Parts of this outline are subject to change. Details regarding dates and assignments will be made at the first course meeting on September 11th, 2020, at 10:00 AM EST.

Course Description

This course is an introduction to probability theory and statistical inference designed for first year graduate students in economics. The course covers econometric models and methods that are most used in economics. We will learn about identification, parameter estimation, and statistical inference. Knowledge of these methods is crucial in order to read and write research papers in economics. More generally, the ability to understand the assumptions behind econometric methods and to interpret both statistical estimation and test results is very important for work in economics, policy, and other social and natural sciences. The course will have a large mathematical / technical component (all statements will be proved) and a programming component. Being mathematically rigorous will be at the forefront of all work in this course.

Prerequisites

Students should have a working knowledge of basic linear algebra (e.g. linear systems of equations, matrix algebra), multivariate calculus (e.g. partial derivatives, multivariate optimization), elementary probability theory (e.g. joint distributions, conditional expectations, variances and correlations), and statistical inference (e.g. consistency, unbiasedness, confidence intervals, hypothesis testing).

- The course will require students to be familiar with certain proof techniques, as proofs will be assigned (the course will have a large theoretical part). To refresh
your memory, take a look over Velleman’s book *How to Prove It: A Structured Approach* (you can find it online if you Google it). For a quick primer, which is not sufficient, check out [the note here](#).

- It is also advisable that you become familiar with Chapter 2 in [Hansen’s note here](#), which should be a quick review of linear regression, with some proof techniques at the end.

**Software**

- R and RStudio, which can be downloaded following [the instructions here](#). Please, try to look over the interactive primers [here](#).

- RMarkdown, which will be used to type and present theoretical and R results. Students will be required to submit most work as an RMarkdown file.
  - This may require that students become familiar with typing in latex. Latex is free and can be found online.

- Please create accounts with [Zoom](#), calendly, and [peergrade.io](#).

**Organization**

**First lecture:** Friday, September 11th, 2020, 10:00 - 11:30 AM EST, will be synchronous / live.

- You will receive a Zoom link for this session in due course.

- Please, make sure you can attend this session. It will not be recorded.

- One of the goals of this session is to facilitate your finding a group with which you will have to work for the remaining of the term. More on that below.

**Before first lecture:**

- On **September 4th, 2020**, you will receive an assignment that you will have to complete by September 10th.
– this assignment will be a review of concepts from probability theory, matrix algebra, and estimation that you are expected to know (see prerequisites)

– on September 10th, you will submit this assignment to peergrade.io (I will send you instructions closer to the date). The assignment will have to be typed in RMarkdown.

– on September 11th, during the first session, you will discuss this assignment with other classmates in Zoom break-out rooms.

• On September 9th, 2020, you should also upload a short (max 3 minute) Zoom video of yourself, telling us:
  
  – where you are located and if that will change over the term (will you be coming to Hamilton/McMaster?),
  
  – what your previous degree is in and where from, and
  
  – what field you are thinking of specializing in.
  
  – The video can include an open question that you are thinking of (related to research), or you can mention a more concrete application (should you be passionate about a particular application).
  
  – The video will be recorded with Zoom, with captions.
  
  – More information on the practical details will be sent to you closer to the date.

Based on these videos, as well as on the group work done in the break out rooms on September 11th, students are expected to form into groups of 3/4/5 students (depending on the total number of students; more precise instructions to follow). Students will have a week starting September 11th to find a group to work with throughout the term. Details will be provided on September 11th.

• As most research work in economics is done in teams, this should serve as an early introduction to the advantages and disadvantages of working in a group. Learning how to navigate group work will have high payoffs in the future.

• Students can work in groups in anyway they want. In particular, they can use any collaborative software that they want. One nice whiteboard app is Limmu. A list of other possible whiteboard apps [here](#).
The remaining of the course will be mostly asynchronous.

Course material will be posted online, lectures and exercise / lab classes will be pre-recorded, and most likely posted on the course website (to be made available sometime before the start of the term).

Office hours will be held synchronously on Zoom on either Monday evening EST or Friday morning EST. Details will follow on September 11th. Students will be asked to sign up in advance using calendly. Econometrics (technical) questions will not be answered by email, rather they will be answered during synchronous office hours.

A discussion board for this course will be set-up in due course; the platform will be either piazza or Avenue to Learn. The purpose of this discussion board is for you to ask your questions related to the assignments and to the lecture material. I will monitor the account, but not actively answer the questions in order to encourage students to interact and answer each others questions. I may answer questions that have not been answered for more than a week.

The software for this course will be R and RStudio. For a primer and resources on RStudio, see RStudio Education. We will also use RMarkdown. For a primer, see primer on RMarkdown.

Grading

The final grade is based on:

1. the first assignment and video due on September 10th and participation in the Zoom break-out rooms on September 11th (5%);

2. 5 assignments (60% group work) – details on due dates during the first meeting on September 11th;

3. an individual Monte Carlo study (35%) that will be due towards the end of the class – details on due dates during the first meeting on September 11th.

There will be 5 assignments (60% of the grade), composed of theoretical problems and coding in R/Matlab. The problem sets will be assigned approximately every two weeks. Students have to work with the others in their group on these assignments.
1. You will have a week to complete the assignment.

2. You will then upload your group’s solution on peergrade.io. Solutions will be typed in RMarkdown and the solutions uploaded as either html or pdf. (This will be made precise in due course.)

3. Each group will have to give feedback to 2 other groups on their homework in order to unlock their own feedback. You will have 1 day (24 hours) to give and receive feedback. I will review the feedback, which will be graded as pass or fail based on the quality of the feedback. The assignment and the feedback will be anonymous to the other groups.

   (a) if you do not provide feedback for 2 groups, you cannot unlock your own feedback, and you will receive a “fail” (or zero) for the feedback portion of the assignment.

   (b) if you do not provide feedback, you can still complete the remaining part of the assignment, but you will receive a zero for the feedback part and you will not be able to improve your own assignment.

   (c) the rubric for “what the feedback should be” will be made precise for each assignment and it will be found on peergrade.io once you upload your assignment.

4. Using the peer feedback received, you will have to rewrite your solution to the problem set. You have to highlight where you used the feedback. You can also choose not to incorporate the feedback, in which case you will have to explain why not. You have to submit the rewritten solutions within 2 days after receiving the feedback.

5. To clarify the timeline: (i) the problem set is uploaded to peergrade.io at time T, (ii) at T+1 day you will have unlocked your feedback (provided that your group gave feedback to 2 other groups), and (iii) at T+3 you will have to submit the rewritten solution.

6. At T+4 each group will be allocated a problem/subset of a problem to “present” to the entire class. This will be done as follows: Each group will choose one person to record a Zoom video with captions on of the answer to the problem assigned
You need to make sure that everyone will get the chance to present by the end of the course. The group will then upload the video so that all of us can watch it. You will have 2 days to create the video. At T+6 the video will be uploaded (details later) so that everyone in the class will have a chance to watch it.

7. The grade on the homework assignment will be composed of a weighted average of: initial grade for submission, pass/fail for feedback, and grade for the video. All people in the group will receive the same grade.

There will be a Monte Carlo study, which will also contain theoretical questions (35% of the grade). You will have 2 weeks to work on this project, which will be an individual project.

No late assignments will be accepted. This means that if you do not submit your work by the deadline specified, you will receive a grade of zero.

- Keep in mind that 60% of the grade is based on group work and that it is your duty to learn how to work in a group and submit materials on time.
- Any late assignment will incur a score of zero.

Resources

There is no required textbook for this class, but readings will be assigned from


- **Hansen**, https://www.ssc.wisc.edu/~bhansen/probability/

- **Hogg, Craig, and McKean**, *Introduction to Mathematical Statistics*.

- **Newey and McFadden**, *Chapter 36 Large sample estimation and hypothesis testing*.
A quick Google search will show that most of these texts can be found online.

Other relevant textbooks are

- **Billingsley**, *Probability and Measure*.
- **Casella and Berger**, *Statistical Inference*.
- **Hayashi**, *Econometrics*.
- **Greene**, *Econometric Analysis*.
- **Stock and Watson**, *Introduction to Econometrics*.
- **Cameron and Trivedi**, *Microeconometrics: Methods and Applications*.
- **Angrist and Pischke**, *Mostly Harmless Econometrics*.
- **Manski**, *Identification Problems in the Social Sciences*.

Feel free to discover your favourite graduate econometrics textbook.

**Tentative Course Outline**

- **Preliminaries**
  Probability Theory and a quick into to Measure Theoretic Probability
  Required Mathematical Tools, in particular Convergence (in probability, almost surely), Laws of Large Numbers, Central Limit Theorems

- **Linear Regression Model**
  Identification
  Asymptotic Properties of the OLS estimator
  Finite Sample Properties of the OLS estimator
  Hypothesis Testing
  Heteroscedasticity Robust (and Clustered) Standard Errors
  Generalized and Weighted Least Squares Estimator
  Instrumental Variables and the Two-Stage Least Squares Estimator
• Maximum Likelihood Estimation
  Maximum Likelihood Estimator
  Large Sample Properties and Inference

• Generalized Method of Moments
  GMM estimator
  Large Sample Properties and Inference

• The Bootstrap and subsampling

• Basic Time Series Models
  Time Series Regressions
  ARMA Processes

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check his/her McMaster email and course websites weekly during the term and to note any changes.
ACADEMIC DISHONESTY

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university. It is your responsibility to understand what constitutes academic dishonesty, please refer to the Academic Integrity Policy here.

Be aware that academic dishonesty can be: 1. Plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained. 2. Improper collaboration. 3. Copying or using unauthorized aids in tests and examinations.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work”.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s Academic Accommodation of Students with Disabilities policy.
ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar’s Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

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