**STAT 8281: ADVANCED TIME SERIES ANALYSIS**

*Department of Statistics  
The George Washington University  
Spring Semester 2014*

**Instructor:** Jonathan Stroud  
**Office:** 551 Rome Hall, 801 22\textsuperscript{nd} St, NW  
**email:** stroud@gwu.edu  
**Phone:** (202) 994-6889  
**Class Time:** Monday 6:10-8:40 pm  
**Classroom:** 2020 K Street, Room 11  
**Office hours:** Wed 4-6 pm and by appt.  
**Webpage:** blackboard.gwu.edu

**Class Description**

This class offers an introduction to time series methods from both a theoretical and applied perspective. Topics to be discussed in this class are: exploratory techniques for time series (autocorrelations, periodogram, etc.); time series regression models; Autoregressive Moving Average (ARMA) models; Box-Jenkins methodology; forecasting in time series; seasonality; diagnostics of time series models, and state-space models (Kalman filter/smooth). Special topics include Bayesian approaches, hidden Markov models, ARCH-GARCH and stochastic volatility models. The methodology will be illustrated with the analysis of different data sets arising in the context of the physical sciences, psychology, economics and finance, etc.

**Prerequisites**

Multivariable Calculus (MATH 33), Mathematical Statistics (STAT 6201/6202) or equivalent. Previous experience with linear regression (STAT 6214/2218) and statistical computing is a plus but not required.

**Program**

This course covers the following aspects in time series: exploratory methods, analysis in the time domain, modeling for stationary processes. We will focus mainly on univariate time series in this class. This is how I expect the course to develop:

- **Introduction to time series and exploratory techniques.** Time plots, calculation of the sample autocorrelation. (Class Notes. Shumway and Stoffer Ch. 1 and 2)
- **Time Series Regression** (Class Notes. Shumway and Stoffer Ch. 2)
- **ARMA modeling.** Estimation of autoregressive moving averages processes via frequentist and Bayesian approaches. Model diagnostics, forecasting and applications. (Class Notes. Shumway and Stoffer Ch. 3)
- **State-space modeling.** Filtering, smoothing, forecasting and estimation for state-space models via frequentist and Bayesian methods (Class Notes. Shumway and Stoffer, Ch. 6)
- **Special topics: Long memory, GARCH, threshold models.** (Shumway and Stoffer Ch. 5)
- **Special topics: Non-stationary time series processes, Stochastic Volatility, Nonlinear, Non-Gaussian state-space models, Hidden Markov Models** (Class Notes, Shumway and Stoffer Ch. 6)
Data sets
One of the main goals of this course is to familiarize the student with different methods for time series through analyzing different data sets. Some of the data that we may study are related to:

- climatology issues involving warming trends.
- study of trends in ozone in urban and rural areas.
- changes in economic behavior and financial settings.
- volatility modeling for financial returns

Computing
I will provide code in R for the different methods discussed in class, although the material is not R-dependent. Matlab can be used as alternative to R or Splus. SAS and SPSS can be used for exploratory analysis and to fit ARIMA models. The R software is free and available at http://cran.r-project.org/.

- For those of you using R for the first time, I recommend you read Introduction to R document available from the Manuals section of R.

Class Materials
- Data files and R code for this text are available at http://www.stat.pitt.edu/stoffer/tsa3/
- I will provide some class notes through the course webpage. Also, I will provide R code with examples.

Other textbooks in time series are:


Learning Outcomes
As a result of completing this course, students will be able to:
1. Build models for time series data incorporating trends, seasonality and autocorrelation.
2. Identify and estimate Box-Jenkins ARIMA models.
3. Identify and estimate state-space models using the Kalman filter and smoother.
4. Generate and evaluate forecasts using these models.
5. Implement these methods using R (or similar) statistical software package.
Grading Policy

**Homeworks**: Homeworks will be assigned on a regular basis. They will include problems from the textbook and R programming assignments. Assignments will typically be due the following week at the start of class.

**Project**: Each student will do an application project on the analysis of time series data, which may include a short in-class presentation. The project will be assigned around Week 9 or 10, and will be due in the final week of the semester.

**The final grade is computed as follows:**
- Homework assignments: 50%
- Final project (may include a short presentation): 50%

CLASS POLICIES

1) **Late hw/project**: Usually not accepted unless appropriate explanations are given.

2) **Laptops**: Students are not allowed to use laptops or other electronic devices during lectures unless asked to.

3) **Incompletes**: A grade of INCOMPLETE will ONLY be given to a student who is passing the course and cannot complete the course due to illness or other (well documented) circumstances beyond his/her control.

4) **University Policy on Religious Holidays**:
   a. Students should notify faculty during the first week of the semester of their intention to be absent from class on their day(s) of religious observance;
   b. Faculty should extend to these students the courtesy of absence without penalty on such occasions, including permission to make up examinations;

ACADEMIC INTEGRITY
I personally support the GW Code of Academic Integrity. It states: “Academic dishonesty is defined as cheating of any kind, including misrepresenting one's own work, taking credit for the work of others without crediting them and without appropriate authorization, and the fabrication of information.” For the remainder of the code, see: http://www.gwu.edu/~ntegrity/code.html

SUPPORT FOR STUDENTS OUTSIDE THE CLASSROOM

**DISABILITY SUPPORT SERVICES (DSS)**
Any student who may need an accommodation based on the potential impact of a disability should contact the Disability Support Services office at 202-994-8250 in the Marvin Center, Suite 242, to establish eligibility and to coordinate reasonable accommodations. For additional information please refer to: http://gwired.gwu.edu/dss/
The University Counseling Center (UCC) offers 24/7 assistance and referral to address students' personal, social, career, and study skills problems. Services for students include:

- crisis and emergency mental health consultations
- confidential assessment, counseling services (individual and small group), and referrals

http://gwi.red.gwu.edu/counsel/CounselingServices/AcademicSupportServices

SECURITY
In the case of an emergency, if at all possible, the class should shelter in place. If the building that the class is in is affected, follow the evacuation procedures for the building. After evacuation, seek shelter at a predetermined rendezvous location.

Tentative Schedule for the Semester

<table>
<thead>
<tr>
<th>Class</th>
<th>Date</th>
<th>Topics</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/13</td>
<td>Overview, Stationary Processes</td>
<td>1.1-1.5</td>
</tr>
<tr>
<td>1</td>
<td>1/20</td>
<td><strong>No Class (MLK Day)</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1/27</td>
<td>Estimators, Properties</td>
<td>1.6</td>
</tr>
<tr>
<td>3</td>
<td>2/03</td>
<td>Regression, Dependence in Reg.</td>
<td>2.1-2.3, 5.6</td>
</tr>
<tr>
<td>4</td>
<td>2/10</td>
<td>Model Selection, Harmonic Reg.</td>
<td>2.2-2.5, 4.1-4.2</td>
</tr>
<tr>
<td>4</td>
<td>2/17</td>
<td><strong>No Class (President’s Day)</strong></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2/24</td>
<td>Smoothing, ARIMA Models</td>
<td>2.4, 3.1-3.3</td>
</tr>
<tr>
<td>6</td>
<td>3/03</td>
<td>Covariances, Forecasting</td>
<td>3.4-3.5</td>
</tr>
<tr>
<td>3/10</td>
<td></td>
<td><strong>Spring Break</strong></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3/17</td>
<td>Estimation, Alternative Estimates</td>
<td>3.6</td>
</tr>
<tr>
<td>8</td>
<td>3/24</td>
<td>Integrated Models, Model Selection</td>
<td>3.7, 5.2-5.3, 3.8</td>
</tr>
<tr>
<td>9</td>
<td>3/31</td>
<td>Multivariate TS, Cointegration</td>
<td>5.7-5.8</td>
</tr>
<tr>
<td>10</td>
<td>4/07</td>
<td>Seasonality, Heteroskedasticity</td>
<td>3.9, 2.3, 5.3</td>
</tr>
<tr>
<td>11</td>
<td>4/14</td>
<td>Estimation, State-Space Models</td>
<td>6.1-6.2</td>
</tr>
<tr>
<td>12</td>
<td>4/21</td>
<td>Properties, Heteroskedasticity</td>
<td>6.2-6.3, 6.10</td>
</tr>
<tr>
<td>13</td>
<td>4/28</td>
<td>Bayesian Methods for SSMs</td>
<td>Notes; 6.10</td>
</tr>
<tr>
<td>14</td>
<td>4/29</td>
<td>Stochastic Volatility Models</td>
<td>Notes; 6.9</td>
</tr>
<tr>
<td>15</td>
<td>4/30</td>
<td>Project Presentations</td>
<td></td>
</tr>
</tbody>
</table>