Brandeis UNIVERSITY

Statistical Modeling with R for Economics and Finance

Course Number
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Instructor

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Office Hours: Monday 1-3 pm

Course Description

Welcome to R for Economics and Finance and welcome to the world of statistical computing! This course is about developing your coding skills to applications in Economics and Finance. Note: no experience in R or coding is required, we start from scratch and develop your coding skills.

Learning Goals

This course has three main goals: to apply statistics to real economic and finance problems; to develop coding skills in R; and to teach you how to make your research process reproducible for others.

The first goal is to apply the statistics you learned or are concurrently learning in ECON 83A to further applications in Economics and Finance. These topics we will cover include: describing data, numerical summary and graphical presentation of data; computing of probability, density, and quantiles based on distributions commonly used in Economics (including the Gaussian distribution, t-distribution, Gamma distribution and the inverse-Gamma distribution), data generation, Markov-Monte Carlo methods, Bayesian linear regression, and writing functions; all with application in Economics and Finance. In our first project we will construct common macroeconomic variables from fundamental data, and in particular pull from Macroeconomics in constructing chain weighted index measures of GDP.

The second goal is to teach/develop your coding skills in R. You will learn the basics of programming in R, including how to write functions, how to use packages, how to store and manage data, and how to produce data visualizations.

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The third goal throughout the course is to emphasize making your research process reproducible in R and RStudio. As you learn new material and build upon your knowledge you will someday either want somebody else to be able to reproduce your work, or have need yourself to reproduce your own work and research. As such we emphasize reproducible research; from the beginning of a project we will create a systematic workflow for: data gathering, data analysis, and presentation of results. Further, we will use LaTeX and RMarkdown, two presentation authoring tools with support for formulas and data visualization, to make our work presentable to broader audiences.

Prerequisites

ECON 83A (or taken concurrently)

Required Texts

1) Reproducible Research with R and RStudio Second Edition,
   Second Edition,
   Christopher Gandrud,
   Chapters: 3, 4,7, 8,

2) Introduction to Applied Bayesian Statistics and Estimation for Social Scientists
   Scott M. Lynch
   Chapters: 1, 2, 3, 4, 6, 7

3) Principles of Economics
   OpenStax
   https://opentextbc.ca/principlesofeconomics/
   Chapters: 1, 14, 17, 19, 25, 29

Required Software and Hardware

1) The ***primary*** material: Pdf lecture presentations and R laboratory assignments

2) R and R-Studio
   Follow this guide to install R and R-Studio (Do not install the SDS Foundations Package)

3) Latte: I will use Latte to post announcements and supporting materials

4) Slack: We will communicate in a group-chat here

5) GitHub Classrooms: We will use GitHub to host our R files, also where we will submit assignments

6) Zoom: Any video recording software is okay, I recommend Zoom for its ease of use. We will record and upload each of the 3 projects as presentations

Projects

0) *Let's Make Research Reproducible! (not graded, but still required to submit)*
   In this project we set up an R-markdown file in the way we expect the projects to be submitted. The .Rmd file should compile as an html file, contain a header, titles for sections, R-code, color dispersed throughout, and display results as a table or graph.
1) *Let's Graph GDP per capita!*
   In this project you will choose 3 countries GDP per capita to look at. Download the following three variables for each country from the Federal Reserve Economic Data (FRED) database: Real Gross Domestic Product, Population, Constant GDP per capita. We will plot these and reproduce the graphs on the page where you downloaded the data, then combine the datasets and plot all three on the same plot, lastly we will construct GDP per capita in our data frame and compare this to the Constant GDP per capita we downloaded. The graph needs to be readable and in a good format!
2) *Let's Form Investment Portfolios!*
   In this project we will create two portfolios. As a class we will construct the first portfolio which will consist of SBUX and AAPL, using closing price data downloaded from yahoo finance. We will then obtain excess market return data from Kenneth French's data library, merge these three datasets so we can estimate these two stocks Betas using the Capital Asset Pricing Model (CAPM). Finally we find portfolio weights of these two stocks to achieve a desired beta. The second portfolio is your 10 chosen stocks, download monthly data from yahoo finance, and create a dynamically adjusted portfolio. Dynamically adjusting means the portfolio weights are changing with time. In our case we will adjust the weights every year (explicitly every January) to the target beta.
3) *Let's Forecast!*
   As practice in out-of-sample forecasting we will forecast the USD/CNY exchange rate out of sample using two methods: OLS, and the Linear Gibbs sampler. We will evaluate which performs better when looking at the

Root-mean-squared-forecast error (RMSFE). In our final project you will then forecast a time-series variable of your choosing downloaded from the World Bank database. Include 10 explanatory variables (downloaded from the same source). Estimate your point forecasts with OLS and your density forecasts with the Gibbs sampler and evaluate which performed better with comparison to the RMSFE. Finally you will expand on this by grouping the data (your choice in how to group, e.g. by GDP quantles, or geographic location) and forecast these values again and re-evaluate how your models performed, make a color coded map of the world (using the rworldmap package) for high, low predictions over the forecast horizon.

Note: For all 3 projects, part of the assignment will be in recording a video and presenting your results to the class, with feedback on two others presentations.

Online Course Content

This course will be conducted online using Brandeis' LATTE site, available at https://moodle2.brandeis.edu. The site contains the course syllabus, assignments, discussion forums, and learning materials. We will complement this online course with Slack and GitHub.The course will run from Monday through Sunday for 10 weeks.

Course Schedule

Week 1: Welcome to Economics! + Using R: The basics	
Objectives	Learn Economics: Introduction to Economics, How Economists use Theories and Models to Understand Economic Issues Learn R: Objects, Component Selection, Subscripts, Functions and commands, Arguments; The workspace & history, Global R options, Installing new packages and loading functions
Learning Materials	Read Chapter 1 in Principles of Economics Read Chapter 3.1 in Reproducible Research with R
Participation Activity	Our first group-chat: What are you hoping to learn from this class?

Assignments	Laboratory 1

Week 2: Economic Growth + Using RStudio, *knitr*, and *markdown*

Objectives	Learn Economics: Economic growth, Labour Productivity, Components of Economic Growth, Economic Convergence Learn R: what *knitr* does, what *rmarkdown* does, file extensions, code chunks, global chunk options, *knitr* package options
Learning Materials	Read Chapter 20 in Principles of Economics Read Chapter 3.2 and 3.3.1 - 3.3.5 in Reproducible Research with R
Participation Activity	Group chat
Assignments	Quiz 1 Laboratory 2

Week 3: Poverty and Inequality + Getting Started with File Management + GitHub

Objectives	Learn Economics: Introduction to Poverty and Income Inequality, Drawing the Poverty Line, The Poverty Trap, The Safety Net, Income Inequality: Measurement and Causes, Government Policies to Reduce Income Inequality Learn R: File paths and naming conventions, Setting up directories for a research project, UNIX commands, Learn GitHub: Clone, Commit, Pull, Push
Learning Materials	Read Chapter 14.1, 14.2, 14.4 in Principles of Economics Read Chapter 4.1 - 4.6 in Reproducible Research with R Read Chapter 5.1, 5.3 in Reproducible Research with R Begin Project 0
Participation Activity	Group chat
Assignments	Quiz 2 Laboratory 3

Week 4: The Keynesian Perspective + Preparing Data for Analysis	
Objectives	Learn R: Cleaning data for merging, reshaping data, renaming variables, renaming variables, subsetting data
Learning Materials	Read Chapter 25 in Principles of Economics Read Chapter 7.1 - 7.2 in Reproducible Research with R Laboratory 4 Begin Project 1
Participation Activity	Group chat
Assignments	Quiz 3 Laboratory 4

Week 5: Financial Markets + *knitr*	
Objectives	Learn: code chunks, LaTeX, Markdown, set.seed. Visualizing histograms
Learning Materials	Read Chapter 17 Principles of Economics Read Chapter 8 in Reproducible Research with R Laboratory 5
Participation Activity	Group chat
Assignments	Quiz 4 Laboratory 5 Finish Project 1

Week 6: Visualizing data + Probability Review	
Objectives	Learn: Visualize data (density plots, box-and-whiskers plots, violin plots, visualize density functions (the normal distribution). Maximum likelihood,

Learning Materials	Read Chapter 1 in Applied Bayesian Statistics Read Chapter 2 in Applied Bayesian Statistics (2.1, 2.2, 2.3.4, 2.3.6, 2.4, 2.5, 2.6) Begin Project 2
Participation Activity	Group chat
Assignments	Quiz 5 Laboratory 6

Week 7: Introduction to Bayesian Statistics

Objectives	Learn: visualize the student t-distribution, gamma distribution, inverse-gamma distribution. Bayes theorem, prior and posterior distributions, the Dirichlet distribution, the inverse-gamma distribution.
Learning Materials	Read Chapter 3 in Applied Bayesian Statistics (3.1, 3.2, 3.3, 3.4, 3.5.1, 3.6, 3.7) Laboratory 7
Participation Activity	Group chat
Assignments	Quiz 6 Laboratory 7 Finish Project 2

Week 8: Graphing in R + The Gibbs sampler + Exchange Rates

Objectives	Learn: plotting using ggplot2; statistics: probability density functions, normal distribution, t-distribution, quantiles. The Gibbs sampler,
Learning Materials	Read Chapter 29 in Principles of Economics Read Chapter 4 in Applied Bayesian Statistics Begin Project 3 Laboratory 8
Participation Activity	Group chat
Assignments	Quiz 7 Laboratory 8

Week 9: Regressions + Markov Chain Monte Carlo	
Objectives	Learn: OLS, Bayesian linear regression, Markov Chain Monte Carlo, trace plots, posterior predictive distributions, bayes factor, bayesian model averaging
Learning Materials	Read Chapter 6 in Applied Bayesian Statistics Laboratory 9
Participation Activity	Group chat
Assignments	Laboratory 9 Finish Project 3

Week 10: Forecasting	
Objectives	Learn: How to perform out-of-sample forecasts, evaluate using RMSFE. The bayesian linear regression model, sampling the linear regression model using a Gibbs sampler
Learning Materials	Read Chapter 7 in Applied Bayesian Statistics (7.1, 7.2.2) Laboratory 10
Participation Activity	Group chat
Assignments	Laboratory 10 Project 3 presentations due (recorded via zoom)

Grading Criteria

Component	Description	Points
Laboratory	10 Laboratory assignments	30 points each
Quizzes	7 Quizzes	20 points each
Class participation	Measured by involvement in the Group chat + dialogue in	50 points total

	Presentations	
Projects	3 Projects	50 points each

Grading Standards

All work will be graded based on Brandeis University's A-E scale. I will provide rubrics to help you understand how each assignment is evaluated. I grade on an achievement scale rather than a percentage scale. This is my preferred method so you may be able to determine how you are doing throughout the course. There are a total of 300 points available from the laboratory assignments, 140 points from the quizzes, 50 points from class participation, and 150 points from the projects. This yields a total perfect score of: 640.

A High Distinction
B Distinction
C Satisfactory
D Passing, but Unsatisfactory
E Failure

Grades are determined from the following table. For example say you get 25s on half of the Laboratory assignments and 30s on the other half, perfect quizzes, 30 in participation, and 45 on each project, then you earn a total of 580 which will earn you an A.

	+		-
A	**620**	**595**	**576**
B	**556**	**531**	**512**
C	**492**	**467**	**448**
D	**428**	**403**	**384**
E		**< 384 points**	

Success in this four-credit 10 week online course is based on the expectation that students will spend a minimum of 18 hours of study time per week for this class (inclusive of all activities, including but not limited to: readings, laboratories, discussion sections, projects, etc.)

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Course Policies and Procedures

Late Work

Late work will receive a 5 point deduction for each day it is late.

Academic Integrity

Every member of the University community is expected to maintain the highest standards of academic integrity. A student shall not submit work that is falsified or is not the result of the student's own effort. Infringement of academic honesty by a student subjects that student to serious penalties, which may include failure on the assignment, failure in the course, suspension from the University or other sanctions (see section 20 of R&R). Please consult Brandeis University Rights and Responsibilities for all policies and procedures related to academic integrity. A student who is in doubt regarding standards of academic honesty as they apply to a specific course or assignment should consult the faculty member responsible for that course or assignment before submitting the work. Allegations of alleged academic dishonesty will be forwarded to the Department of Student Rights and Community Standards. Citation and research assistance can be found at Brandeis Library Guides - Citing Sources.

Student Support

Accommodations

Brandeis seeks to welcome and include all students. If you are a student who needs accommodations as outlined in an accommodations letter, I want to support you. In order to provide test accommodations, I need the letter more than 48 hours in advance. I want to provide your accommodations, but cannot do so retroactively. If you have questions about documenting a disability of requesting accommodations, please contact Student Accessibility Support (SAS) at 781.736.3470 or access@brandeis.edu.

Financial Barriers

If you are having difficulty purchasing course materials, please make an appointment with your Student Financial Services or Academic Services advisor to discuss possible funding options and/or textbook alternatives.

Research and Software Help

The Brandeis Library collections and staff offer resources and services to support Brandeis students, faculty and staff. These include workshops, consultations, collaboration, materials and instruction on emerging trends in technologies such as machine learning, emerging trends in research such as data visualization, and emerging trends in scholarship such as open access. Librarians at the Circulation Desk, Research Help Desk, Archives & Special Collections, Sound & Image Media Studios, MakerLab, AutomationLab, and Digital Scholarship Lab are available to help you.

Other Campus Resources

Brandeis University is committed to supporting all our students so they can thrive. The following resources are available to help with the many academic and non-academic factors that contribute to student success (finances, health, food supply, housing, mental health counseling, academic advising, physical and social activities, etc.). Please explore the many links on this Support at Brandeis page to find out more about the resources that Brandeis provides to help you and your classmates to achieve success.