specific demand, 113, 225–226, 416, 528, 543
  - oil price, 136, 226–227, 243, 289–290, 405, 465, 638, 651–652
  - oil price expectation, 604–605
  - oil supply, 113, 208, 225–226, 416, 528, 543, 579
  - preferences, 179
  - profitability, 466
  - speculative demand, 470, 604
  - supply, 113, 213, 269, 421–424
  - tastes, 468
  - technology, 109, 177, 208, 271, 278, 282, 289, 299, 323–333, 467–468, 594, 606
- Shocks with
  - permanent effects, 235, 279
  - transitory effects, 235, 279, 283
- Short-run restrictions
  - combining short- and long-run restrictions, 287–292, 310–320
  - estimation subject to, 242–268
  - nonrecursive models, 223–224, 235–236
  - recursive models, 219–221
  - semistructural models, 227–235
- Sieve approximations, 27–28, 43–46, 51, 61, 96–97, 181–182, 328–329, 338–339, 392, 566

- Sign restrictions
  - dynamic restrictions, 432, 435
  - elasticity bounds, 432–434
  - shape restrictions, 425
  - static restrictions, 421–432
  - verification of, 435–436
- Skewness, 67–68, 359
- Square root matrix, 68, 83, 248, 519, 520
- Stability condition, 21–22, 25
- State-space model
  - measurement equation, 632
  - observation equation, 559
  - state equation, 632
  - transition equation, 559, 563, 570, 632, 634
- State-space representation of
  - DSGE model, 177, 182, 185, 188
  - dynamic factor model, 558–559
  - FAVAR model, 566
  - time-varying coefficient model, 631–632
- Stationarity, 19, 21–22
- Structural analysis, 187
- Structural autoregressive representation, 216–219
- Structural change
  - breaks in stochastic component, 669–671
  - smooth structural change, 671–672
- Structural estimation
  - Bayesian, 265–268, 440–464
  - generalized method of moments, 253–258
  - instrumental variables, 258–262, 307–310, 315–316
  - maximum likelihood, 262–265, 306–307
  - method of moments, 242–253, 301–306, 311–315
- Structural forecast error variance
  - decompositions
  - definition, 113–116
  - inference, 336, 375, 369, 439
- Structural impulse responses
  - linear models, 110–113
  - nonlinear models, 614–619
- Structural moving average representation, 111
- Structural shocks
  - correlated, 525–526
  - independent, 526–528
  - uncorrelated, 2, 219–220, 494, 528–530
- Structural vector error correction model
  - definition, 298–299
  - estimation, 307–310
- Subrotation, 474
- Subset VAR models, 72–73
- TRAMO-SEATS, 668
- Trends
  - combining trend specifications, 662–663
  - common, 75–77, 660
  - deterministic, 20, 108
  - stochastic, 20–21
  - trend filters
    - band pass filter, 660–661
    - Hodrick-Prescott (HP) filter, 659–660
    - moving-average filter, 660–661
- Unit roots
  - Dickey-Fuller test, 83, 380, 384, 376
  - integrated processes, 21–23
  - limitations of tests for unit roots and cointegration, 106
- Variables
  - cross-sectional aggregation, 180
  - exogenous, 200–201
  - predetermined, 199–200
  - linear transformation, 29, 180
  - temporal aggregation, 29–30
- Variance decomposition, 114
- VARMA model, 27–28, 43–45, 62, 172–173, 177–178, 180–182, 328–329, 392, 568
- VARX model, 74, 173, 543
- VECM
  - model specification, 99–105
  - recovering VAR parameters, 78, 95
  - representation, 77–80
  - role of intercept and trend, 80–82
  - sieve approximations, 96–97
  - triangular representation, 372–373
- Volatility models
  - GARCH errors, 517–524
  - Markov switching in variance, 505–511
  - smooth transitions in variance, 511–517
  - stochastic, 632
  - with extraneously specified volatility changes, 496–505
- White noise, 20, 24
- Wold decomposition theorem, 27
- Wold moving average representation, 460
- X-12 ARIMA seasonal adjustment, 668