GESIS TRAINING

gesis Leibniz Institute for the Social Sciences

# 48th GESIS Spring Seminar: Bayesian Modelling in the Social Sciences

## Cologne, 11–29 March 2019

## Syllabus for week 1: "Introduction to Bayesian Models for the Social Sciences"


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| Lecturers: | Prof. Dr. Susumu Shikano | Dr. Taehee Kim |
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***Date:*** 11-15 March 2019
***Time:*** Tuesday to Friday 09:00-17:00 (Monday 10:00-18:00)

## About the Lecturers:

*Prof. Dr. Susumu Shikano* is Professor of Political Methodology at the University of Konstanz. He is also affiliated with the Mannheim Centre for European Social Research and the Hanse Institute for Advanced Study in Delmenhorst. His research interests are spatial models of party competition and various topics in political behavior. His works appeared in Public Choice, Political Psychology, Party Politics, West European Politics, British Journal of Political Science among others.

*Dr. Taehee Kim* is a lecturer at the Social Science Department of the Carl von Ossietzky University Oldenburg. She received her PhD in Political Science from Keio University, Japan.

## Course Description:

Social scientists increasingly apply the Bayesian approach to diverse kinds of research topics. To motivate further political scientists to use this approach, this course provides participants the following three points: First, the course provides a conceptual background for Bayesian inference. Second, participants will be guided how to read the literature using Bayesian statistics and interpret the results. Third, this course introduces to a software for Bayesian analysis with political science examples. The course consists of lectures (morning) and lab sessions (afternoon). The lecture deals with relevant background knowledge as well as specific skills for Bayesian analysis. In lab sessions, these skills are applied to political and social science data. Hence, course participants also learn the basic knowledge of JAGS, which is needed to conduct Bayesian estimation.

## Keywords:

Prior, posterior, likelihood, Markov-Chain-Monte-Carlo

## Course Prerequisites:

- Prior knowledge of statistics including regression models with different types of dependent variables.
- Knowledge about maximum likelihood estimation (MLE), in particular the participants should be able to distinguish likelihood.
- Basic knowledge of R.

## Target Group:

Participants will find the course useful if they

- Are estimating complex models whose parameters can hardly be identified by the maximum-likelihood procedure.
- Are working on data with many missing values.
- Are working on data with smaller number of observations
- Are working on non-sampled data
- Wish to integrate some prior knowledge into data analysis.

## Course and Learning Objectives:

By the end of the course participants will

- Understand the basic concepts needed for Bayesian inference.
- Be able to conduct Bayesian analysis using Markov-Chain-Monte-Carlo and present their results.
- Be able to interpret the Bayesian analysis of the other researchers.

## Software and hardware requirements:

The course uses R and JAGS. GESIS provides participants with workshop computers and all relevant software.

## Long Course Description:

Social scientists increasingly apply the Bayesian approach to diverse kinds of research topics. This development is due to a series of its attractive features: e.g. handling aggregate data without sampling processes, analysing small N data, estimating models with complex likelihood functions. Furthermore, the increasing capacity of modern computers enables a wider range of researchers to conduct such computationally intensive estimations.

Despite of these advantages there are still some deficits to be followed up: First, it is not enough acknowledged that Bayesian statistics and conventional statistics are based on different views concerning theory and data. Second, the literature, including text books, is in general too technical to motivate most political scientists to apply Bayesian analysis to their own research questions. Third, the programs needed for Bayesian analysis is not user friendly enough for most social scientists.

The course aims to close these gaps. First, the course provides a conceptual background for Bayesian analysis. Second, participants will be guided how to read the literature using Bayesian statistics and interpret the results. Third, this course introduces to a specific software for Bayesian analysis with political science examples.

More specifically, the course covers the following topics: Fundamentals of Bayesian analysis, estimation of linear regression models using conjugacy and Markov Chain Monte Carlo (MCMC), estimation of various regression models (binary logit/probit, poisson, multi-level, robust regression etc.) in Bayesian framework. The course consists of lectures and lab sessions. The lecture deals with relevant background knowledge as well as specific skills for Bayesian analysis. In lab sessions, these skills are applied to political and social science data. Hence, course participants also learn the basic knowledge of JAGS, which enables to conduct Bayesian estimation using MCMC.

Participants are required to have knowledge in statistical analysis including regression models with different types of dependent variables. Further, they are also required to have knowledge about maximum likelihood estimation (MLE). At least, participants have to know how to calculate the likelihood of certain parameter sets of a statistical model given observed data. In lab sessions participants learn how to use JAGS from R. Therefore, the basic knowledge in R is also required.

Note that this is an introductory one week course. This course, therefore, cannot thoroughly treat the wide range of statistical models and further advanced topics in Bayesian statistics. For those who have basic knowledge in Bayesian statistics and can conduct regression analysis using JAGS, this course is not adequate.

## Preparatory Reading:

- Shikano, Susumu, Bayesian estimation of regression models, Henning Best and Christof Wolf, eds. Regression Analysis and Causal Inference, Sage, 2014; p.31-54
- Ben Lambert, A Student's Guide to Bayesian Statistics. Sage,2018

## Recommended Literature to Look at in Advance:

- Gelman, Andew and Hill, Jennifer. Data Analysis using Regression and Multilevel/Hierarchical Models. Cambridge University Press; 2007

## Day-to-day Schedule and Literature:

| Day | Topic(s) |
|---|---|
| 1 | General introduction<br>Basics of Bayesian inference, Conjugacy analysis<br>Markov-Chain-Monte-Carlo |
| | Suggested reading:<br>▪ Shikano, Susumu, Bayesian estimation of regression models, Henning Best and Christof Wolf, eds. Regression Analysis and Causal Inference. Sage, 2014, p. 31-54<br>▪ Ben Lambert, A Student's Guide to Bayesian Statistics. Sage, 2018, Chapters 2-7 |
| 2 | Introduction to JAGS<br>Linear and discrete regression models |
| | Suggested reading:<br>▪ Ben Lambert, A Student's Guide to Bayesian Statistics. Sage, 2018, Chapter 18 |
| 3 | Advanced regression models |
| | Suggested reading:<br>▪ Ben Lambert, A Student's Guide to Bayesian Statistics. Sage, 2018, Chapter 19 |
| 4 | Further advanced topics (model selection, Bayes factor, model averaging and data augmentation) |
| | Suggested reading:<br>▪ Ben Lambert, A Student's Guide to Bayesian Statistics. Sage, 2018, Chapters 10-11 |
| 5 | Bayesian multilevel models |
| | Suggested reading:<br>▪ Gelman, Andew and Hill, Jennifer. Data Analysis using Regression and Multilevel/ Hierarchical Models. Cambridge University Press, 2007. |