

Advanced Time Series Analysis

Syllabus: Version 1e (May 18, 2026)

Instructor: Mikkel Plagborg-Møller, mikkelpm@uchicago.edu

Lectures: Tue/Thu 3.30–4.50pm, SHFE 242

Office hours: Wed 9.00–10.00am, SHFE 316

Website: <https://canvas.uchicago.edu/courses/70813>

Description. The course covers modern tools for reduced-form and structural time series analysis, with a view towards applications in macroeconomics. Topics covered include frequentist and Bayesian inference in VARMA models, spectral analysis, estimation of dynamic causal effects with structural VARs and local projections, state space models, dynamic factor models, estimation of structural models with representative or heterogeneous agents, and analysis of non-stationary models. Problem sets will involve a mix of theory, coding, and empirical work.

Prerequisites. ECON 31000, ECON 31100, and ECON 31200, or equivalent. Students from outside the Economics PhD program should contact the instructor to obtain permission to take the course.

Material. There is no required textbook for the course. Handouts will be made available on the website. Attached to this syllabus is a list of optional readings that are useful for a deeper understanding of the material.

Some students might find it useful to have a textbook as an additional reference. Good reference books include:

Brockwell, P. J., and Davis, R. A. (1991). *Time Series: Theory and Methods*. 2nd edition, Springer. (Beautiful mathematical treatment of the classic theory of covariance stationary time series, but not aimed at economists.)

Davidson, J. (1994). *Stochastic Limit Theory*. Oxford University Press. (Thorough, technical treatment of stochastic limit theory for dependent data.)

- Hamilton, J. D. (1994). *Time Series Analysis*. Princeton University Press. (Comprehensive reference for time series econometrics methods developed before the mid-1990s.)
- Hayashi, F. (2000). *Econometrics*. Princeton University Press. (Accessible treatment of GMM and stochastic limit theory for time series data.)
- Herbst, E. P., and Schorfheide, F. (2015). *Bayesian Estimation of DSGE Models*. Princeton University Press. (Recent reference on Bayesian inference in structural time series models.)
- Kilian, L., and Lütkepohl, H. (2017). *Structural Vector Autoregressive Analysis*. Cambridge University Press. (Recent reference on SVAR methods.)

Homework. Problem sets will be posted on the course website approximately every two weeks. Students are encouraged to collaborate on the problem sets, but answers and computer code must be typed up independently. The problem sets will be graded coarsely, i.e., a full score will be given as long as the work demonstrates dedication and thoughtfulness. I reserve the right to subtract points for sloppy exposition, including unreadable code. If you find a grading error, please resubmit your problem set along with a one-paragraph explanation; I reserve the right to re-grade the entire problem set.

Project presentation. In lieu of a midterm and final exam, students will present a project during exam week. Students may choose to collaborate in groups of two. The project may be original work, an in-depth critical assessment of an existing paper from the literature, or somewhere in between. Students should receive prior approval from the instructor of their choice of project topic.

Grading. The final course grade will be a monotonic function of the average of (i) the average problem set score (40% weight) and (ii) the project presentation score (60% weight).

AI use. While students are encouraged to think and code on their own as a way to understand the course material, the use of AI tools is allowed on all assignments. No citation is required.

Code of conduct. Students may not record lectures or office hours without the express permission of the instructor. Students are expected to comply with University regulations

regarding honest work. If you are in doubt about what constitutes academic dishonesty, speak with me before the assignment is due. Failure to maintain academic integrity on an assignment will result in a penalty befitting the violation, up to and including failing the course and further University sanctions. For more information, consult the student manual.

Accommodations for students with disabilities. The University of Chicago is committed to ensuring equitable access to our academic programs and services. Students with disabilities who have been approved for the use of academic accommodations by Student Disability Services (SDS) and need a reasonable accommodation(s) to participate fully in this course should follow the procedures established by SDS for using accommodations. Timely notifications are required to ensure that your accommodations can be implemented. Please meet with me to discuss your access needs in this class after you have completed the SDS procedures for requesting accommodations.

Important dates.

Mar 24 (Tue): First class

May 21 (Thu): Last class

May 26 (Tue) and/or May 28 (Thu): Project presentations

Course outline. The following outline is preliminary and may change without warning.

1. Refresher: Stationary models.
 - i) Strict/covariance stationarity, projection.
 - ii) Lag operators, linear filters, VARMA.
 - iii) Wold decomposition.
 - iv) Likelihood factorization, maximum likelihood estimation.
 - v) Bayesian VARs.
 - vi) Model selection.
2. Spectral analysis.
 - i) Spectrum of linear filter.
 - ii) Estimation: sieve-VAR, periodogram smoothing.
3. Inference with weakly dependent data.
 - i) Central Limit Theorem, martingale difference sequences, mixing.
 - ii) Applications to GMM, moment matching.
 - iii) Bootstrap.
4. Causal identification in macroeconomics.
 - i) SVMA, SVAR, relationship with structural models.
 - ii) Invertibility, recoverability.
 - iii) Identification through exclusion restrictions.
 - iv) Local Projection versus VAR estimation of impulse responses.
 - v) Identification using instruments/proxies.
 - vi) Partial identification through sign/magnitude restrictions.
 - vii) Nonlinear models, identification through higher moments.
5. State space models.
 - i) Linear-Gaussian models, Kalman filter and smoother.

- ii) Basics of Markov Chain Monte Carlo.
 - iii) Estimation of linearized DSGE models.
 - iv) Estimation of heterogeneous agent models.
 - v) Dynamic factor models.
6. Functional Central Limit Theorem.
- i) Testing for structural breaks.
7. Non-stationary models.
- i) $I(1)$ processes, Beveridge-Nelson decomposition, VARIMA.
 - ii) Frequentist asymptotics for unit roots, local-to-unity.
 - iii) Bayesian vs. frequentist perspective.
 - iv) Spurious regression.
 - v) Cointegration, VECM.
 - vi) Detrending.

Optional reading list

Introductory readings are listed first and marked with a star (*). Other readings are included for your reference. Original contributions are not always cited when good survey references are available. The reading list is preliminary and may change without warning.

1 Stationary models

Models, prediction, estimation

* Hayashi: chapters 6.1–6.4.

* Kilian and Lütkepohl: chapters 2.1–2.5.

Brockwell and Davis: chapters 1.1–1.5, 2.1–2.9, 3.1–3.5, 5.1–5.5, 5.7, 11.1–11.4.

Hamilton: chapters 2–4, 10–12.

Herbst and Schorfheide: chapters 3.1–3.2.

Kilian and Lütkepohl: chapters 2, 5.

Giannone, D., Lenza, M., and Primiceri, G. E. (2015). “Prior Selection for Vector Autoregressions.” *Review of Economics and Statistics* 97(2), 436–451.

Model selection

* Kilian and Lütkepohl: chapter 2.6.

Brockwell and Davis: chapter 9.

Claeskens, G., and Hjort, N. L. (2008). *Model Selection and Model Averaging*. Cambridge University Press. Chapters 1–4.

Geweke, J., and Meese, R. (1981). “Estimating regression models of finite but unknown order.” *International Economic Review* 22(1), 55–70.

Hansen, B. E. (2005). “Challenges for Econometric Model Selection.” *Econometric Theory* 21(1), 60–68.

Leeb, H., and Pötscher, B. M. (2005). “Model Selection and Inference: Facts and Fiction.” *Econometric Theory* 21(01), 21–59. Sections 1–2.

Applications

- * Stock, J. H., and Watson, M. W. (2017). “Twenty Years of Time Series Econometrics in Ten Pictures.” *Journal of Economic Perspectives* 31(2), 59–86.
- Bernanke, B. S., and Kuttner, K. N. (2005). “What Explains the Stock Market’s Reaction to Federal Reserve Policy?” *Journal of Finance* 60(3), 1221–1257.
- Sims, C. A. (1972). “Money, Income, and Causality.” *American Economic Review* 62(4), 540–552.
- Stock, J. H., and Watson, M. W. (2003). “Forecasting Output and Inflation: The Role of Asset Prices.” *Journal of Economic Literature* 41(3), 788–829.

2 Spectral analysis

Representation theory and inference

- * Hamilton: chapter 6.
- Brockwell and Davis: chapters 4, 10.1–10.5, 11.6.
- Berk, N. (1974). “Consistent Autoregressive Spectral Estimates.” *Annals of Statistics* 2(3), 489–502.
- Hannan, E. J. (1970). *Multiple Time Series*. John Wiley & Sons. Chapters III.2–3, III.5.

Applications

- Dew-Becker, I., and Giglio, S. (2016). “Asset Pricing in the Frequency Domain: Theory and Empirics.” *Review of Financial Studies* 29(8), 2029–2068.
- King, R. G., and Watson, M. W. (1996). “Money, Prices, Interest Rates and the Business Cycle.” *Review of Economics and Statistics* 78(1), 35–53.
- Qu, Z., and Tkachenko, D. (2012). “Frequency Domain Analysis of Medium Scale DSGE Models with Application to Smets and Wouters (2007).” In *Advances in Econometrics, Volume 28: DSGE Models in Macroeconomics – Estimation, Evaluation and New Developments*, edited by Balke, N., Canova, F., Milani, F., and Wynne, M. A., Emerald Group Publishing, 319–385.

- Sala, L. (2015). “DSGE Models in the Frequency Domain.” *Journal of Applied Econometrics* 30(2), 219–240.
- Sargent, T. J., and Surico, P. (2011). “Two Illustrations of the Quantity Theory of Money: Breakdowns and Revivals.” *American Economic Review* 101(1), 109–128.
- Watson, M. W. (1993). “Measures of Fit for Calibrated Models.” *Journal of Political Economy* 101(6), 1011–1041.

3 Inference with weakly dependent data

Theory

* Hayashi: chapters 2, 6.5–6.6.

Brockwell and Davis: chapters 6–7.

Davidson: chapters 13–14, 24.

Hamilton: chapter 7.

GMM, moment matching

* Hayashi: chapters 7.1–7.4.

Cocci, M. D., and Plagborg-Møller, M. (2025). “Standard Errors for Calibrated Parameters.” *Review of Economic Studies* 92(5), 2952–2978.

Hansen, L. P., Heaton, J., and Yaron, A. (1996). “Finite-Sample Properties of Some Alternative GMM Estimators.” *Journal of Business & Economic Statistics* 14(3), 262–280.

Hansen, L. P., and Heckman, J. J. (1996). “The empirical foundations of calibration.” *Journal of Economic Perspectives* 10(1), 87–104.

Hansen, L. P., and Singleton, K. (1991). “Computing Semiparametric Efficiency Bounds for Linear Time Series Models.” In *Nonparametric and semiparametric methods in econometrics and statistics: Proceedings of the Fifth International Symposium in Economic Theory and Econometrics*, edited by Barnett, W. A., Powell, J., and Tauchen, G. E., Cambridge University Press, chapter 15, 388–411.

- Kydland, F., and Prescott, E. (1996). “The computational experiment: an econometric tool.” *Journal of Economic Perspectives* 10(1), 69–85.
- Nakamura, E., and Steinsson, J. (2018). “Identification in Macroeconomics.” *Journal of Economic Perspectives* 32(3), 59–86.
- Newey, W. K., and McFadden, D. L. (1994). “Large sample estimation and hypothesis testing.” In *Handbook of Econometrics, Volume IV*, edited by Engle, R. F., and McFadden, D. L., Elsevier, chapter 36, 2111–2245.

Long-run variance estimation

- * Hayashi: 6.5–6.6.
 - * Lazarus, E., Lewis, D. J., Stock, J. H., and Watson, M. W. (2018). “HAR Inference: Recommendations for Practice.” *Journal of Business and Economic Statistics* 36(4), 541–559. With comments and rejoinder.
- Brockwell and Davis: chapters 10.1–10.5, 11.6.
- Andrews, D. W. K. (1991). “Heteroskedasticity and autocorrelation consistent covariance matrix estimation.” *Econometrica* 59(3), 817–858.
- Andrews, D. W. K., and Monahan, J. C. (1992). “An Improved Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimator.” *Econometrica* 60(4), 953–966.
- Den Haan, W. J., and Levin, A. (1997). “A practitioner’s guide to robust covariance matrix estimation.” In *Handbook of Statistics, Volume 15*, edited by Maddala, G. S., and Rao, C. R., North-Holland, 299–342.
- Dou, L. (2024). “Optimal HAR Inference.” *Quantitative Economics* 15(4), 1107–1149.
- Ibragimov, R., and Müller, U. K. (2010). “ t -Statistic Based Correlation and Heterogeneity Robust Inference.” *Journal of Business and Economic Statistics* 28(4), 453–468.
- Jansson, M. (2004). “The Error in Rejection Probability of Simple Autocorrelation Robust Tests.” *Econometrica* 72(3), 937–946.
- Kiefer, N. M., and Vogelsang, T. J. (2005). “A New Asymptotic Theory for Heteroskedasticity–Autocorrelation Robust Tests.” *Econometric Theory* 21(6), 1130–1164.

- Lazarus, E., Lewis, D. J., and Stock, J. H. (2021). “The Size-Power Tradeoff in HAR Inference.” *Econometrica* 89(5), 2497–2516.
- Müller, U. K. (2007). “A theory of robust long-run variance estimation.” *Journal of Econometrics* 141(2), 1331–1352.
- Müller, U. K. (2014). “HAC Corrections for Strongly Autocorrelated Time Series.” *Journal of Business & Economic Statistics* 32(3), 311–322.
- Newey, W. K., and West, K. D. (1987). “A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix.” *Econometrica* 55(3), 703–708.
- Pötscher, B. M. (2002). “Lower Risk Bounds and Properties of Confidence Sets for Ill-Posed Estimation Problems with Applications to Spectral Density and Persistence Estimation, Unit Roots, and Estimation of Long Memory Parameters.” *Econometrica* 70(3), 1035–1065.
- Sun, Y. (2014). “Let’s Fix It: Fixed- b Asymptotics versus Small- b Asymptotics in Heteroscedasticity and Autocorrelation Robust Inference.” *Journal of Econometrics* 178(3), 659–677.
- Sun, Y., Phillips, P. C. B., and Jin, S. (2008). “Optimal Bandwidth Selection in Heteroskedasticity–Autocorrelation Robust Testing.” *Econometrica* 76(1), 175–194.

Bootstrap

* Kilian and Lütkepohl: chapters 12.1–12.5.

- Brüggemann, R., Jentsch, C., and Trenkler, C. (2016). “Inference in VARs with conditional heteroskedasticity of unknown form.” *Journal of Econometrics* 191(1), 69–85.
- Gonçalves, S., and Kilian, L. (2004). “Bootstrapping autoregressions with conditional heteroskedasticity of unknown form.” *Journal of Econometrics* 123(1), 89–120.
- Horowitz, J. L. (2001). “The Bootstrap.” In *Handbook of Econometrics, Volume 5*, edited by Heckman, J. J., and Leamer, E., Elsevier, chapter 52, 3159–3228.
- Kilian, L. (1998). “Small-sample Confidence Intervals for Impulse Response Functions.” *Review of Economics and Statistics* 80(2), 218–230.

Applications

- Christiano, L., Eichenbaum, M., and Evans, C. (2005). “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy.” *Journal of Political Economy* 113(1), 1–45.
- Dew-Becker, I. (2017). “How Risky Is Consumption in the Long-Run? Benchmark Estimates from a Robust Estimator.” *Review of Financial Studies* 30(2), 631–666.
- Hansen, L. P., and Singleton, K. J. (1982). “Generalized Instrumental Variable Estimation of Nonlinear Rational Expectation Models.” *Econometrica* 50(5), 1269–1286.
- Mankiw, N. G., Reis, R., and Wolfers, J. (2004). “Disagreement about Inflation Expectations.” In *NBER Macroeconomics Annual 2003, Volume 18*, edited by Gertler, M., and Rogoff, K., National Bureau of Economic Research, 209–248.
- Mavroeidis, S., Plagborg-Møller, M., and Stock, J. H. (2014). “Empirical Evidence on Inflation Expectations in the New Keynesian Phillips Curve.” *Journal of Economic Literature* 52(1), 124–188.

4 Causal identification in macroeconomics

Exclusion restrictions, instruments/proxies

- * Stock, J. H., and Watson, M. W. (2018). “Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments.” *Economic Journal* 128(610), 917–948.
- Kilian and Lütkepohl: chapters 4, 7–12, 15.
- Blanchard, O., and Quah, D. (1989). “The Dynamic Effects of Aggregate Demand and Supply Disturbances.” *American Economic Review* 79(4), 655–673.
- Jordà, O. (2005). “Estimation and Inference of Impulse Responses by Local Projections.” *American Economic Review* 95(1), 161–182.
- McKay, A., and Wolf, C. K. (2023). “What Can Time Series Regressions Tell Us About Policy Counterfactuals?” *Econometrica* 91(5), 1695–1725.

- Montiel Olea, J. L., Stock, J. H., and Watson, M. W. (2021). “Inference in SVARs Identified with External Instruments.” *Journal of Econometrics* 225(1), 74–87.
- Plagborg-Møller, M., and Wolf, C. K. (2021). “Local Projections and VARs Estimate the Same Impulse Responses.” *Econometrica* 89(2), 955–980.
- Rubio-Ramírez, J. F., Waggoner, D. F., and Zha, T. (2010). “Structural vector autoregressions: Theory of identification and algorithms for inference.” *Review of Economic Studies* 77(2), 665–696.
- Sims, C. A. (1980). “Macroeconomics and Reality.” *Econometrica* 48(1), 1–48.

Inference

- * Montiel Olea, J. L., Plagborg-Møller, M., Qian, E., and Wolf, C. K. (2026). “Local Projections or VARs? A Primer for Macroeconomists.” *NBER Macroeconomics Annual* 40, 111–152.
- Barnichon, R., and Brownlees, C. (2019). “Impulse Response Estimation By Smooth Local Projections.” *Review of Economics and Statistics* 101(3), 522–530.
- Inoue, A., and Kilian, L. (2020). “The Uniform Validity of Impulse Response Inference in Autoregressions.” *Journal of Econometrics* 215(2), 450–472.
- Mikusheva, A. (2012). “One-Dimensional Inference in Autoregressive Models With the Potential Presence of a Unit Root.” *Econometrica* 80(1), 173–212.
- Montiel Olea, J. L., and Plagborg-Møller, M. (2019). “Simultaneous Confidence Bands: Theory, Implementation, and an Application to SVARs.” *Journal of Applied Econometrics* 34(1), 1–17.
- Montiel Olea, J. L., and Plagborg-Møller, M. (2021). “Local Projection Inference is Simpler and More Robust Than You Think.” *Econometrica* 89(4), 1789–1823.
- Montiel Olea, J. L., Plagborg-Møller, M., Qian, E., and Wolf, C. K. (2026). “Double Robustness of Local Projections and Some Unpleasant VARithmetic.” *Econometrica*, forthcoming.
- Xu, K.-L. (2025). “Local Projection Based Inference under General Conditions.” *Review of Economic Studies*, forthcoming.

Invertibility, recoverability

- Chahrour, R., and Jurado, K. (2022). “Recoverability and Expectations-Driven Fluctuations.” *Review of Economic Studies* 89(1), 214–239.
- Fernández-Villaverde, J., Rubio-Ramírez, J. F., Sargent, T. J., and Watson, M. W. (2007). “ABCs (and Ds) of Understanding VARs.” *American Economic Review* 97(3), 1021–1026.
- Forni, M., Gambetti, L., and Sala, L. (2019). “Structural VARs and noninvertible macroeconomic models.” *Journal of Applied Econometrics* 34(2), 221–246.
- Lippi, M., and Reichlin, L. (1994). “VAR analysis, nonfundamental representations, Blaschke matrices.” *Journal of Econometrics* 63(1), 307–325.
- Plagborg-Møller, M. (2019). “Bayesian Inference on Structural Impulse Response Functions.” *Quantitative Economics* 10(1), 145–184.
- Plagborg-Møller, M., and Wolf, C. K. (2022). “Instrumental Variable Identification of Dynamic Variance Decompositions.” *Journal of Political Economy* 130(8), 2164–2202.

Sign/magnitude restrictions

- * Baumeister, C., and Hamilton, J. D. (2015). “Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information.” *Econometrica* 83(5), 1963–1999.
- Gafarov, B., Meier, M., and Montiel Olea, J. L. (2018). “Delta-Method Inference for a Class of Set-Identified SVARs.” *Journal of Econometrics* 203(2), 316–327.
- Giacomini, R., and Kitagawa, T. (2021). “Robust Bayesian Inference for Set-Identified Models.” *Econometrica* 89(4), 1519–1556.
- Uhlig, H. (2005). “What are the effects of monetary policy on output? Results from an agnostic identification procedure.” *Journal of Monetary Economics* 52(2), 381–419.
- Wolf, C. K. (2020). “SVAR (Mis)Identification and the Real Effects of Monetary Policy.” *American Economic Journal: Macroeconomics* 12(4), 1–32.

Nonlinear models, identification through higher moments

- * Kolesár, M., and Plagborg-Møller, M. (2025). “Dynamic Causal Effects in a Nonlinear World: the Good, the Bad, and the Ugly.” *Journal of Business & Economic Statistics* 43(4), 737–754. With comments and rejoinder.
- * Lewis, D. J. (2025). “Identification Based on Higher Moments in Macroeconometrics.” *Annual Review of Economics* 17, 665–693.
- Angrist, J. D., Jordà, O., and Kuersteiner, G. M. (2018). “Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited.” *Journal of Business & Economic Statistics* 36(3), 371–387.
- Gallant, A. R., Rossi, P. E., and Tauchen, G. (1993). “Nonlinear dynamic structures.” *Econometrica* 61(4), 871–907.
- Gonçalves, S., Herrera, A. M., Kilian, L., and Pesavento, E. (2024). “Nonparametric Local Projections.” Manuscript, McGill University.
- Gouriéroux, C., Monfort, A., and Renne, J.-P. (2017). “Statistical inference for independent component analysis: Application to structural VAR models.” *Journal of Econometrics* 196(1), 111–126.
- Gouriéroux, C., Monfort, A., and Renne, J.-P. (2020). “Identification and Estimation in Non-Fundamental Structural VARMA Models.” *Review of Economic Studies* 87(4), 1915–1953.
- Koop, G., Pesaran, M. H., and Potter, S. M. (1996). “Impulse response analysis in nonlinear multivariate models.” *Journal of Econometrics* 74(1), 119–147.
- Mavroeidis, S. (2021). “Identification at the Zero Lower Bound.” *Econometrica* 89(6), 2855–2885.
- Rambachan, A., and Shephard, N. (2025). “When do common time series estimands have nonparametric causal meaning?” arXiv:1903.01637.
- Rigobon, R. (2003). “Identification Through Heteroskedasticity.” *Review of Economics and Statistics* 85(4), 777–792.

Applications

- * Ramey, V. A. (2016). “Macroeconomic Shocks and Their Propagation.” In *Handbook of Macroeconomics, Volume 2A*, edited by Taylor, J. B., and Uhlig, H., Elsevier, chapter 2, 71–162.
- Angeletos, G.-M., Collard, F., and Dellas, H. (2020). “Business-Cycle Anatomy.” *American Economic Review* 110(10), 3030–3070.
- Bauer, M. D., and Swanson, E. T. (2023). “A Reassessment of Monetary Policy Surprises and High-Frequency Identification.” *NBER Macroeconomics Annual* 37, 87–155.
- Forni, M., Gambetti, L., Lippi, M., and Sala, L. (2017). “Noisy News in Business Cycles.” *American Economic Journal: Macroeconomics* 9(4), 122–152.
- Gertler, M., and Karadi, P. (2015). “Monetary Policy Surprises, Credit Costs, and Economic Activity.” *American Economic Journal: Macroeconomics* 7(1), 44–76.
- Känzig, D. R. (2021). “The Macroeconomic Effects of Oil Supply News: Evidence from OPEC Announcements.” *American Economic Review* 111(4), 1092–1125.
- Mertens, K., and Ravn, M. O. (2010). “Measuring the Impact of Fiscal Policy in the Face of Anticipation: A Structural VAR Approach.” *Economic Journal* 120(544), 393–413.
- Mertens, K., and Ravn, M. O. (2013). “The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States.” *American Economic Review* 103(4), 1212–1247.
- Ramey, V. A., and Zubairy, S. (2018). “Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data.” *Journal of Political Economy* 126(2), 850–901.

5 State space models

Linear state space models, DSGE estimation

- * Hamilton: chapter 13.
- * Herbst and Schorfheide: chapters 1–3.
- * Griffoli, T. M. (2013). “Dynare User Guide.” Sections 3, 5.

- Auclert, A., Bardóczy, B., Rognlie, M., and Straub, L. (2021). “Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models.” *Econometrica* 89(5), 2375–2408.
- Blanchard, O. J., and Kahn, C. M. (1980). “The Solution of Linear Difference Models under Rational Expectations.” *Econometrica* 48(5), 1305–1311.
- Durbin, J., and Koopman, S. J. (2012). *Time Series Analysis by State Space Methods*. 2nd edition, Oxford University Press.
- Liu, L., and Plagborg-Møller, M. (2023). “Full-Information Estimation of Heterogeneous Agent Models Using Macro and Micro Data.” *Quantitative Economics* 14(1), 1–35.
- Sims, C. A. (2002). “Solving Linear Rational Expectations Models.” *Computational Economics* 20(1–2), 1–20.
- Winberry, T. (2018). “A method for solving and estimating heterogeneous agent macro models.” *Quantitative Economics* 9(3), 1123–1151.

Markov Chain Monte Carlo

- * Chib, S. (2001). “Markov Chain Monte Carlo Methods: Computation and Inference.” In *Handbook of Econometrics, Volume 5*, edited by Heckman, J. J., and Leamer, E., Elsevier, chapter 5, 3564–3634.

Herbst and Schorfheide: chapter 4.

Dynamic factor models

- * Stock, J. H., and Watson, M. W. (2016). “Dynamic Factor Models, Factor-Augmented Vector Autoregressions, and Structural Vector Autoregressions in Macroeconomics.” In *Handbook of Macroeconomics, Volume 2A*, edited by Taylor, J. B., and Uhlig, H., Elsevier, chapter 8, 415–525. Sections 1–3, 5–6.
- Bai, J. (2003). “Inferential Theory for Factor Models of Large Dimensions.” *Econometrica* 71(1), 135–171.
- Bai, J., and Ng, S. (2002). “Determining the Number of Factors in Approximate Factor Models.” *Econometrica* 70(1), 191–221.

- Barigozzi, M., and Hallin, M. (2026). “The Dynamic, the Static, and the Weak: Factor Models and the Analysis of High-Dimensional Time Series.” *Journal of Time Series Analysis* 47(1), 201–219.
- Doz, C., Giannone, D., and Reichlin, L. (2012). “A Quasi-Maximum Likelihood Approach for Large, Approximate Dynamic Factor Models.” *Review of Economics and Statistics*, 94(4), 1014–1024.
- Forni, M., Giannone, D., Lippi, M. and Reichlin, L. (2009). “Opening the Black Box: Structural Factor Models with Large Cross Sections.” *Econometric Theory* 25(5), 1319–1347.
- Forni, M., Hallin, M., Lippi, M., and Reichlin, L. (2000). “The Generalized Dynamic-Factor Model: Identification and Estimation.” *Review of Economics and Statistics* 82(4), 540–554.
- Onatski, A. (2009). “Testing Hypotheses About The Number of Factors in Large Factor Models.” *Econometrica* 77(5), 1447–1479.
- Stock, J. H., and Watson, M. W. (2002). “Forecasting Using Principal Components From a Large Number of Predictors.” *Journal of the American Statistical Association* 97(460), 1167–1179.

Applications

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