

## **ECON 424: Computational Finance and Financial Econometrics**

University of Washington

Summer 2017

Tuesday and Thursday, 1:10-3:20pm,

Bank of America Executive Education Center (EXED) 125

**Course Instructor:** Anthony Sanford

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**Office Hours:** Thursday 12-1PM and 3:20-4:20 (contact me if you want to speak with me via Zoom)

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**Office Hours:** Monday 6-7PM and Tuesday 10-11AM (all via Zoom)

**Quiz Section:** Friday 8-9AM Sav 117 Computer Lab

### **Course Overview:**

This course is an introduction to computational finance and financial econometrics - data science applied to finance. The course covers computer programming and data analysis in R, econometrics (statistical analysis), financial economics, microeconomics, mathematical optimization, and probability models. A free online version of this course is available on Coursera and has been taken by over 100,000 students worldwide.

The emphasis of the course will be on making the transition from an economic model of asset return behavior to an econometric model using real data. This involves: (1) exploratory data analysis; (2) specification of models to explain the data; (3) estimation and evaluation of models; (4) testing the economic implications of the model; (5) forecasting from the model. The modeling process requires the use of economic theory, matrix algebra, optimization techniques, probability models, statistical analysis, and statistical software.

### *Course objectives:*

Upon completion of this course, you will be able to:

1. Understand basic mathematical concepts of finance, financial economics, and financial econometrics;
2. Apply concepts of financial economics;
3. Convey information effectively in writing;
4. Use statistical software like R and Excel.

**Prerequisites:**

Formally, the prerequisites are Econ 300 and an introductory statistics course (Econ 311 or equivalent). Econ 482 (Econometric Theory) is not a prerequisite. More realistically, the ideal prerequisites are a year of calculus (through partial differentiation and constrained optimization using Lagrange multipliers), some familiarity with matrix algebra, a course in probability and statistics using calculus, intermediate microeconomics and an interest in financial economics (Econ 422 would be helpful).

**Readings:**

There are two required books for this course, two highly recommended books, and four recommended books that some of you may find useful. One of the required textbooks is available through Canvas (Zivot) on the Syllabus page and the other is available for free through the library.

**Required Books:**

An Introduction to Computational Finance and Financial Econometrics with R, by Eric Zivot, manuscript in preparation for publication by CRC Press. Updated: July 7, 2016.

Statistics and Data Analysis for Financial Engineering with R Examples, by David Ruppert and David Matteson, Springer-Verlag. The UW library has access to the UseR series of books from Springer-Verlag. If you have a UW net ID then you can get access to these ebooks through the UW library page. If you are connecting from a computer that is off campus be sure to use the Off Campus login link which can be found on Canvas.

**Highly Recommended Books:**

A Beginner's Guide to R by Alain Zuur, Elena Ieno and Erik Meesters, Springer-Verlag. A direct link to A Beginner's Guide to R is here available on Canvas.

R Cookbook by Paul Teetor, O'Reilly.

**Recommended Books:**

Introductory Statistics with R, Second, by Peter Dalgaard, Springer-Verlag, New York.

Modern Portfolio Theory and Investment Analysis, by E.J. Elton et al., Wiley, New York. This text gives a very detailed

treatment of portfolio theory.

Financial Modeling, by Simon Benninga. MIT Press. This textbook covers financial modeling using Microsoft Excel.

Statistical Analysis of Financial data in R, by Rene Carmona, Springer-Verlag, 2014. This is a great book but is a bit too advanced for this course. It is used at Princeton in their Masters Program in Financial Engineering. The UW library has access to the UseR series of books from Springer-Verlag. If you have a UW net ID then you can get access to these ebooks through the UW library page.

**Canvas:**

The principal means of communication for this course is Canvas - the university-wide learning management system. You can access the course syllabus, class lecture notes, course assignments, discussion boards, and grades at the course website in Canvas.

**Software:**

The course will utilize R for data analysis and statistical modeling and Microsoft Excel for spreadsheet modeling.

Excel is included with all versions of Microsoft office and is available on all PC computers around campus.

R is a free open-source statistical modeling and graphical analysis language built upon the S language developed at Bell Labs and is available on many computers throughout the UW campus. It can be downloaded from [www.r-project.org](http://www.r-project.org). There are versions available for PC, Mac and various forms of LINUX. The CSSCR lab, on the 1st floor of Savery Hall, has R on most of the PCs. I highly recommend using RStudio ([www.rstudio.org](http://www.rstudio.org)) as a free integrated development environment for R (runs on windows, MAC and LINUX).

We will be using several user-created packages (libraries of R functions) specifically designed for the analysis of financial time series data. R packages are maintained on the web and can be automatically downloaded from within R. The R package IntroCompFinR is the companion package for the book used in this class - An Introduction to Computational Finance and Financial Econometrics and is available on R-Forge (see link on Canvas). This package contains data for all of the examples in the book as well as a number of useful functions for data, portfolio and risk analysis.

**Course Structure:**

The class will combine (1) lecturing by the instructor, (2) interactive discussions of readings, (3) homeworks and labs, (4) exams, and (5) a final research paper.

**Course Requirements:**

Your grade in this class is comprised of four main parts (all submitted through Canvas except for the Midterm):

<i>Assignment</i>	<i>Percentage</i>	<i>Due Date</i>
Midterm exam	25%	July 20, 2017 (tentative date)
Final exam	25%	August 17, 2017 (tentative date)
Homeworks	25%	Multiple dates, see online schedule
Final Paper	25%	August 17, 2017

Quizzes ():

This is for econ 424 students **only**: in the event that students stop attending lectures, I reserve the right to add pop quizzes to the final course grades. If this happens, the quizzes will be worth 15% of your grade, the midterms will be worth 20% each, and the paper will be worth 20%.

Exams (50%):

There are two in-class exams in this course: a midterm and a final (non-cumulative). All the material covered in the course may appear in the exams, including all assigned readings, lectures, presentations, movies, etc. You are allowed to bring one cheat sheet for the exams. You can use both sides of the sheet but it must be handwritten by you. In other words, you cannot print your note sheet. If it is not written by you, you will not be allowed to use the sheet during the exam.

**Important:** copying past questions and solutions onto your cheat sheet will be considered cheating.

Homework (25%):

You will have homework due every week during the quarter. Some of these homeworks will be long and hard so please do not wait until the last minute to start them. These are meant for you to apply the material that we have learnt throughout the week. They will also be extremely valuable for the final project! So I strongly encourage you to make sure that you look at and understand the solutions that will be provided online. For the homework, I will only be grading one question thoroughly. The rest of the questions will only be checked for completeness rather than accuracy. So, again, make sure that you look at the solutions and that you understand them.

Final Paper (25%):

Specific instructions for the final paper will be posted on Canvas. The paper is meant to replace a final exam. That means that you will be expected to thoroughly use the tools and techniques that you developed throughout the course. The expected length of the paper will be approximately 20 pages, double spaced. You will be submitting a final paper as well as the code used to generate your results. This will be a formal research paper and so I

expect you to treat it as such. I expect proper grammatical form as well as full and detailed explanations of everything you are doing or including in the paper. Note that Cheating will not be tolerated.

**Late Submission and Make-Up Policy:**

Make-up examinations and deadline extensions will not be allowed without prior permission from the instructor except in emergency situations. Emergency situations do not include waking up late, missing the bus, forgetfulness, etc. Proper documentation is required from the student in all cases of make-ups and extensions (e.g., doctor's note, mechanic's work order, etc.). You must turn in your assignments on time.

**Grading Appeals Policy:**

If you would like to appeal a grade, please follow the following steps:

1. Carefully read all comments.
2. Wait 24 hours and reread your answer and the comments.
3. Within one week of receiving a grade, provide a typed statement to me explaining specifically why the grade you received should be altered.
4. Bring the work in question, along with a paper copy of your statement, to me during office hours (or by appointment). I will re-read the material, re-grade it if appropriate, and return it to you with comments within a three-day period (excluding weekends).

*Please note that the exam or assignment will be completely reevaluated and that I reserve the right to change your grade up or down as a result.*

**Professor Responsibilities:**

I have high expectations not only for you but also for myself. You should expect that I will:

- be prepared for class, read and return your work in a timely manner, and be interested and engaged in your work;
- remember that each of you brings a different background, experience, and perspective to this course;
- learn from you;
- meet with you individually or in groups upon request and be available in person, by telephone, and by email; and
- work hard, have fun, and empower you to develop greater understandings of the topics that are covered in this course.

**Accommodations for Students with Disabilities:**

Your experience in this class is important to me. If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to me as early as possible, and preferably no later than two weeks after the beginning of the course.

If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health

impacts), you are welcome to contact DRS at 206-543-8924 or uwdrs@uw.edu or disability.uw.edu. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between you, your instructor(s) and DRS. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law.

**Academic Honesty:**

The University of Washington requires that each student be honest, submit products that are from their own effort, and engage in academic behavior that is ethical and honorable. Specific definitions of honesty and professionalism relate to plagiarism, cheating on examinations, unauthorized collaboration, and falsification. Students are expected to be familiar with University of Washington's Policy on Academic Honesty (found [here](#)).

Plagiarism and academic dishonesty include (but are not limited to) the following:

- Reusing material developed for other courses to meet writing assignments in the current course;
- Collaborating with other students when not authorized to do so or with outside consultants (i.e. professional editor) for writing assignments;
- Copying information or ideas from a book, article, or website without proper credit to the author.
- Cheating on examinations (giving or receiving unauthorized help before, during, or after an examination)
- Copying code for homework assignments or writing assignments.

Academic dishonesty will not be tolerated in this class. If a violation of the University policy on academic honesty is suspected, I will refer the case to the proper administrative authorities to determine further penalties. Disciplinary action could result in receiving an "F" in the course, suspension, or even expulsion from the university. Please see me if you have any questions about the academic violations described in the academic honesty policy, especially as they relate to particular requirements for this course.

**Respect for Diversity:**

It is my intent that students from all diverse backgrounds and perspectives be well-served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender and gender identity, sexual orientation, disability, age, socioeconomic status, ethnicity, race, culture, perspective, and other background characteristics. Your suggestions about how to improve the value of diversity in this course are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups.

**Course Policies:**

- **My email communications with you:** Please note that I will use Canvas directly or your uw.edu email address should I need to contact you outside of class. Make sure to forward your emails to another account if you do not check your UW account regularly.
- **Your email communications with me:** I expect communications to be respectful and courteous. Please avoid “text talk” (I am not a fluent speaker of it, unfortunately) and please include basic greetings in your emails. I believe it is important to be especially courteous and professional in emails as online communications can often lead to misunderstandings. I will answer all emails within 48 hours or less except on weekends or holidays. If your question requires a long answer, I will ask you to make an appointment with me during my office hours.
- **Use of technology:** You are welcome to bring technology to the classroom as long as you can handle it responsibly and respectfully. That means not carrying on conversations (either out loud or in text form), not playing games, and not visiting unrelated websites during class. Text messaging will not be tolerated in class. Any student found to be sending or checking text messages during class will be invited to make a choice either to cease the texting or leave the classroom. You are welcome to bring your laptop to class and use it to take notes, access readings we are discussing, and the like. You are *not* welcome to do social networking, check email, or otherwise perform non-class-related activities during class. Inappropriate uses of cellphones and laptops will be noted and may affect your final grade.
- **Punctuality:** Out of respect for your fellow classmates, be on time for class.
- **Respect for others:** The only way this course will provide an experience that we will all be excited about is by respecting other students in the classroom and making all persons feel comfortable enough to contribute, even when and if they know that students will disagree with them. Direct your thoughtful responses to the argument or position being offered, not the person. I will encourage healthy debate and discussions of contrasting ideas and points of view, with the expectation that these will be conducted with civility and respect.

**Copyright Notice:**

Student or professor materials created for this course (including presentations and posted notes, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s). *You may **NOT** record lectures without prior permission from the professor.*

**Course Evaluations:**

Upon completion of this course, please take the time to fill out the online course evaluation. You will receive reminders about evaluations towards the end of the quarter. Your honest assessment of the course is an important source of feedback for both the professor and the Department of Economics. I take your feedback very seriously.

**\*\*\* The course syllabus provides a general plan for the course;  
deviations may be necessary. \*\*\***

**Course Schedule (Tentative)**

- June. 20  
(wk 1)      **Course Overview/Introduction, Return Calculations and Introduction to Probability Theory**  
Required Readings:
- Zivot, chapter 1 – Return Calculations
  - Zivot, chapter 2 – Review of Random Variables
  - Ruppert, chapter 2 – Returns
  - Ruppert, appendix A – Facts from Probability, Statistics, and Algebra, sections 1-9 only
- June. 27  
(wk 2)      **Univariate, Bivariate, and Multivariate Random Variables and Matrix Algebra Review**  
Required Readings:
- Zivot, chapter 2 – Review of Random Variables
  - Zivot, chapter 3 – Matrix Algebra Review
  - Ruppert, appendix A – Facts from Probability, Statistics, and Algebra
- Homework 1 due – June 27<sup>th</sup>, submit via Canvas**
- July. 4  
(wk 3)      **Matrix Algebra, Time Series Concepts, and Descriptive Statistics for Financial Data**  
Required Reading:
- Zivot, chapter 3 – Matrix Algebra Review
  - Zivot, chapter 4 – Time Series Concepts
  - Zivot, chapter 5 – Descriptive Statistics for Financial Data
  - Ruppert, chapter 4 – Exploratory Data Analysis
  - Ruppert, chapter 12 – Time Series Models: Basics
- Homework 2 due – July 4<sup>th</sup>, submit via Canvas**
- July. 11  
(wk 4)      **Descriptive Statistics and Financial Data, Introduction and Estimation of the CER model**  
Required Reading:
- Zivot, chapter 5 – Descriptive Statistics for Financial Data
  - Zivot, chapter 6 – CER model
  - Zivot, chapter 7 – Estimation of the CER model
  - Ruppert, chapter 4 - Exploratory Data Analysis
- Homework 3 due – July 11<sup>th</sup>, submit via Canvas**
- July. 18  
(wk 5)      **Estimation of CER, Bootstrapping, and Midterm Exam**  
Required Reading:
- Zivot, chapter 7 – Estimation of the CER model
  - Zivot, chapter 8 – Bootstrapping
  - Ruppert, chapter 6 – Resampling
  - Ruppert, appendix section 10, 11, 16, and 17
- Homework 4 due – July 18<sup>th</sup>, submit via Canvas**

- July. 20  
(wk 5)      **MIDTERM EXAM IN CLASS**
- July. 25  
(wk 6)      **Portfolio Theory**  
Required Reading:
  - Zivot, chapter 11 – Introduction to Portfolio Theory
  - Zivot, chapter 12 – Portfolio Theory with Matrix Algebra
  - Ruppert, chapter 16 – Portfolio Selection**Homework 5 due – July 25<sup>th</sup>, submit via Canvas**
- Aug. 1  
(wk 7)      **Portfolio Theory and Rolling Estimation of CER**  
Required Readings:
  - Zivot, chapter 12 – Portfolio Theory with Matrix Algebra
  - Zivot, chapter 13 – Portfolio Theory with no Short Sales
  - Zivot, chapter 9 – Hypothesis Testing in the CER model
  - Zivot, chapter 9 – Rolling Estimation (sections 4.3 and 4.4)
  - Ruppert, chapter 16 – Portfolio Theory**Homework 6 due, August 1<sup>st</sup>, submit via Canvas**
- Aug. 8  
(wk 8)      **Risk Budgeting and Statistical Analysis of Portfolios**  
Required Readings:
  - Zivot, chapter 14 – Risk Budgeting
  - Zivot, chapter 15 – Statistical Analysis of Portfolios**Homework 7 due, August 8<sup>th</sup>, submit via Canvas**
- Aug. 15  
(wk 9)      **Rolling Analysis of Optimized Portfolios and Final Paper Discussions**  
Required Reading:
  - Ruppert, chapter 16 – Portfolio Theory
  - Final Paper Open Questions**No Homework!**
- Aug. 17      **Final Paper Due** via Canvas
- Aug. 17      **Final Exam** – in class

**Instructions  
Final Paper**

**Due date:** August 17, 2017 by 8:00pm

**Location:** Dropbox on Canvas

**Guidelines:**

- To be Announced on Canvas

**Formatting:**

- Paper length: around 20 pages, excluding reference page but including tables and graphs
- Paper format: 12-point, Times New Roman font, double spaced, with one-inch margins.
- You must include a reference page/bibliography (not counted in your 2-page limit) and use a recognized citation style (e.g. MLA, APA, Chicago style).