# Introduction to Applied Bayesian Modeling
**ICPSR Summer Program 2017**

**Ryan Bakker** (Weeks 1–2)
Associate Professor
Department of Political Science
University of Georgia
rbakker@uga.edu

**Johannes Karreth** (Weeks 3–4)
Assistant Professor
Department of Politics & International Relations
Ursinus College
jkarreth@ursinus.edu

> **This syllabus may be updated prior and during the workshop. Please visit** www.jkarreth.net/bayes-icpsr.html **for the most recent information on topics, labs, rooms, and assigned readings.**

**Course:** 9am–11am / Room: See the Summer Program handbook.
**Office:** 2329 Perry Building
**Office hours:** 11am-12pm and 1pm-2pm, M–F. Feel free to stop by the office any time and come in if the door is open. We're also happy to schedule meetings at most other times during the day.

## Teaching assistants

**Sarah Hunter**
University of Georgia
sghunter@uga.edu
Office: 2332C Perry Building
Office hours: 11am–1pm, M–F, and by appointment.

**Rob Williams**
University of North Carolina at Chapel Hill
jrw@live.unc.edu
Office: 2332D Perry Building
Office hours: 1pm–3pm, M–F, and by appointment.

## Course description

This course introduces the basic theoretical and applied principles of Bayesian statistical analysis in a manner geared toward students and researchers in the social sciences. The Bayesian paradigm is particularly useful for the type of data that social scientists encounter given its recognition of the mobility of population parameters, its ability to incorporate information from prior research, and its ability to update estimates as new data are observed. The course begins with a discussion of the strengths of the Bayesian approach for social science data and the philosophical differences between Bayesian and frequentist analyses. Next, the course covers the theoretical underpinnings of Bayesian modeling and provides a brief introduction to the primary estimation algorithms. The bulk of the course focuses on estimating and interpreting Bayesian models from an applied perspective. Participants are introduced to the Bayesian forms of the standard statistical models taught in regression and MLE courses (i.e., linear, logit/probit, poisson, etc.). Additional topics include measurement models, model comparison, and an in-depth treatment of multilevel modeling. Participants should have a solid understanding of the linear model and matrix algebra and some exposure to models with limited dependent variables. The course relies mostly on R and WinBUGS/JAGS for estimation, with a short segment on Stan, a new, but rapidly growing tool for Bayesian inference. Prior experience with R is preferred but not assumed or necessary. We offer several lab sessions to familiarize participants with R, WinBUGS, JAGS, and Stan.

**Goals.**    Upon conclusion of this course, we aim for participants to be able to:

· appreciate the fundamental differences and similarities between frequentist and Bayesian approaches to inference
· apply Bayes' rule to statistical inference
· formulate linear and generalized linear models in the Bayesian framework
· estimate linear and generalized linear models in the Bayesian framework using customizeable code
· exploit the advantages of Bayesian estimation with regard to

– incorporating prior information
– estimating uncertainty in parameter estimates
– dealing with missing data
– measuring latent concepts
– incorporating variance at multiple levels of observation

· present and communicate results from Bayesian (and frequentist) estimation in an effective manner
· have fun learning new methods and better understanding familiar ones!

**A note on computing.**    This course mostly uses JAGS and WinBUGS (and its open-source twin OpenBUGS) as the primary software options to fit Bayesian models, with one unit toward the end dedicated to Stan. We access JAGS and Win/OpenBUGS through R. Most lectures build on JAGS and Win/OpenBUGS. The languages of these two programs are nearly identical. Win/OpenBUGS run on Macs only with Windows emulation software, but can be a bit buggy. JAGS runs on all platforms, including Macs. We offer special Mac-friendly lab sessions and support both JAGS and Win/OpenBUGS. JAGS code for all models encountered in this course and other JAGS-specific code and examples are provided.

## Course resources

**M-Box:**    All slides, code used in course sessions, and problem sets will be posted on M-Box. Details will be provided on the first day of the workshop. The TAs are also always available to point you to these materials.

**Google Group:**    The TAs will collect your email address on the first day of class to sign you up for a Google Group for this workshop. We will use this Google Group to share information related to the workshop during the ICPSR Summer Program.

**Course website with additional materials:** Additional code, tutorials, and other materials for weeks 3–4 are posted on Johannes' website: `http://www.jkarreth.net/bayes-icpsr.html`.

## Reading materials

### Books

The main required texts for this course are:

· Gelman, Andrew and Hill, Jennifer. 2007. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. New York, NY: Cambridge University Press.
· Gill, Jeff. 2014. *Bayesian Methods: A Social and Behavioral Sciences Approach, Third Edition*. Boca Raton, FL: Chapman / Hall/CRC.

You may also find the following titles useful for many of the topics discussed in this course. They are available in the ICPSR Summer Program Library for borrowing:

· Congdon, Peter D. 2003. *Applied Bayesian Modelling*. Chichester: Wiley.
· Congdon, Peter D. 2010. *Applied Bayesian Hierarchical Methods*. Boca Raton, FL: Chapman / Hall/CRC.
· Gelman, Andrew et al. 2013. *Bayesian Data Analysis, Third Edition*. Boca Raton, FL: Chapman / Hall/CRC.
· Jackman, Simon. 2009. *Bayesian Analysis for the Social Sciences*. Chichester: Wiley.
· Kruschke, John. 2014. *Doing Bayesian Data Analysis, Second Edition: A Tutorial with R, JAGS, and STAN*. Oxford: Academic Press / Elsevier.
· Lunn, David et al. 2012. *The BUGS Book: A Practical Introduction to Bayesian Analysis*. Boca Raton, FL: Chapman / Hall/CRC.
· Ntzoufras, Ioannis. 2009. *Bayesian Modeling Using WinBUGS*. Hoboken, NJ: Wiley.

As a general primer for R, we recommend:

· Fox, John and Weisberg, Sanford. 2011. *An R Companion to Applied Regression, Second Edition*. Thousand Oaks: Sage.
· Monogan, James E. 2015. *Political analysis using R*. Cham, Switzerland: Springer.

### Articles

All articles listed in the syllabus are made available to you on M-Box and through the University of Michigan library website from the campus network. Please contact the TAs if you have trouble locating any of the articles listed in the syllabus.

## Software

This course relies mostly on R, JAGS/WinBUGS/OpenBUGS, and Stan. We may also briefly discuss Stata as an alternative for some applications. We provide assistance installing R and JAGS/WinBUGS/OpenBUGS on your computers during labs in the first week of the course. These programs are available at no cost from:

· `http://www.cran.r-project.org`
· `http://www.mrc-bsu.ca.ac.uk/bugs` and `http://www.openbugs.net/w/FrontPage` (both are equivalent)
· `http://mcmc-jags.sourceforge.net`

Each website links to relevant documentation and user manuals. There is a learning curve for these programs, but you need not have any computer programming background to learn them rather easily—just patience and desire. Our goal is to make you as comfortable as possible with these programs by the end of this course so that you will be able to use them with ease at your home institutions and in your own work.

*Mac and JAGS users*: See Johannes' website for more information on installing JAGS.

## Homework assignments

Homework exercises are assigned in class. Our goal is to make sure participants receive sufficient feedback to complete all assignments successfully. We distribute between 2 and 4 assignments per week. They are mostly computer-based with the exception of the first assignment. Please submit your assignments via email. Also always include all code you used to complete your assignments; the TAs will show you how to best do this. The TAs will aim to return graded assignments to you within 2-3 days with comments via email. We (the instructors and TA) are more than happy to provide help with assignments during office hours: don't be afraid to come by and ask.

## Labs

We offer several labs with guided hands-on exercises. Lab sessions will be held at the times in the room(s) listed in the schedule below. Additional labs and exact locations will be announced in class and posted in the updated version of this syllabus. Likely topics:

1 Installing and using R
2 Using R and RMarkdown for an integrated and reproducible workflow for Bayesian (and frequentist) statistics
3 Installing and accessing JAGS/BUGS from R
4 Obtaining convergence diagnostics using R
5 Model presentation
6 Using Stan

## Preparing for each workshop meeting

To get the most out of this workshop, we recommend that you read the assigned background & textbook readings for each day in depth and skim at least one of the applied studies if any are listed. Particularly in the second half of the workshop, we provide a larger number of applied works—pick one that is closest to your area of interest.

You should also feel strongly encouraged to come to our office hours on any day of the workshop to follow up on topics discussed during workshop meetings and to discuss how any topic we discussed might relate to your own work.

## Course content and schedule

The following dates and topics may be modified as the course proceeds. The most recent version of the syllabus will always be at www.jkarreth.net/bayes-icpsr.html.

**Monday, June 26**
**No course meeting**

Recommended: *Introduction to the LaTeX Text Processing System*, 5:30pm–7:30pm.

**Day 1, Tuesday, June 27**
**Introduction: Background and Basics of Bayesian Inference**

Please read:

· Gill: Chapter 1.
· Siegfried, Tom. 2010. "Odds are, it's wrong: Science Fails to Face the Shortcomings of Statistics." *Science News* 177 (7): 26–29.
· Senn, Stephen. 2003. "Bayesian, Likelihood, and Frequentist Approaches to Statistics." *Applied Clinical Trials* 12 (8): 35–38.

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**Day 2, Wednesday, June 28**
**Review of Generalized Linear Models**

Refresher:

· Gill: Section 2.2.
· Gelman & Hill: Chapter 6.

**Labs 1 and 2 combined** (5:15–6pm, Angell Hall Classroom A)

· Installing and using R
· Using R and RMarkdown for an integrated and reproducible workflow for Bayesian (and frequentist) statistics

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**Day 3, Thursday, June 29**
**Probability and Bayes' Rule**

Please read:

· Gill: Chapter 2.
· Western, Bruce and Jackman, Simon. 1994. "Bayesian Inference for Comparative Research." *American Political Science Review* 88 (2): 412–423.

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**Day 4, Friday, June 30**
**Priors**

Please read:

· Gill: Chapter 4.
· Gill, Jeff and Walker, Lee D. 2005. "Elicited Priors for Bayesian Model Specifications in Political Science Research." *Journal of Politics* 67 (3): 841–872.
· Seaman, John W. III, Seaman, John W. Jr., and Stamey, James D. 2012. "Hidden Dangers of Specifying Noninformative Priors." *The American Statistician* 66 (2): 77–84.

**HW 1 assigned: Prior and posterior distributions.**

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**Day 5, Monday, July 3**
**Sampling Methods and Introduction to the BUGS/JAGS Language**

Please read:

- Gill: Chapters 9 & 10.
- Spiegelhalter, David J. et al. 2003. "WinBUGS Version 1.4 User Manual."
- Plummer, Martyn. 2013. "JAGS Version 3.4.0 User Manual."

**Lab 3** (5:15–6pm, Angell Hall Classroom A)

- Installing and accessing JAGS/BUGS from R

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**Tuesday, July 4**
**No lecture**

Instructor & TAs are available for office hours by appointment.

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**Day 6, Wednesday, July 5**
**Convergence Diagnostics**

Please read:

- Robert, Christian and Casella, George. 2010. *Introducing Monte Carlo Methods with R*. New York, NY: Springer, Chapter 8
- Plummer, Martyn et al. 2006. "CODA: Convergence Diagnosis and Output Analysis for MCMC." *R News* 6 (1): 7–11.

Background on specific convergence diagnostics:

- Cowles, Mary Kathryn and Carlin, Bradley P. 1996. "Markov Chain Monte Carlo Convergence Diagnostics: A Comparative Review." *Journal of the American Statistical Association* 91 (434): 883–904

R implementations of different convergence diagnostics:

- Tsai, Tsung-han and Gill, Jeff. 2012. "superdiag: A Comprehensive Test Suite for Markov Chain Non-Convergence." *The Political Methodologist* 19 (2): 12–18
- Marín, Xavier Fernández-i. 2016. "ggmcmc: Analysis of MCMC Samples and Bayesian Inference." *Journal of Statistical Software* 70 (1): 1–20

**HW 2 assigned: Becoming familiar with WinBUGS/JAGS.**

**Lab 4:** (5:15–6pm, Angell Hall Classroom A)

- Obtaining convergence diagnostics using R

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## Day 7, Thursday, July 6
## The Normal Distribution; Priors (ctd.)

Please read:

· Gill: Chapter 3
· Kerman, Jouni. 2011. "Neutral noninformative and informative conjugate beta and gamma prior distributions." *Electronic Journal of Statistics* 5:1450–1470 (if you want to know more about noninformative priors).
· Kass, Robert E. and Wasserman, Larry. 1996. "The Selection of Prior Distributions by Formal Rules." *Journal of the American Statistical Association* 91 (435): 1343–1370 (if you want to know more about how to select priors).

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## Day 8, Friday, July 7
## The Bayesian Linear Model

Please read:

· Gill: Chapter 5.
· Efron, Brad. 1986. "Why Isn't Everyone a Bayesian?" *American Statistician* 40 (1): 1–5.

Sample application:

· Blais, André, Guntermann, Eric, and Bodet, Marc A. Forthcoming. "Linking Party Preferences and the Composition of Government: A New Standard for Evaluating the Performance of Electoral Democracy." *Political Science Research and Methods*.

HW 3 assigned: Linear model.
HW 4 assigned: Debugging BUGS/JAGS code.

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## Day 9, Monday, July 10
## Binary Outcomes

If you'd like a refresher for generalized linear models and their interpretation, please read:

· Gelman & Hill, Chapter 5.
· King, Gary, Tomz, Michael, and Wittenberg, Jason. 2000. "Making the Most of Statistical Analyses: Improving Interpretation and Presentation." *American Journal of Political Science* 44 (2): 347–361.
· Hanmer, Michael J. and Kalkan, Kerem Ozan. 2013. "Behind the Curve: Clarifying the Best Approach to Calculating Predicted Probabilities and Marginal Effects from Limited Dependent Variable Models." *American Journal of Political Science* 57 (1): 263–277.

HW 5 assigned: Logistic regression model.

**Day 10, Tuesday, July 11**
**Ordered and Categorical Outcomes**

If you'd like a refresher on today's models, please read:

· Gelman & Hill, section 6.5.

Also, please read one of:

· Duch, Raymond M., May, Jeff, and Armstrong, David A. 2010. "Coalition-directed Voting in Multiparty Democracies." *American Political Science Review* 104 (4): 698–719.
· Stegmueller, Daniel. 2013b. "Modeling Dynamic Preferences: A Bayesian Robust Dynamic Latent Ordered Probit Model." *Political Analysis* 21 (3): 314–333.
· Stegmueller, Daniel et al. 2012. "Support for Redistribution in Western Europe: Assessing the Role of Religion." *European Sociological Review* 28 (4): 482–497.
· Alvarez, R. Michael and Nagler, Jonathan. 1998. "When Politics and Models Collide: Estimating Models of Multiparty Elections." *American Journal of Political Science* 42 (1): 55–96.
· Lacy, Dean and Burden, Barry C. 1999. "The Vote-Stealing and Turnout Effects of Ross Perot in the 1992 U.S. Presidential Election." *American Journal of Political Science* 43 (1): 233–255.
· Imai, Kosuke and Dyk, David A. van. 2005. "A Bayesian analysis of the multinomial probit model using marginal data augmentation." *Journal of Econometrics* 124 (2): 311–334.

**HW 6 assigned: Ordered or multinomial logit model.**

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**Day 11, Wednesday, July 12**
**Count Outcomes**

If you'd like a refresher on today's models, please read one of the following:

· Gelman & Hill, section 6.2.
· Ntzoufras, sections 7.4 and 8.3

Also, please read one of:

· Martin, Andrew D. 2003. "Bayesian Inference for Heterogeneous Event Counts." *Sociological Methods & Research* 32 (1): 30–63.
· Ghosh, Sujit K., Mukhopadhyay, Pabak, and Lu, Jye-Chyi. 2006. "Bayesian analysis of zero-inflated regression models." *Journal of Statistical Planning and Inference* 136 (4): 1360–1375.
· Neelon, Brian H, O'Malley, A James, and Normand, Sharon-Lise T. 2010. "A Bayesian model for repeated measures zero-inflated count data with application to outpatient psychiatric service use." *Statistical Modelling* 10 (4): 421–439.

**HW 7 assigned: Poisson model.**

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**Day 12, Thursday, July 13**
**Measurement Models**

For background, please read:

- On factor models:

    – Lopes, Hedibert Freitas. 2014. "Modern Bayesian Factor Analysis." In *Bayesian Inference in the Social Sciences*, ed. by Jeliazkov, Ivan and Yang, Xin-She, 115–153. John Wiley & Sons, Inc., sections 5.1 and 5.2.

- On IRT models:

    – Jackman, Simon. 2001. "Multidimensional Analysis of Roll Call Data via Bayesian Simulation: Identification, Estimation, Inference, and Model Checking." *Political Analysis* 9 (3): 227.
    – Clinton, Joshua D. and Jackman, Simon. 2009. "To Simulate or NOMINATE?." *Legislative Studies Quarterly* 34 (4): 593–621.

Please read one of these sample applications:

- Bakker, Ryan. 2009. "Re-measuring Left–Right: A Comparison of SEM and Bayesian Measurement Models for Extracting Left–Right Party Placements." *Electoral Studies* 28 (3): 413–421.
- Bakker, Ryan and Poole, Keith T. 2013. "Bayesian Metric Multidimensional Scaling." *Political Analysis* 21 (1): 125–140.
- Benson, Brett V. and Clinton, Joshua D. 2016. "Assessing the Variation of Formal Military Alliances." *Journal of Conflict Resolution* 60 (5): 866–898.
- Campbell, Susanna P., Findley, Michael G., and Kikuta, Kyosuke. Forthcoming. "An Ontology of Peace: Landscapes of Conflict and Cooperation with Application to Colombia." *International Studies Review*.
- Caughey, Devin and Warshaw, Christopher. 2015. "Dynamic Estimation of Latent Opinion Using a Hierarchical Group-Level IRT Model." *Political Analysis* 23 (2): 197–211.
- Caughey, Devin and Warshaw, Christopher. 2016. "The Dynamics of State Policy Liberalism, 1936-2014." *American Journal of Political Science* 60 (4): 899–913.
- Clinton, Joshua D. and Jackman, Simon. 2009. "To Simulate or NOMINATE?." *Legislative Studies Quarterly* 34 (4): 593–621.
- Copelovitch, Mark S., Gandrud, Christopher, and Hallerberg, Mark. "Financial Regulatory Transparency and Sovereign Borrowing Costs."
- Fariss, Christopher J. 2014. "Respect for Human Rights has Improved Over Time: Modeling the Changing Standard of Accountability." *American Political Science Review* 108 (2): 297–318.
- Fox, Jean-Paul and Glas, Cees. 2001. "Bayesian Estimation of a Multilevel IRT Model Using Gibbs Sampling." *Psychometrika* 66 (2): 271–288.
- Fox, Jean-Paul and Glas, Cees A.W. 2003. "Bayesian modeling of measurement error in predictor variables using item response theory." *Psychometrika* 68 (2): 169–191.
- Garrett, Elizabeth S. and Zeger, Scott L. 2000. "Latent Class Model Diagnosis." *Biometrics* 56 (4): 1055–1067.
- Gray, Julia and Slapin, Jonathan B. 2012. "How Effective are Preferential Trade Agreements? Ask the Experts." *Review of International Organizations* 7 (3): 309–333.
- Hare, Christopher et al. 2015. "Using Bayesian Aldrich-McKelvey Scaling to Study Citizens' Ideological Preferences and Perceptions." *American Journal of Political Science* 59 (3): 759–774.
- Hollyer, James R., Rosendorff, B. Peter, and Vreeland, James Raymond. 2014. "Measuring Transparency." *Political Analysis* 22 (4): 413–434

- Linzer, Drew A. and Staton, Jeffrey K. 2015. "A Global Measure of Judicial Independence, 1948-2012." *Journal of Law and Courts* 3 (2): 223–256.
- Manatschal, Anita and Bernauer, Julian. 2016. "Consenting to Exclude? Empirical Patterns of Democracy and Immigrant Integration Policy." *West European Politics* 39 (2): 183–204.
- Rosas, Guillermo, Shomer, Yael, and Haptonstahl, Stephen R. 2015. "No News Is News: Nonignorable Nonresponse in Roll-Call Data Analysis." *American Journal of Political Science* 59 (2): 511–528.
- Selin, Jennifer L. 2015. "What Makes an Agency Independent?" *American Journal of Political Science* 59 (4): 971–987.
- Slapin, Jonathan B. and Proksch, Sven-Oliver. 2008. "A Scaling Model for Estimating Time-Series Party Positions from Texts." *American Journal of Political Science* 52 (3): 705–722.
- Treier, Shawn and Jackman, Simon. 2008. "Democracy as a Latent Variable." *American Journal of Political Science* 52 (1): 201–217.

**HW 8 assigned: Factor or IRT model.**
**Lab 5: Exercises on model presentation.** (5:15–6pm, Angell Hall Classroom A)

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**Day 13, Friday, July 14**
**Bayes Factors and Bayesian Model Averaging**

Please read:

- Montgomery, Jacob M. and Nyhan, Brendan. 2010. "Bayesian Model Averaging: Theoretical Developments and Practical Applications." *Political Analysis* 18 (2): 245–270.
- Warren, T. Camber. 2014. "Not by the Sword Alone: Soft Power, Mass Media, and the Production of State Sovereignty." *International Organization* 68 (1): 111–141 (skim as an example of an application of BMA).
- Pepinsky, Thomas B. 2014. "The Politics of Capital Flight in the Global Economic Crisis." *Economics & Politics* 26 (3): 431–456 (skim as an example of an application of BMA).
- Raftery, Adrian E. 1995. "Bayesian Model Selection in Social Research." *Sociological Methodology* 25:111–163 (Background on BMA, read if you're interested)
- Gelman, Andrew and Rubin, Donald B. 1995. "Avoiding Model Selection in Bayesian Social Research." *Sociological Methodology* 25:165–173 (Background on BMA, read if you're interested)
- Bartels, Larry M. 1997. "Specification Uncertainty and Model Averaging." *American Journal of Political Science* 41 (2): 641–674 (Background on BMA, read if you're interested)
- Montgomery, Jacob M., Hollenbach, Florian M., and Ward, Michael D. 2012. "Improving Predictions Using Ensemble Bayesian Model Averaging." *Political Analysis* 20 (3): 271–291 (if you are interested prediction & forecasting).

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**Day 14, Monday, July 17**
**Model Checking and Model Presentation**
**Multilevel Models (Intro)**

Please read:

- Gill: Chapters 6 & 7.
- Gelman, Andrew et al. 2000. "Diagnostic Checks for Discrete Data Regression Models Using Posterior Predictive Simulations." *Journal of the Royal Statistical Society. Series C (Applied Statistics)* 49 (2): 247–268.

· Quinn, Kevin M., Martin, Andrew D., and Whitford, Andrew B. 1999. "Voter Choice in Multi-Party Democracies: A Test of Competing Theories and Models." *American Journal of Political Science* 43 (4): 1231–1247 (if you are interested in model comparison).

**HW 9 assigned: Model checking for linear regression.**

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## Day 15, Tuesday, July 18
## Multilevel Models (Fundamentals)

Please read:

· Gelman & Hill: Chapter 16 or/and Gill: Chapter 10
· Gelman & Hill: Chapter 11 (for a refresher on multilevel models).
· Steenbergen, Marco R. and Jones, Bradford S. 2002. "Modeling Multilevel Data Structures." *American Journal of Political Science* 46 (1): 218–237 (for a refresher on multilevel models).
· Shor, Boris et al. 2007. "A Bayesian Multilevel Modeling Approach to Time-Series Cross-Sectional Data." *Political Analysis* 15 (2): 165–181 (if you work with TSCS data).
· Bell, Andrew and Jones, Kelvyn. 2015. "Explaining Fixed Effects: Random Effects Modeling of Time-Series Cross-Sectional and Panel Data." *Political Science Research and Methods* 3 (1): 133–153 (if you work with TSCS data).
· Greenland, Sander. 2007. "Bayesian perspectives for epidemiological research. II. Regression analysis." *International Journal of Epidemiology* 36 (1): 195–202 (if you work with more complex nesting structures).
· Gelman, Andrew, Hill, Jennifer, and Yajima, Masanao. 2012. "Why We (Usually) Don't Have to Worry About Multiple Comparisons." *Journal of Research on Educational Effectiveness* 5 (2): 189–211.

**HW 10 assigned: Multilevel model.**

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## Day 16, Wednesday, July 19
## Multilevel Models (non-continuous outcomes; time-series cross-sectional data as multilevel data)
## Multilevel regression with poststratification (MRP)

Please continue to read:

· Gelman & Hill: Chapter 17 (Chapter 15 for a refresher).

as well as any of these empirical articles using MLMs that is/are in your area of interest:

· Pang, Xun. 2010. "Modeling Heterogeneity and Serial Correlation in Binary Time-Series Cross-sectional Data: A Bayesian Multilevel Model with AR(p) Errors." *Political Analysis* 18:470–498.
· Pang, Xun. 2014. "Varying Responses to Common Shocks and Complex Cross-Sectional Dependence: Dynamic Multilevel Modeling with Multifactor Error Structures for Time-Series Cross-Sectional Data." *Political Analysis* 22 (4): 464–496.
· Ward, Michael D., Siverson, Randolph M., and Cao, Xun. 2007. "Disputes, Democracies, and Dependencies: A Reexamination of the Kantian Peace." *American Journal of Political Science* 51 (3): 583–601.
· Blaydes, Lisa and Linzer, Drew A. 2012. "Elite Competition, Religiosity and Anti-Americanism in the Islamic World." *American Political Science Review* 106 (2): 225–243.
· Lock, Kari and Gelman, Andrew. 2010. "Bayesian Combination of State Polls and Election Forecasts." *Political Analysis* 18 (3): 337–348.

· Masters, Ryan K., Hummer, Robert A., and Powers, Daniel A. 2012. "Educational Differences in U.S. Adult Mortality." *American Sociological Review* 77 (4): 548–572.
· Stegmueller, Daniel. 2013a. "How Many Countries for Multilevel Modeling? A Comparison of Frequentist and Bayesian Approaches." *American Journal of Political Science* 57 (3): 748–761.
· Chaudoin, Stephen, Milner, Helen V., and Pang, Xun. 2015. "International Systems and Domestic Politics: Linking Complex Theories with Empirical Models in International Relations." *International Organization* 69 (2): 275–309.
· Beazer, Quintin H. and Woo, Byungwon. 2016. "IMF Conditionality, Government Partisanship, and the Progress of Economic Reforms." *American Journal of Political Science* 60 (2): 304–321.
· Danneman, Nathan and Ritter, Emily Hencken. 2014. "Contagious Rebellion and Preemptive Repression." *Journal of Conflict Resolution* 58 (2): 254–279.
· Quaranta, Mario and Martini, Sergio. 2016. "Does the economy really matter for satisfaction with democracy? Longitudinal and cross-country evidence from the European Union." *Electoral Studies* 42:164–174.
· Eagle, David. 2016. "The Negative Relationship between Size and the Probability of Weekly Attendance in Churches in the United States." *Socius* 2.
· Cao, Xun and Ward, Hugh. 2017. "Transnational Climate Governance Networks and Domestic Regulatory Action." *International Interactions* 43 (1): 76–102.
· Helgason, Agnar Freyr and Mérola, Vittorio. Forthcoming. "Employment Insecurity, Incumbent Partisanship, and Voting Behavior in Comparative Perspective." *Comparative Political Studies*.

Overview and applications of multilevel regression with poststratification (MRP):

· Park, David K., Gelman, Andrew, and Bafumi, Joseph. 2004. "Bayesian Multilevel Estimation with Poststratification: State-Level Estimates from National Polls." *Political Analysis* 12 (4): 375–385.
· Lax, Jeffrey R. and Phillips, Justin H. 2009. "How Should We Estimate Public Opinion in The States?" *American Journal of Political Science* 53 (1): 107–121.
· Kastellec, J. P., Lax, J. R., and Phillips, J. H. (2014). Estimating State Public Opinion With Multi-Level Regression and Poststratification using R. *Working paper*. Available at `http://www.princeton.edu/~jkastell/MRP_primer/mrp_primer.pdf`.
· Selb, Peter and Munzert, Simon. 2011. "Estimating Constituency Preferences from Sparse Survey Data Using Auxiliary Geographic Information." *Political Analysis* 19 (4): 455–470.
· Warshaw, Christopher and Rodden, Jonathan. 2012. "How Should We Measure District-Level Public Opinion on Individual Issues?" *Journal of Politics* 74 (1): 203–219.
· Buttice, Matthew K. and Highton, Benjamin. 2013. "How Does Multilevel Regression and Poststratification Perform with Conventional National Surveys?" *Political Analysis* 21 (4): 449–467.
· Toshkov, Dimiter. 2015. "Exploring the Performance of Multilevel Modeling and Poststratification with Eurobarometer Data." *Political Analysis* 23 (3): 455–460.
· Flores, Andrew R, Herman, Jody L, and Mallory, Christy. 2015. "Transgender inclusion in state non-discrimination policies: The democratic deficit and political powerlessness." *Research & Politics* 2 (4).
· Leemann, Lucas and Wasserfallen, Fabio. Forthcoming. "Extending the Use and Prediction Precision of Subnational Public Opinion Estimation." *American Journal of Political Science*.

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**Day 17, Thursday, July 20**
**Bayesian Analysis of Spatial Data**

If interested, please read the following for background and applications of spatial modeling using Bayesian inference:

· Lunn et al.: Section 11.3.
· Sparks, Corey S. 2011. "Violent crime in San Antonio, Texas: An application of spatial epidemiological methods." *Spatial and Spatio-temporal Epidemiology* 2 (4): 301–309.

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**Day 18, Friday, July 17: Using Bayesian Modeling in Your Applied Work**

Please read:

· Gelman, Andrew. 2008. "Objections to Bayesian Statistics." *Bayesian Analysis* 3 (3): 445–450.
· Humphreys, Macartan and Jacobs, Alan M. 2015. "Mixing Methods: A Bayesian Approach." *American Political Science Review* 109, no. 4 (04): 653–673.

And also have a look at:

· Stan example models "*ARM Models Sorted by Chapter*" at `https://github.com/stan-dev/example-models/wiki/ARM-Models-Sorted-by-Chapter`.