

Syllabus

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Course: Bayesian macroeconometrics

Professor:

2024 FIRST SEMESTER

COURSE OUTLINE

This course provides an introduction to modern macroeconometrics using Bayesian techniques. We will discuss the estimation, inference, and evaluation of Bayesian vector autoregressive models (BVARs) and linearized dynamic stochastic general equilibrium (DSGE) models. Therefore, the course discusses the likelihood computation via the Kalman filter and posterior simulation via standard Markov Chain Monte Carlo (MCMC) methods. The course will present some theoretical foundations of Bayesian estimation and focus on applications and implementation issues in macroeconomics.

Previous knowledge of time-series econometrics and advanced macroeconomic theory on DSGE models is required. In the applications, some basic knowledge of programming is necessary.

Most applications related to BVARs are in MATLAB, while those associated with DSGE will use Dynare.

PROGRAM

1. Introduction to Bayesian econometrics
2. Monte Carlo methods
3. Bayesian VAR (reduced form)
4. Structural Bayesian VAR
5. State-Space models and the Kalman filter
6. DSGE estimation with Bayesian methods
7. DSGE-VAR methodology

BIBLIOGRAPHY

Books:

[G] Greenberg, Edward (2007) Introduction to Bayesian Econometrics, Cambridge University Press.

[K] Koop (2003) Bayesian Econometrics, John Wiley & Sons Inc.

[DS] Del Negro, Marco and Schorfheide, Frank (2011): "Bayesian Macroeconometrics," in: The Oxford Handbook of Bayesian Econometrics, p.293-389.

[HS] Herbst, Edward and Schorfheide, Frank (2016): Bayesian Estimation of DSGE Models, Princeton University Press.

[KK] Koop and Korobilis (2009): Bayesian Multivariate Time Series Methods for Empirical Macroeconomics Foundations and Trends in Econometrics Vol. 3, No. 4, 267–358

[KN] Kim and Nelson (1999) State-Space Models with Regime Switching Classical and Gibbs-Sampling Approaches with Applications, The MIT Press.

[CR] Casella and Robert (2004), Monte Carlo Statistical Methods, 2nd edition, Springer.

[BM] Blake, Andrew and Mumtaz, Haroon (2017) Applied Bayesian econometrics for central bankers, Centre for Central Banking Studies.

[H] Hamilton (1994) Time Series Analysis. Princeton University Press.

[Z] Zellner, A. (1971), An Introduction to Bayesian Inference in Econometrics, John Wiley & Sons.

There is no key reference when it comes to Bayesian estimation in macroeconomics. Here is some guidance on the myriad of books suggested here:

- Bayesian econometrics with a simple approach: Koop
- Bayesian econometrics advanced and seminal reference: Zellner
- Bayesian econometrics and posterior simulation with a simple approach: Greenberg
- Monte Carlo optimization and simulation, advanced: Casella and Robert
- Key reference on time-series with an interesting chapter on Bayesian econometrics: Hamilton
- Covers all topics but very blunt: Del Negro and Schorfheide
- Covers all topics except DSGE with a practical approach and focused on coding: Blake and Haroon
- A good reference for Time-varying parameters VAR with codes: Koop and Korobilis
- A great reference on state-space models and regime switching (classical and Bayesian): Kim and Nelson
- DSGE models with Bayesian econometrics with an emphasis on methods: Herbst and Schorfheide

In the following, there are some suggestions for each topic. The bold ones are the suggested reading, and others are complementary.

Introduction to Bayesian econometrics

[K] Ch. 2-3, [G] Ch. 4, [HS] Sec. 3.1-3.2, [H] ch. 12, [Z] ch. 2-3

Classical Monte Carlo methods:

Direct sampling, importance sampling

[G] Ch. 5, [CR] Ch. 3

Markov Chain Monte Carlo (MCMC) methods:

Markov chain theory

[G] Ch. 6, [CR] Ch. 6

Gibbs sampling

[G] Ch. 7, [CR] Ch. 9-10

Metropolis-Hastings algorithm.

[G] Ch. 7, [HS] ch. 4, [CR] Ch. 7

Siddhartha Chib & Edward Greenberg (1995) Understanding the Metropolis-Hastings Algorithm, *The American Statistician*, 49:4, 327-335

Chib, S., I. Jeliazkov (2001), 'Marginal Likelihood from the Metropolis-Hastings Output,' *Journal of the American Statistical Association*, 96, 270–281.

Reduced-Form Bayesian VARs.

[DS] ch. 2.1-2.2. [H] ch. 12, [BM] ch.1

Kadiyala, K. R. and Karlsson, S. (1997), 'Numerical methods for estimation and inference in bayesian var-models', *Journal of Applied Econometrics* 12, 99-132.

Giannone, D., Lenza, M. and Primiceri, G. E. (2015), Prior selection for vector autoregressions, *The Review of Economics and Statistics* 97:2, 436-451

Domenico Giannone, Michele Lenza & Giorgio E. Primiceri (2019) Priors for the Long Run, *Journal of the American Statistical Association*, 114:526, 565-580.

Bayesian Structural VARs

[DS] Sec. 2.4-2.5.

Sims, Christopher, and Tao Zha, 1998, Bayesian Methods for Dynamic Multivariate Models, *International Economic Review* 39(4), 949—68.

Waggoner, D. F. and Zha, T. (2003a), 'A Gibbs sampler for structural vector autoregressions', *Journal of Economic Dynamics & Control* 28, 349-366.

Rubio-Ramirez, J. F., Waggoner, D. F. and Zha, T. (2010), 'Structural vector autoregressions: Theory of identification and algorithms for inference', *The Review of Economic Studies* 77, 665-696.

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.

Topics in Bayesian VARs

Time-varying parameters: [KK] ch. 3, [BM] ch. 3

Stochastic volatility: [KK] ch. 4,

Uhlig, H. (1997): "Bayesian Vector Autoregressions with Stochastic Volatility," *Econometrica*, 65(1), 59–73.

Time-varying parameters and Stochastic volatility: [DS] ch. 5,

Primiceri, G. (2005). Time Varying Structural Vector Autoregressions and Monetary Policy. *The Review of Economic Studies*, 72(3), 821-852

Markov switching: [BM] ch. 4

Sims, Christopher, A., and Tao Zha. 2006. "Were There Regime Switches in U.S. Monetary Policy?" *American Economic Review*, 96 (1): 54-81.

Factor Augmented VAR: [BM] ch. 3

Bernanke, Ben S., Jean Boivin and Piotr Elias. "Measuring The Effects Of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach," *Quarterly Journal of Economics*, 2005, v120(1, Feb), 387-422.

State-space models

Kalman filter:

[H] ch.13

Gibbs sampler:

[KN] ch. 8, [BM] ch.3

Carter, C. K., and R. Kohn. "On Gibbs Sampling for State Space Models." *Biometrika*, vol. 81, no. 3, 1994, pp. 541–553.

DSGE Solution methods

Perturbation methods

Wouter's lecture notes (<http://www.wouterdenhaan.com/numerical/perturbation.pdf>)

Schmitt-Grohé and Uribe (2004) Solving dynamic general equilibrium models using a second-order approximation to the policy function. *Journal of Economic Dynamics and Control* Volume 28, Issue 4, January 2004, Pages 755–775

Solution methods for linear rational expectation models

[HS] ch. 2

Blanchard, O. J., and C. M. Kahn (1980), "The Solution of Linear Difference Models under Rational Expectations," *Econometrica*, 48(5), 1305–1312

Klein, P. (2000), "Using the Generalized Schur Form to Solve a Multivariate Linear Rational Expectations Model," *Journal of Economic Dynamics and Control*, 24(10), 1405–1423

Sims, Christopher A., 2002, Solving Linear Rational Expectations Models, *Computational Economics* 20(1), 1–20.

From DSGE solution to the data: forming likelihood from Kalman filter

Guerrón-Quintana, P. and J. Nason (2013), "Bayesian Estimation of DSGE Models" ch 21 in Hashimzade, N. and M. Thornton (eds.), *Handbook of Research Methods and Applications in Empirical Macroeconomics*.

Estimating a DSGE Model

Likelihood: [HS] ch.2, [DS] ch. 4.1-4.2.

Choosing priors:

Del Negro M, Schorfheide F (2008) Forming priors for DSGE models (and how it affects the assessment of nominal rigidities). *J Monet Econ* 55:1191–1208

Metropolis-hastings

[HS] ch. 3.5, 4.1 - 4.2, [DS] ch. 4.3,

Surveys/aplications covering the bayesian estimation

An, Sungbae and Frank Schorfheide, 2007, Bayesian Analysis of DSGE Models, *Econometric Reviews* 26(2-4), 113–172.

Guerrón-Quintana, P. and J. Nason (2013), "Bayesian Estimation of DSGE Models" ch 21 in Hashimzade, N. and M. Thornton (eds.), Handbook of Research Methods and Applications in Empirical Macroeconomics.

Some applications

Fernández-Villaverde, J., and J. F. Rubio-Ramírez (2004), "Comparing Dynamic Equilibrium Models to Data: a Bayesian Approach," Journal of Econometrics, 123(1), 153 – 187

Rabanal, P. and J. F. Rubio-Ramírez (2005), "Comparing New Keynesian Models of the Business Cycle: A Bayesian Approach", Journal of Monetary Economics 52 (2005) 1151–1166

Smets, Frank, and Rafael Wouters. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." American Economic Review, 97 (3): 586-606.

Adolfson, M., S. Laséen, J. Lindé, and M. Villani, (2007), 'Bayesian estimation of an open economy DSGE model with incomplete pass-through,' Journal of International Economics, 72(2), 481–511.

Del Negro, M., F. Schorfheide, F. Smets, R. Wouters (2007), 'On the Fit and Forecasting Performance of New Keynesian Models,' Journal of Business and Economic Statistics, 25 (2),123–162.

DSGE Model Evaluation.

[DS] ch. 4.7.

Geweke, J. (1999), 'Using simulation methods for bayesian econometric models: Inference, development and communication', Econometric Reviews 18, 1-126.

DSGE-VAR Methodology

Theory:

[DS] ch. 4.7.

Ingram, B., and C. Whiteman (1994): "Supplanting the Minnesota Prior- Forecasting Macroeconomic Time Series Using Real Business Cycle Model Priors," Journal of Monetary Economics, 49(4), 1131–1159.

Del Negro, M., and F. Schorfheide (2004), "Priors from General Equilibrium Models for VARs," International Economic Review, 45(2), 643 – 673

Applications:

Adolfson, M., S. Laséen, J. Lindé and M. Villani (2008), "Evaluating an Estimated New Keynesian Small Open Economy Model", Journal of Economic Dynamics and Control, 32(8), 2690-2721

Ghent, A. (2009), "Comparing DSGE-VAR forecasting models: How big are the differences?", Journal of Economic Dynamics and Control, 33(4), 864-882

Cole, S., and F. Milani (2017), "The Misspecification of Expectations in New Keynesian Models: A DSGE-VAR Approach", Macroeconomic Dynamics, 1-34

Advanced MCMC methods (not covered in class):

Tailored Random Block MH (TaRBMH) algorithm

Chib, Siddhartha & Ramamurthy, Srikanth. (2010). Tailored randomized block MCMC methods with application to DSGE models. Journal of Econometrics. 155. 19-38.

Sequential Monte Carlo Methods

[HS] ch. 5

Herbst, E., and F. Schorfheide (2014): "Sequential Monte Carlo Sampling for DSGE Models," Journal of Applied Econometrics, 19(7), 1073–1098.

DETAILED PROGRAM

1	Introduction to Bayesian econometrics
2	Introduction to Bayesian econometrics
3	Monte Carlo methods
4	Reduced-form BVAR: Prior and Likelihood
5	Reduced-form BVAR: Monte carlo
6	Structural BVAR
7	State-Space models
8	DSGE and state-space models
9	DSGE: Prior and Likelihood
10	DSGE: estimating via Metropolis-Hastings
11	DSGE: estimating via Metropolis-Hastings
12	DSGE: convergence diagnostics and model evaluation
13	DSGE-VAR methodology
14	Short paper presentation

GRADING

Problem sets (50%)

Short Paper (replication) (50%)

PROFESSOR – EMAILS