FIN 285A-2: Computer Simulations and Risk Assessment
Fall 2019
Tuesday 6:30-9:20 PM
Location: Lee Hall

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Office Hours: M/W 2:30-4:00 PM, or by appointment
TA: Mark McAvoy
TA Email: mcavoy@brandeis.edu
TA Office Hours: TBA

Prerequisites
1. FIN 201a, or a basic knowledge of finance is essential.
2. Econ213a or Econ184a: A basic working knowledge of mathematical statistics is important too. You need to know about random variables, probability distributions and densities. Also, a little knowledge of linear regression will be useful too. A standard one semester course in math stats with calculus will cover this.
3. Fin 270a (Options and derivatives) would also be useful, but it is not required.
4. Although all computer skills will be taught in the course, some enthusiasm for programming will be useful. No programming skills are assumed.
5. The course also assumes basic calculus equivalent to about 1 semester of calculus at the undergraduate level.

This course is designed for 2nd year IBS masters’ students (MA, MSF, MBA) and PhD students.

Course Description
Measuring and managing financial risk has been a critical task for institutions, regulators, and investors. At the root of disciplined, modern quantitative investment processes are two things: risk and return. While the notion of total return is obvious, seeking to better assess and manage risks has always been important in financial industry. Over the last half century, as markets have become more complex, this task has become more important. Modern technology has changed the playing field in risk measurement. Computers allow for measurement of risk across the enterprise at near up to the minute frequencies, which has led to demands for processing and interpreting this information. Computational tools have provided a key component in this mission. Analyses based on monte-carlo, or computer simulation methods allow us to produce future scenarios from which we can judge the overall risks we are currently exposed to. This course will introduce the computational tools and show
how they can be used in various forms of financial risk assessment and portfolio construction. We will look at classic statistical methods such as bootstrapping and GARCH model, and also other modern methods such as conditional forecasting and copulas. We will apply these in different financial settings involving both market and credit risk. Finally, we will look at these computational tools from the perspective of the recent crisis and global financial policy going forward. Students are asked to do hands-on programming through both research projects and homework. This course has been taught in various programming languages and current iteration is done through Python. Teaching Python is not the objective of this course but we will spend some time at the beginning of the course to get everyone up to speed.

**Learning Goals**

1. Ability to apply computational statistical methods such as bootstrapping, and monte-carlo to questions of risk measurement in financial settings.
2. Understand how to implement small programs in the Python programming language for use in financial analysis.
3. Assess the confidence of various risk measures given available data sets.
4. Learn how to quantify the impact of tail risk in many situations.
5. This course can be a rough preparation (with some more reading) for taking the financial risk manager (FRM) exam from the Global Association of Risk Professionals (GARP).

**Required Readings**

1. Lecture notes (The course materials, i.e. notes and example codes, are mainly based on the platform designed and developed by Professor Blake LeBaron.)

**Recommended Books**

5. Efron/Hastie, *Computer Age Statistical Inference*, Cambridge University Press, 2016. (This book is very optional, but it is a very nice, complete view of how computer simulation is currently being used in many parts of stats- tics. Many more than we will talk about.)

**Helpful Websites**

- [Quant finance site](#)
- [Datacamp](#)
• **Statistical ideas**

**Required Software**
The Python programming language, and tools in the Anaconda download will be assumed (https://www.anaconda.com/). This is an open source package. You will be able to run this on your own laptop.

**Grading**
Final grades will be based on weighted average of following:
- Problem sets (15%)
- Midterm exam (30%), October 29\(^{th}\), in-class, closed-book
- Group research project (20%), due Tuesday, December 10\(^{th}\).
- Final exam (35%), TBA

**Workload**
Success in this four-credit course is based on the expectation that students will spend a minimum of 10 hours of study time per week in preparation for class (readings, papers, discussion sections, preparation for exams, etc.).

**Communications**
You are responsible for all announcements and materials in class. Also, much of the information in class will be sent over Latte and the class website.

**Rules specific to Fin285**
- Exams
  - Your own work
  - Closed book
  - No laptops, no cell phones, no pda’s
- Problem sets
  - Hand in your own work
  - Can discuss and assist each other
  - Use all resources
- Group research project
  - Own work for the group
  - Hand in one writeup per group

**Academic Integrity**
You are expected to be honest in all of your academic work. Please consult *Academic Integrity at Brandeis* and Brandeis University *Rights and Responsibilities* for all policies and procedures related to academic integrity. Students may be required to submit work to TurnItIn.com software to verify originality. Allegations of alleged academic dishonesty will be forwarded to the Director of
Academic Integrity. Sanctions for academic dishonesty can include failing grades and/or suspension from the university. Citation and research assistance can be found at LTS - Library guides.

Disabilities

If you are a student with a documented disability on record at Brandeis University and wish to have a reasonable accommodation made for you in this class, please see me at the beginning of the term.

Course Outline

Syllabus refers to pages in core textbook, Hilpisich. Most sections are now covered by lecture notes only, and Python code examples. All available on website, or Latte. Some data sets are on Latte since they are proprietary, and should NOT be shared outside of the Brandeis community.

1. Introduction
2. Tools
   2.1. Probability basics (review)
   2.2. The Python computer language
       2.2.1. Basics (H, pp 79-94)
       2.2.2. Numpy (H, pp95-107)
       2.2.3. Matplotlib (H, pp 109-131)
       2.2.4. Pandas (H, 137-156 skim)
   2.3. Computational statistics (refer: Efron/Hastie)
       2.3.1. Sampling, monte-carlo, and bootstrapping
       2.3.2. Hypothesis tests/Confidence intervals
   2.4. Time series basics
3. Financial data review
   3.1. Financial data basics
   3.2. Getting financial data
   3.3. Stylized facts of financial data
4. Value at Risk (VaR) analytics
   4.1. Basics and interpretations
   4.2. VaR issues
   4.3. Expected shortfall
5. Estimating VaR (H, pp 298-302)
   5.1. Parametric methods
   5.2. Historical VaR
   5.3. Monte-carlo methods for VaR (H, pp 265-274, skim)
   5.4. VaR precision, confidence intervals, and the bootstrap
       5.4.1. VaR confidence intervals
       5.4.2. The antithetic bootstrap
       5.4.3. Monte-carlo tests of the bootstrap
   5.5. Method comparisons
6. Extending VaR
   6.1. Time aggregation
   6.2. Extreme Value Theory
7. Volatility forecasting
   7.1. Modeling volatility
   7.2. Using volatility forecasts
      7.2.1. Basic empirical conditional volatility
      7.2.2. Implied volatility and VIX
      7.2.3. Realized volatility
      7.2.4. Time series models, and volatility forecasting

8. Options and Monte-Carlo measures
   8.1. Option pricing with simulation (H, pp 290-294)
   8.2. Options and partial risk hedges
   8.3. Exotic options (Barriers and Asian)
   8.4. Convergence trades and pairs trading (Funding risk)

9. Backtesting / stress testing (refer: Christoffersen 13)
   9.1. Backtests and VaR evaluation
   9.2. Capital requirements and VaR Hull, chapter 12(skim), 13.1/13.2
   9.3. Stress tests Hull, chapter 19
   9.4. Model risk
### Course Schedule/Outline (updated on 8/20/2019)

Please pay attention to the announcement and update on the Latte course site.

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Readings</th>
<th>Assignment</th>
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<tbody>
<tr>
<td>9/3</td>
<td>Introduction&lt;br&gt;Probability basics review&lt;br&gt;The Python compute language</td>
<td>Lecture notes; H, pp79-94;95-107;109-131;137-156(skim)</td>
<td>Install Python (Anaconda)</td>
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<tr>
<td>9/10</td>
<td>The Python compute language&lt;br&gt;Computational statistics</td>
<td>Lecture notes</td>
<td>Problem Set 1</td>
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<tr>
<td>9/17</td>
<td>Time series basics&lt;br&gt;Financial data review</td>
<td>Lecture notes</td>
<td>Problem Set 2</td>
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<tr>
<td>9/24</td>
<td>Financial data review&lt;br&gt;VaR analytics</td>
<td>Lecture notes</td>
<td>Problem Set 3</td>
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<td>10/1</td>
<td><strong>HOLIDAY-NO CLASSES</strong></td>
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<tr>
<td>10/8</td>
<td>Estimating VaR</td>
<td>Lecture notes; H, pp 265-274;298-302</td>
<td>Problem Set 4</td>
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<td>10/15</td>
<td><strong>Monday class in effect</strong></td>
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<tr>
<td>10/22</td>
<td>Methods comparison&lt;br&gt;Review</td>
<td>Lecture notes</td>
<td>Problem Set 5</td>
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<td>10/29</td>
<td><strong>Mid-term Exam (in-class, closed-book)</strong></td>
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<td>11/5</td>
<td>Extending VaR</td>
<td>Lecture notes</td>
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<td>11/12</td>
<td>Modeling volatility</td>
<td>Lecture notes</td>
<td>Problem Set 6</td>
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<tr>
<td>11/19</td>
<td>Using volatility forecasts</td>
<td>Lecture notes</td>
<td>Problem Set 7</td>
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<td>11/26</td>
<td>Option pricing with simulation&lt;br&gt;Options and partial risk hedges</td>
<td>Lecture notes; H, pp-290-294</td>
<td>Problem Set 8 (opt.)</td>
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<tr>
<td>12/3</td>
<td>Exotic options&lt;br&gt;Convergence trades and pairs trading</td>
<td>Lecture notes</td>
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<td>12/10</td>
<td>Backtesting/stress testing&lt;br&gt;Review</td>
<td>Lecture notes; Hull,Chp12, 13.1-13.2</td>
<td>Project due</td>
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<td>Dec. ??</td>
<td><strong>Final Exam: TBA</strong></td>
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