1 Course Description & Objectives

This is a graduate course on applied Bayesian statistics for the social sciences. This course is intended to introduce students to theory of Bayesian statistics and Markov chain Monte Carlo and provide students with techniques to build sophisticated statistical models to answer substantive research questions. Students in the class will be able to implement Bayesian models using modern software tools, make inferences based on posterior distributions, and conduct model assessment and convergence diagnostics. Students who excel in the course will be in a position to develop innovative models and MCMC algorithms of their own, thus contributing to the field of political methodology.

This is a lecture course, but most of the learning will take place outside of the classroom. To enhance understanding and build intuition, students need to devote a large amount of time and effort to solve homework problems, write code, analyze data, and work on research projects. Ultimately students will only get from this course what they put into it.

2 Prerequisites

Since this is an advanced quantitative analysis course, basic knowledge of mathematics and statistics is assumed. The following are more specific prerequisites:

1. Mathematics covered in POL 502 or an equivalent course
2. Probability covered in POL 571 or an equivalent course
3. Statistics covered in POL 572 and POL 573 or equivalent courses
4. Statistical software R

For those students who have not taken the listed courses or other equivalent courses, you should discuss with the instructor to decide whether the course is a right one for you this year.
3 Primary Textbooks

Many readings will be taken from the following primary textbooks:


You may also find the following books useful for reference


4 Requirements & Grading

Students are required to do the readings ahead of time, attend class, and complete all assignments.

4.1 Grading

The final grade will be a weighted average of grades in the following areas:

- 30% Completion of problem sets (weekly or biweekly)
- 10% A brief description of the final research project, no longer than two pages, due on March 10
- 60% A final research paper, at least twenty pages (references not included), due on the Dean’s Date (May 10)

4.2 Important Notes on the Final Research Project

As the instructor, I will be more than happy to provide guidance and help along the way even beyond this course. You should schedule a meeting with me to discuss your final project at least twice during the semester. It’s never too early to start thinking about the final project. There are several important notes on the final project.

- The two-page description of the final project is an informal research proposal. It should include the following:
  - What is the research question? One or two sentences.
  - What are the potential substantive contributions?
  - What are the data to be used to answer the question?
  - What are the most important methodological issues presented by the research question and the empirical data?
  - What is the statistical model to be applied or developed?
  - Is there any potential methodological contribution?
  - No references
• Students are allowed to work on a collaborative final project with another student in the class. If a collaborative project involves more than two students in the class, you should talk to me. Permission may be denied.

• Students are encouraged to work on innovative models, but the most important thing is to use or develop models and methods to help answer the research question(s). A complicated or fancy model means nothing if it does not help answer real questions.

• The final project can be motivated by either substantive or methodological research questions. No matter whether it is primarily a substantive or methodological project, it should include empirical data analysis. The final paper will be regarded as incomplete if the paper only has Monte Carlo studies.

5 Tentative Course Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topics</th>
<th>Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb.1</td>
<td>Introduction</td>
<td>No readings</td>
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<tr>
<td>Feb.3</td>
<td>Bayesian vs. Frequentist Methods</td>
<td>Gill, pp1-37 (Chapter 1)</td>
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<tr>
<td>Feb.8</td>
<td>Subjective Probabilities</td>
<td>Greenberg, pp.7-11 (Chapter 2.1)</td>
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<pre><code>                          | 2. Gill, pp.39-70 (Chapter 2)       |
</code></pre>
<p>| Feb.15 | Posterior Distribution and Inference I                     | Greenberg, pp.20-39 (Chapter 3)    |
| Feb.17 | Posterior Distribution and Inference II                    | Greenberg, pp.20-39 (Chapter 3)    |
| Feb.22 | Prior Distributions I                                       | Greenberg, 4.3 &amp; 4.9               |
| Feb.24 | Prior Distributions II                                      | Gill, pp.135-185 (Chapter 5)       |
| Mar.1  | Model Quality Assessment                                    | Gill, pp. 191-220 (Chapter 6)      |
| Mar.3  | Bayesian Hypothesis Testing                                 | Gill, pp.229-271 (Chapter 7)       |
| Mar.8  | Simulation: Classical Methods I                             | Greenberg, pp.63-75 (Chapter 5)    |
| Mar.10 | Simulation: Classical Methods II                            | Greenberg, pp.63-75 (Chapter 5)    |
| 2. Greenberg, pp.76-87 (Chapter 6)  |
| 2. Greenberg, pp.76-87 (Chapter 6)  |
| 2. Greenberg, pp.91-95 (Chapter 7.1) |</p>
| Mar.31 | Metropolis-Hasting Algorithm                                | 1. Gill, pp.368-375 (Chapter 9.4)   
<pre><code>                          | 2. Greenberg, pp.96-104 (Chapter 7.2) |
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<tr>
<th>Date</th>
<th>Topics</th>
<th>Readings</th>
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<tbody>
<tr>
<td>Apr.5</td>
<td>Two Examples: Probit &amp; Autoregressive Models</td>
<td>Greenberg Chapter. 8.22 &amp; 10.1</td>
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<td>Apr.7</td>
<td>Convergence Diagnostics</td>
<td>Gill, pp. 460-492 (Chapter 12)</td>
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<td>Apr.12</td>
<td>Bayesian Hierarchical Models I</td>
<td>Gill, pp. 395-431 (Chapter 10)</td>
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<tr>
<td>Apr.14</td>
<td>Bayesian Hierarchical Models II</td>
<td>Gill, pp. 395-431 (Chapter 10)</td>
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<tr>
<td>Apr.19</td>
<td>Bayesian Panel Data Analysis</td>
<td>Greenberg, pp. 144-149</td>
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<td>Apr.21</td>
<td>Bayesian Nonparameterics I</td>
<td>TBA</td>
</tr>
<tr>
<td>Apr.26</td>
<td>Bayesian Nonparameterics II</td>
<td>TBA</td>
</tr>
<tr>
<td>Apr.28</td>
<td>Review</td>
<td>No readings</td>
</tr>
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### 6 References

If you are interested in knowing more about Bayesian theory, Markov Chain Monte Carlo theory and techniques, or hierarchical models (or more specifically panel data analysis), you may find the following books and articles are fun to read.

#### 6.1 Bayesian Books


#### 6.2 Markov Chain Monte Carlo


xpang@princeton.edu  http://www.princeton.edu/politics/


### 6.3 Hierarchical Models and Panel Data Analysis


