ECON 488, Causal Inference, Spring 2019

Lectures: TU/TH 5:30-7:20 PM, SAV 264

Instructor and TA: Instructor: Melissa Tartari (mtartari@gmail.com); Instructor's Office Hours: TH 7:30-8:20 PM in SAV 264 (extra office hours are scheduled on a need basis). TA: Chi-Hui Yen (cyen31@uw.edu@uw.edu); TA's Office Hours: W 5:00-6:00 PM Location TBA; TA's Lab Sessions: TU 7:30-8:30 PM in SAV 264 (if need be, we use the computer lab SAV 117); any extra Lab Session is held TH 7:30-8:30 PM in SAV 264.

Content, Objectives, and Target Audience: In this course we study statistical methods for causal inference. Causal inference focuses on uncovering (i.e. learning about) causal relationships: the scientist is interested in quantifying the effect of a cause (also called a treatment, an action, or an intervention) on one or more outcome variables of interest. Methods of causal inference are widely used both in academia and industry to *ex-post* assess the effect of policy interventions, where the term policy is to be broadly understood to include any intervention of interest by public or private agents, or by nature. In this course we study the following inferential tools: matching (exact, nearest-neighbor, caliper, block, with regression adjustment, etc.), difference-in-difference, synthetic controls, instrumental variables and LATE, and regression discontinuity design (sharp and fuzzy). We conclude the course with a brief overview of how machine learning has recently been used to enrich the classical methods, for instance to: a) retrieve in a flexible and data-driven fashion causal impacts that are heterogeneous across units (e.g. customers, firms, locations, etc.), and, b) handle large number of observable confounders. By the end of the course, students will be able to approach problems of causal inference that are routinely considered at public and private research institutions and agencies, economic consulting companies, as well as in major technology companies and retailers. This includes the ability to set up, run, and interpret the findings of the methods learned in class. The instructor develops the theory during lectures and guides students to discover results for themselves following a teaching style termed "guided discovery," which is based on a series of hands-on applications. This course is designed for upper-lever undergraduate, or master-level, students in economics and related fields. This course is a natural companion of ECON 484 "Econometrics and Data Science".

Prerequisites: Student are required to have taken ECON 482 (or equivalent). Prior to the start of the quarter, students are encouraged to read Abadie and Cattaneo (2018)'s article "Econometric Methods for Program Evaluation", Annual Review of Economics, 10:465-503 (Link). Students are not expected to know and / or understand every detail / part of this survey article. However, the article provides an accessible and comprehensive overview of the methods covered during the course (and more). By coming back to this article at the end of the course, students should be able to recognize the value added of the course by taking note of how much their understanding has increased relative their first reading of the article. Students are also strongly encouraged to read Gentzkow and Shapiro's tutorial "Code and Data for the Social Sciences: A Practitioner's Guide" (Link) – HTML version available here, to learn how to best organize their code and their research projects.

Lecture and Discussion Sessions: The instructor holds nineteen 1 hour and 50 minute long lectures with a ten minute break midway. The TA holds ten 50 minute long lab / discussion sessions. During the discussion sessions the TA goes over problem sets (henceforth, pset) solutions, and gives students hints for upcoming psets. Students should take note of the following salient dates, cancellations, and repurposing:

First Lecture	TU April 2
First Discussion Session (R Refresher)	TU April 2
Cancelled TA Office Hours	W April 3
Repurposed TA Office Hours (Introduction to LyX and LaTeX)	TH April 4
Cancelled Lecture (Day of Midterm Exam)	TH May 9
Last Discussion Session	TU June 4
Last Lecture	TH June 6

Communications and Administration: We use Canvas at `https://apps.canvas.uw.edu/wayf` as a centralized location for posting announcements, psets, solutions to psets (when distributed), and grades. In addition, students find lecture notes and tutorials. We maintain a diary on Canvas for due dates and deadlines. We email students from Canvas exclusively to handle emergencies. Students shall check the Canvas site regularly.

Online Discussion: To foster communication and avoid duplications we use Piazza at `https://piazza.com/washington/spring2019/econ488/home`. On Piazza's discussion forum students can converse with classmates and the instructional team. The forum makes questions asked by some viewable by all - so students won't miss out on interesting topics raised by classmates. Folders are used to filter questions/comments by a particular pset or lecture. Students are strongly encouraged to use this forum *while* they work on psets, as opposed to waiting to ask questions and seek clarification during office hours. Students shall not email the instructor nor the TA with questions that can be addressed at the Piazza's discussion forum. Students shall address all questions regarding installing software (e.g. **R**, Lyx, LaTeX, see below) to the TA and make sure to use her office hours to resolve any technical issue related with using software. Technical/software problems are **not** an accepted excuse for not submitting or submitting with delay solutions to a pset.

Textbooks: The lecture notes are the main reference for the course, they are self-contained so no textbook is required. There are three recommended textbooks: 1) Wooldridge (2015) Introductory Econometrics: A Modern Approach, 6th Edition, South-Western College Publishing Company (W); 2) Angrist and Pischke (2009) Mostly Harmless Econometrics, Princeton University Press (AP09); and 3) Angrist and Pischke (2014) Mastering Metrics: The Path from Cause to Effect, Princeton University Press (AP14). The 4th edition of Wooldridge's book is acceptable and is available as a PDF file at no charge (Link). From time to time we also reference content in the following books: 1) Cameron and Trivedi (2005) Microeconometrics: Methods and Applications, Cambridge University Press (CT05); 2) Wooldridge (2010) Econometric Analysis of Cross Section and Panel Data, 2nd Edition, The MIT Press; 4) Imbens and Rubin (2015), Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction, Cambridge University Press.

Course Outline with Textbook References:

The Rubin Causal Model and RCTs	AP09 Ch2, Lecture Notes
Matching	AP09 Ch 3, Lecture Notes
Difference in Differences	W15 Ch 13-14, AP09 Ch 5, Lecture Notes
Panel Data Methods	AP09 Ch 5, Lecture Notes
Synthetic Controls	Lecture Notes
IV-2SLS and LATE	W15 Ch15-16, AP09 Ch 4, Lecture Notes
Regression Discontinuity	AP09 Ch 6, Lecture Notes
Machine Learning for Causal Inference	Lecture Notes

Statistical Software: Students must be familiar with programming in **R**. **R** is a language and environment for statistical computing and graphics. Students can download it free of charge from `https://cran.r-project.org` and install on their personal computer. Students should also install **R**-Studio Desktop available at `https://www.rstudio.com`. An old version of **R** (**R** for Windows Version 2.15.1) is available at all student computers at all research libraries (Link). The TA provides a refresher to programming in **R** during the first week of classes, in place of the weekly discussion session (see salient dates above). Students who want to catch up on **R** before the start of the quarter may start off with Emmanuel Paradis's tutorial "**R** for Beginners" (Link) and Trevor Martin's tutorial "The Undergraduate Guide to **R**" (Link). For a more hands-on approach, students may choose to take DataCamp's free "**R** Tutorial" (Link): this site provides interactive lessons that get the user write real code in minutes. Student will then want to progress to the free book "**R** for Data Science" (Link) to learn more about selected topics such as plotting, data manipulation, and fitting linear regression models. Scripting for psets must abide by the style guidelines available at `http://jef.works/R-style-guide/`.

Journal Articles: Mostly in conjunction with problem sets, students are asked to read about 4 journal articles which will be made available at the Canvas site.

Problem Sets: There are 8 psets, they test and expand upon material covered during class lectures. Pset#1 is to be submitted individually. Students are encouraged to submit 2 or 3 student group work for psets #2 through #8: one submission per group. Groups may change over time, though it may be more productive if they do not. Group work is allowed to foster cooperation amongst students. Detailed submission instructions are posted on Canvas. Late submissions are not accepted, no matter the reason. Students who want their pset re-graded must make a request in writing to the TA within 1 week upon the return of your pset. Psets are graded based on a 0 to 100 scale. The score in pset #1 is not counted towards the final grade. We understand that sometimes emergencies creep up and that a student may not be able to turn in a pset on its due date. For this reason we drop a student's lowest pset score (out of the 7 psets whose score is counted towards the final grade) calculating her total score. Psets will take quite a bit of your time and are rewarded accordingly: the weight given to the psets is **30**% (that the best 6 psets out of psets 2 through 8 each count for **5**%). If a student fails to submit a pset by the due date it automatically receives a 0 score out of 100. Typewritten answers to psets provide from 0 to 2 points to be added to the course final score as a bonus. Type-writing points are assigned in proportion to how many psets are typewritten out of 8 e.g. if a student typewrites 7 psets out of 8 she harnesses $2 \times \frac{7}{8} = 1.75$ bonus type-writing points. Thus, typewriting psets is rewarded but **not** compulsory. That is, we encourage students to typewrite answers to psets as this leads to much more professionally looking work and pushes students to acquire valuable skills. We recommend the use of LaTeXand/or the open source program Lyx as front-end for LaTeX. Students can find a tutorial for Lyx here. We provide template .TEX and .LYX files for submitting solutions to psets at the Canvas site. Students find detailed instructions concerning how to submit solutions to pset at the Canvas site (e.g. which file format to use, how to include the R scripts, and their log files, etc.). The TA provides a brief tutorial to Lyx and LaTeXduring the first week of classes, in place of the weekly office hours (see salient dates above). Due dates of psets are provided below.

Exams: The midterm is a written exam: it lasts 1 hour and 50 minutes. The final exam is a standard written exam: it lasts 2 hours . All exams are closed-book, closed-notes, no calculators, no phones, no laptops. The TA proctors both the midterm and the final exams. All exams are graded based on a 0 to 100 scale. The weights are as follows: the midterm exam's weight is **35**% and the final exam's weight is **35**%. If a student does not take the midterm exam (e.g. because they fall sick or have to travel out of the country on that day), the midterm exam's weight is **0**% and the final 's weight is **70**%.

Psets and Exam Schedule:

Pset 1	TH April 11
Pset 2	TH April 18
Pset 3	TH April 26
Pset 4	TH May 2
MIDTERM	TH May 9
Pset 5	TH May 16
Pset 6	TH May 23
Pset 7	TH May 30
Pset 8	TH June 6
FINAL	TBA (sometimes between June 8 and 14)

Make up of the Midterm and Final Exams: There is no make-up for the midterm exam. If a student does not take the midterm exam the weight associated with their final exam is **70**%, see above. A word of advice: not taking the midterm exam for reasons other than a sudden illness is highly risky because the final exam automatically carries a large weight. Requests for a make-up final exam must be accompanied by an email to the instructor and Cced to Ahna Kotila (akotila@uw.edu) that explains the grounds (e.g. health emergency) for the request and must be sent before the day of the exam.

Grading: In the Canvas folder "Scores" students find files containing statistics for psets and the midterm exam in tabular and graphical form. Both files are updated as new pets are graded. These statistics do not affect a student's grade: a student's grade is solely based on their total score, irrespective of what other students' scores are. That is, there is no grade "curve". A student's weighted sum of the scores in the best 6 psets, the midterm exam, and the final exam, plus the bonus points for type-writing psets produce a *numerical score* that ranges from 0 to 102 (where the 2 extra points come from type-writing psets (1)). The *numerical grade* is based on the following mapping from numerical scores (right) to numerical grades (left):*

0.0 (E)	< 30
0.8 (D-)	$[30, 35)$
1.0 (D)	$[35, 40)$
1.3 (D+)	$[40, 45)$
1.7 (C-)	$[45, 50)$
2.0 (C)	$[50, 55)$
2.3 (C+)	$[55, 60)$
2.7 (B-)	$[60, 65)$
3.0 (B)	$[65, 70)$
3.3 (B+)	$[70, 80)$
3.7 (A-)	$[80, 90)$
4.0 (A)	$[90, 102]$

If a student wants to withdraw from the class they have to communicate their intention to do so by the day before the final exam. An Incomplete is granted only for medical reasons as supported by a doctor's note and a justification from the student's counselor.

Students Joining the Course Late, Adding/Dropping the Course and Withdrawing: For organizational purposes we take attendance at each lecture and each lab session. Students who join the course late are recorded as absent on the day of the lecture that they have not attended. Un-submitted psets are automatically assigned a zero score. For rules and regulations about adding/dropping courses, or to withdraw from a course read the instructions at this link.

Academic Honesty: As a University of Washington student, each student the course has agreed to abide by the University's academic honesty policy. All academic work must meet the standards of conduct described in Student Governance and Policies, Chapter 209 (Link), in particular Section 5.B.1. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation.

*The equivalence scale between numerical grades and letter grades accords with `http://www.washington.edu/students/gencat/front/Grading_Sys.html`.