EMORY UNIVERSITY
QTM 110 - Fall 2020
Introduction to Research Design

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Synchronous Sessions:
Time Slots:
> Wednesday 11:20 AM - 12:35 PM
> Thursday 1:00 PM - 2:15 PM
> Thursday 9:00 PM - 10:15 PM

Virtual Group Office Hours:
> Wednesday 1:30 PM - 2:30 PM
> Wednesday 9:00 PM - 10:00 PM

Virtual Individual Office Hours:
> By appointment

Zoom Rooms:
For Synchronous Sessions: https://emory.zoom.us/j/92184741126
> Password: **Randomized**
For Office Hours: https://emory.zoom.us/j/97143015007
> Password: **Stratified**

Course Dates:
August 19th - December 3rd
> First Synchronous Sessions: August 19th - 20th
> Last Synchronous Sessions: November 18th - 19th

COURSE DESCRIPTION

QTM 110 is the first course in the sequence of requirements for the Quantitative Sciences (QSS) major; as an introductory course, there are no prerequisites. The course is designed to introduce students to the style of analytic thinking required for research and the concepts and procedures used in the conduct of empirical research. In short, this course teaches a set of skills that are essential for both understanding the research you will encounter in substantive classes, and being able to produce high-quality original research of your own. Beyond simply learning how to be a more critical participant in the academic research community, you will also be better-prepared for career opportunities using statistical tools and the products thereof. Whatever the individual career goal, students will learn the principles of critical thinking essential for drawing well-reasoned inferences from data.

The course is organized into four parts. In part one, students will be introduced to the key concept of causality. What is causality and how is it different from correlation? In part two, we examine the "gold standard" of causal inference, experimental empirical research. While an excellent tool for identifying causal empirical relationships, we cannot always use experiments to answer important empirical questions. Part three introduces the alternative, observational empirical data analysis. Critically, we discuss inferential challenges to using observational data, as well as some tools that can help overcome those challenges. Finally, the fourth part covers some topics critical to doing empirical research whether experimental or observational, including how we can use priors in empirical data analysis, and universal challenges to empirical causal inference.

TEACHING AND LEARNING DURING THE PANDEMIC

Due to the unusual nature of the semester, communication is important. I will try my very best to respond to emails and questions posted to canvas within 48 hours. There will be well over 100 students taking QTM 110 this semester. In order to facilitate efficient communication, I ask that you post questions related to material and administrative policy to Canvas and to check canvas and the syllabus before asking a question. If you have a question of a personal nature then please email me. I will likely be slower on weekends and it is usually not a great idea to ask questions on a Friday night or right before something is due.

If your situation changes regarding health, housing, or in any other regard with respect to your ability to participate in the class, please contact the appropriate Emory student support organization first and then me as soon as feasible. It is easier for me to address your needs if I know about them as soon as they arise. This does not mean I can successfully respond to every request for consideration, but I emphasize that my goal is to treat you all equitably and do what I can to help you succeed in this course.

ATTENDANCE POLICIES

This semester, due to the pandemic, some students might be sick or will need to go into isolation or quarantine. If you are sick, understand that I will be flexible about attending synchronous sessions and keeping up with work. Please make sure to email me so that we can discuss your individual circumstances. For students in quarantine who are well as long as you have the technology you need, you should not be adversely affected.

ACCESSIBILITY AND ACCOMMODATIONS

As the instructor of this course I endeavor to provide an inclusive learning environment. I want every student to succeed. The Department of Accessibility Services (DAS) works with students who have disabilities to provide reasonable accommodations. It is your responsibility to request accommodations. In order to receive consideration for reasonable accommodations, you must register with the DAS at http://accessibility.emory.edu/students/ . Accommodations cannot be retroactively applied so you need

to contact DAS as early as possible and contact me as early as possible in the semester to discuss the plan for implementation of your accommodations.

For additional information about accessibility and accommodations, please contact the Department of Accessibility Services at (404) 727-9877 or accessibility@emory.edu.

HEALTH CONSIDERATIONS

At the very first sign of not feeling well, *stay at home* and reach out for a health consultation. Please consult the campus FAQ for how to get the health consultation. As you know, Emory does contact tracing if someone has been diagnosed with COVID-19. A close contact is defined as someone you spend more than 15 minutes with, at a distance less than 6 feet, not wearing facial coverings. This typically means your roommates, for example.

CLASS SESSION RECORDINGS

Our class sessions on Zoom may be recorded, but at the moment, I am not planning on making them available unless they are needed as part of an accommodation. That may change over the semester.

Lectures and other classroom presentations presented through video conferencing and other materials posted on Canvas are for the sole purpose of educating the students enrolled in the course. The release of such information (including but not limited to directly sharing, screen capturing, or recording content) is strictly prohibited. Doing so without the permission of the instructor will be considered an Honor Code violation and may also be a violation of other state and federal laws, such as the Copyright Act.

Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image.

Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live.

Please read the Rules of Zoom Engagement for further advice on participating in our Zoom class sessions.

AN EXPLANATORY NOTE: THE ONLINE ASPECT

The online version of Introduction to Research Design will be broken into weekly asynchronous and synchronous sessions. Material is organized to help promote student learning. Weekly reading assignments will provide valuable background for the week's lesson as well as initial exposure to the key concepts and material. The asynchronous content both reinforces and expands on the reading assignments through conceptual lessons and examples. We will also use case studies that will serve as the basis of discussion for our synchronous sessions. Additionally, we are developing web-based applications to help reinforce some concepts.

Synchronous sessions will consist of a mix of case study discussion, simulations using online applications, polls, breakout exercise and live lecturing. The synchronous sessions typically will open with some general comments and a question and answer period. That will often be followed by breakout sessions to analyze a case study or to address a problem presented by the instructor. Finally, the class will reconvene and one of the breakout groups will lead off discussion.

Note: We are adding an additional 9pm meeting time for the class. This is being done for two reasons. First, this will make our synchronous sessions more engaging and personal as will we have 20-23 students rather than 30-35 students. Second, this later time will make the class easier to take for students in unfavorable times zones. Towards the second goal, students in unfavorable time zones will be given priority admission to the late session. This later extra session is being offered on entirely volunteer basis by the instructors of this course and is a significant amount of additional work.

COURSE REQUIREMENTS

IMPORTANT NOTE: All times listed on this syllabus are given in Eastern Standard Time, the time zone at Emory's campus in Atlanta, GA. Please be sure to take any time zone differences into account when submitting assignments. No special considerations will be made for missed assignments due to time zone differences - adequate time for completion of assignments will be given regardless of your time zone.

Synchronous Sessions: There will be three synchronous sessions each week: Wednesday from 11:20 AM - 12:35 PM, Thursday from 1:00 PM - 2:15 PM, and Thursday from 9:00 PM - 10:15 PM. In the first week of the course, a survey will be posted to Canvas where we will figure out everyone's preference for their assigned synchronous time. **Each student will be allowed to remain in their currently enrolled session.** For the first week of classes, please try to attend the section in which you are enrolled. I will be holding a synchronous session starting at 9:00 PM on August 20th for anyone who may be in a time zone that makes attending the first set of sessions difficult.

The synchronous sessions will assume that the week's asynchronous material has already been reviewed. We will begin each session with a short overview of the week's topic and a question and

answer session. Then, we will move into a more interactive application of each topic - case studies, discussions of potential research snags, etc. This will often occur as smaller discussions in breakout groups and I expect that everyone will attempt to contribute to the discussions. Finally, I will randomly select one group to lead off that week's discussion. Please remember to be respectful and courteous in our discussions and have some patience for any technical issues that will almost certainly occur.

Synchronous Session Etiquette/Conventions: In-person sessions will take place via Zoom and these links will be posted to Canvas. **Please only attend the session in which you are assigned after the first week - Zoom classes work best with a smaller number of students, so making sure that each session is attended by approximately 20 students will give everyone the best overall experience.** When you join the session, please make sure that your microphone is muted and only unmute when speaking - we will use the Zoom text chat to ask questions, make comments, etc. and I will try to call specific names to discuss with the rest of the class. Turn on your video, if you are comfortable. Please make sure that your Zoom name is entered as what you would like to be called (first and last name).

Asynchronous Materials: The synchronous sessions will operate on the assumptions that all students have watched the asynchronous lectures, completed the readings, and completed other materials that have been posted on Canvas for that week. After completing the asynchronous portion for the week, be sure to ask any questions in the relevant discussion thread. These threads will be used to drive the Q&A at the beginning of each synchronous session, so please contribute often.

Participation: Students are encouraged and expected to participate in the synchronous sessions. However, there will be no formal grade associated with participation.

Discussion Threads: Discussion threads will be used to post questions about class material. Direct emails to the instructor are reserved solely for questions pertinent only to that student. This policy ensures that all students benefit from instructor feedback and clarification of material, as well as allows for fruitful interaction among students around that material.

Quizzes: You will be asked to complete four quizzes for the class. Quizzes will cover material from the course and the group assignments. Quiz due dates will be noted in the schedule below and reminder notifications will be posted along with the quiz on Canvas. The lowest quiz grade will be dropped.

Group Assignments: You will complete four group assignments during the class. Each of these assignments will help you understand and apply the conceptual material. Reminders to work on group assignments are included on the syllabus. The instructor assigns a grade for the project as a whole. At the beginning of the semester students will enter a "scramble." Each student will submit their timezone and name, and then the instructor will randomly assign groups within each synchronous session based upon timezone. The lowest group assignment grade will be dropped.

Exams: In this course, you will complete two midterms and one final exam. The dates of the exams are indicated in the syllabus below. The second midterm only will cover the material since the prior midterm. The final exam will be cumulative. Each exam will be open book, open note. The exams will be

two-hour timed tests that can be taken over a 48-hour period, starting 9 AM on Wednesday and closing at 9 AM on Friday of the respective week. Midterms will not cover material from the week in which they occur.

Students are expected to adhere to the Emory Honor Code when completing all aspects of the class, including the assignments and final project.

ACTIVITY	SOFTWARE	POINTS
Quizzes	Canvas	30%
Group Problem Sets	Canvas	25%
2 Midterms	Canvas	30%
Final Exam	Canvas	15%

LATE ASSIGNMENT POLICY

You will lose 50% of the possible points for any assignment that you submit late without my explicit prior approval. If issues arise over the course of the semester, please let me know early; I understand that the current state of the world has brought about new challenges and demands for all of us. Beyond these new challenges, life happens quickly and unexpectedly. Please keep me in the loop and I will try my best to fairly adjudicate.

COURSE RESOURCES

As the semester progresses, class materials (e.g., asynchronous materials, lecture presentations, notes, readings and links to other resources) will be posted on canvas.

Required Textbooks:

Ellenberg, Jordan. 2014. How Not to Be Wrong: The Power of Mathematical Thinking. Penguin Books.

Bueno de Mesquita, Ethan and Anthony Fowler. 2019. Thinking Clearly in a Data-Driven Age. Unpublished manuscript (available on the course website) – Referenced as BDM-F below

Bueno de Mesquita, Ethan. 2014. Thinking: A Practitioner's Guide. Unpublished manuscript (available on the course website) – This is an older version of the BDM-F text, we will use it sometime as an additional optional resource. It will be referenced as BDM-2014 below

Additional readings listed in the course schedule will be provided in PDF format on the Canvas site. The readings should be completed before coming to class on the day they are listed.

If you have any special needs, please contact me at the beginning of the semester and we will discuss the necessary arrangements (see Emory's Access, Disability Services and Resources).

Logging onto Zoom for the synchronous sessions: For our synchronous sessions, please go to the Zoom link in Canvas (in the Modules section) and log in as a guest or using your emory email. You should just type your name (or preferred name). The link to zoom meeting and password will be posted on canvas. (Please view the video on using Zoom before our first synchronous session.)

Software and Technical Requirements: Information on the software we will be using and the technical requirements for the online class are located at the end of the syllabus. Please note that there are video tutorials on Canvas for each of the software packages (Zoom; Canvas).

One more important piece of information….
Canvas may be down occasionally for maintenance. Please plan ahead!

PROCEDURE FOR APPEALING A GRADE

If you believe that your grade on any assignment or exam question is incorrect or unfair, you should submit your concerns, in writing, to the professor. The written appeal should fully summarize what you believe the problems are and why. The professor and the TA responsible for the particular problem will consider your appeal. If you are not satisfied with the response, you may resubmit the assignment or question for regrading in its entirety by the professor. This grade will be final. Note that grades may go up or down during an appeal. Failure to comply with this appeal process means that you forfeit your appeal.

<u>DEADLINES</u>

All deadlines are 9pm Eastern (Atlanta time) unless otherwise noted.

Friday August 21: Submit answers to intro survey on Canvas

Monday September 7: Group Problem Set 1

Thursday September 10: Individual Quiz 1

Friday Sept 18: Group Problem Set 2

Monday September 21: Individual Quiz 2

Tuesday September 29: Midterm 1 Due by **10am** Atlanta time (!)

Friday October 16: Group Assignment 3

Monday October 19: Individual Quiz 3

Friday November 6: Group Assignment 4

Tuesday November 10: Midterm 2 Due by **10am** Atlanta time (!)

Monday November 16: Individual Quiz 4

Date of Final Exam **TBD**

Part 1: Causality

In Part 1 of this class, we introduce the concepts of correlation and causation and why they are different. We arrive at our final key definition of causation: Counterfactual Dependence and discuss limits to coherent causal questions. We then discuss fundamental mistakes in identifying causal relationships in data.

Week 0:
Read Syllabus, look over canvas website and complete survey on canvas

Week 1: T Aug 18 - F Aug 21

Course Introduction		
Day	**Task**	**Reminders**
Tu 8/18	**Read:** Syllabus and look over Canvas website	
W 8/19 - T 8/20	Synchronous Session	Please log in to Zoom via Canvas Link
W 8/19- T 8/20	**Read**: ● BDM-F, Chapter 1 ● Ellenberg, Introduction ● Lecture Notes 1 (Optional) Try (Optional): https://seeing-theory.brown.edu/	
F 8/21	**Do:** Complete Group Survey	

Learning Objectives:

● Data and Thinking.
● Example of best practices
● Course Policies

Week 2: M Aug 24 - F Aug 28

Intro to Correlation and Causation		
Day	**Task**	**Reminders**
M	**Read:** BDM-F, Chapter 2,3 Lecture Notes 2 and 3 (Optional)	**Groups Announced and Posted**
Tu	**Watch:** Module 2-0*: Some Terms Module 2-1: Intuitive Intro Module 2-2: Formalizing correlation Module 2-3: Correlation, what is good for? Module 2-4: Linearity Module 2-5: Intro to Causation Module 2-6*: Candidates for Causation Definition Module 2-7: Counterfactual Dependence Model Module 2-8: Limits to Counterfactual Dependence *Optional	
W - Th	**Attend:** Synchronous Session	
W - Th	**Try:** https://kmcalist.shinyapps.io/expvarcov/	
F	**Read:** BDM-F, Chapter 4 Lecture Notes 4 (optional)	**Group Problem Set 1 assigned**

Week 2: Learning objectives:
- Definition of correlation
- Different ways to measures correlation
- Definitions of Causation
- Basics of Prediction
- Linearity

Week 3: M Aug 31- F Sept 4

Day	Task	Reminders
Selecting on the Dependent		
M	**Watch:** Module 3-1: Correlation requires variation Module 3-2: Selecting on DV details Module 3-3: More Examples Module 3-4: Strategic Logic of Terrorism Module 3-5*: Necessary and Sufficient Conditions * *Optional	
Tu	**Review:** Case Material	
W - Th	**Attend:** Synchronous Session	
F	**Read:** BDM-F, Chapter 6 Lecture Notes 5,6 and 7 (Optional) BDM-2014, Chapter 2 (Optional)	

Week 3: Learning objectives:
- Selecting on the Dependent Variable and the problems it creates

Week 4: M Sept 7- F Sept 11

From Correlation to Causation: Bias and Noise (Part 1)		
Day	**Task**	**Reminders**
M	**Watch:** Module 4-1: Intro and Roadmap Module 4-2*: Digression on Expectations Module 4-3: A useful equation Module 4-3extra*: Where things go wrong Module 4-4: Confounding and Examples *Optional	**Group Problem Set 1 due** **Individual Quiz 1 posted**
Tu	**Review:** Case Material	
W-Th	**Attend:** Synchronous Session	
F	**Read:** BDM-F, Chapter 9 Lecture Notes 5, 6 and 7 (Optional) BDM-2014, Chapter 3 (Optional)	**Individual Quiz 1 due** **Group Problem Set 2 posted**

Week 4: Learning objectives:
- Definitions of Bias, Noise, Estimand, Estimator, Estimate
- Understand difference between precision and bias
- Confounding

Part 2: Experiments, Bias and Noise

Week 5: M Sept 14- F Sept 18

From Correlation to Causation: Bias and Noise (Part 2)		
Day	**Task**	**Reminders**
M	**Watch:** Module 4-5: ATE and Bias Module 4-6: Randomness and Omniscient Powers Module 4-7: Reverse Causation and Wrap Up * *Optional	
Tu		
W-Th	**Attend:** Synchronous Session	
F	**Read:** BDM-F, Chapter 11 Angrist and Pischke, Chapter 1 Lecture Notes 7 (Optional)	**Group Problem Set 2 due** **Individual Quiz 2 posted**

Week 5 Learning Objectives:
- Average Treatment Effect (ATE), Average Treatment Effect on Treated (ATT)
- Definitions of Confounders and Reverse Causality

Week 6: M Sept 21- F Sept 25

Experiments and Inference		
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD	**Individual Quiz 2 due**
Tu	**Try:** https://kmcalist.shinyapps.io/permutationdashboard/	
W-Th	**Attend:** Synchronous Session	
F	**Midterm 1: Distributed at 9am (2 hour window)**	**Midterm 1 Posted**

Week 6 Learning objectives:
- Learn the concepts: Randomization, Experiment, Standard Errors, Inference, Hypothesis Testing, Confidence Intervals
- Learn how experiments can be a solution to the fundamental problem of causal inference

Week 7: M Sept 28- F Oct 2

Threats to Internal and External Validity with Experiments		
Day	**Task**	**Reminders**
M	**Read:** Lecture Notes 7 (Optional)	
Tu	**Watch:** Module Breakdown TBD	**Midterm 1 must be completed by 10am Eastern**
W-Th	**Attend:** Synchronous Session	
F	**Read:** Angrist and Pischke, Chapter 2 BDM-F, Chapter 5, 10 Lecture Notes 9 (Optional)	

Week 7 Learning objectives:
- Learn the concepts: Internal Validity, External Validity
- Learn about threats to experiments and ethical considerations

Part 3: Observational Design

Frequently important research questions do not lend themselves to experimental analysis. Often researchers instead turn to observational data, data that comes from the real world. In part 2 of the class we introduce students to observational data, the workhorse regression approach to analyzing observational data, critical inferential challenges to drawing causal inferences from observational data, and methods used to overcome these challenges.

Week 8: M Oct 5 - F Oct 9

Observational Methods I: Regression, Matching and Selection on Observables		
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD	
Tu	**Review:** Case Materials on Canvas	
W - Th	**Attend:** Synchronous Session	
F	**Read:** BDM-F, Chapter 12 Lecture Notes 10 and 12 (Optional)	**Group Assignment 3 Posted**

Week 8 Learning objectives:
- Learn the concepts: Observational Data, Regression, Matching, and Selection on Observables
- Learn why comparing apples to apples is harder than it sounds

Week 9: M Oct 12 - F Oct 16

Observational Methods II: Difference in Difference and Regression Discontinuity Design		
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD	
Tu	**Review:** Case Materials on Canvas	
W - Th	**Attend:** Synchronous Session	
F	**Read:** Lecture Notes 11 and 12	**Group Assignment 3 due** **Individual Quiz 3 goes live**

Week 9 Learning objectives:
- Learn the concepts: Difference-in-Difference, credibility, within unit change, parallel trends
  - When Diff-in-diff is unbiased vs biased.
- Learn the concepts: natural and quasi-experiments, Instrumental variables, regression discontinuity design

Week 10: M Oct 19- F Oct 23

Observational Methods III: Regression Discontinuity Design and Instrumental Variables		
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD	**Individual Quiz 3 Due**
Tu	**Review:** Case Material	
W - Th	**Attend:** Synchronous Session	
F	**Read:** BDM-F, Chapter 7 Ellenberg, Chapters 6, 7 and 9 Lecture Notes 13 (Optional)	

Week 10 Learning objectives:
- Learn the concepts: natural and quasi-experiments, Instrumental variables, regression discontinuity design
- Definitions: Noncompliance, exclusion restriction, Wald estimator, Continuity, LATE

Part 4: Further topics in empirical research

The fourth section covers further topics useful for many types of empirical research, whether experimental or observational, as well as for being an informed consumer of research .

Week 11: M Oct 26- F Oct 30

Reporting Bias, Multiple Testing and Misinterpreting Outliers		
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD	
Tu	**Review:** Case Material	
W - Th	**Attend:** Synchronous Session	
F	**Read:** Ellenberg, Chapter 10 BDM-F, Chapter 14 Lecture Notes 14 (Optional)	**Group Assignment 4 Posted**

Week 11 Learning objectives:
- Learn the concepts: multiple testing, p-hacking, p-screening, file drawer problem
- Problem of relying on outliers.

Week 12: M Nov 2- F Nov 6

Bayesian Inference	
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD	
Tu	**Review:** Case Material	
W- Th	**Attend:** Synchronous Session	
F	**Midterm 2: Distributed at 9am (2 hour window)**	**Group Assignment 4 Due** **Midterm 2 Posted**

Week 12 Learning objectives:
- Learn the concepts: Bayes Rule, Priors, Posteriors, Base Rates
- Learn how to use Bayes Rule and learn how to interpret base rates correctly

Week 13: M Nov 9- F Nov 13

Signal to Noise and Prediction		
Day	**Task**	**Reminders**
M	**Read:** Ellenberg, Chapter 14 and 15 Lecture Notes 15 (Optional)	
Tu	**Watch:** Module Breakdown TBD	**Midterm 2 must be completed by 10am Eastern**
W - Th	**Attend:** Synchronous Session	
F	**Read:** BDM-2014, Chapter 4 Lecture Notes 16	**Individual Quiz 4 goes live**

Week 13 Learning objectives:
- Learn the concepts: Regression to the Mean, Signal to Noise

Week 14: M Nov 16- F Nov 20

Adaptation and Prediction Wrap-up		
Day	**Task**	**Reminders**
M	**Watch:** Module Breakdown TBD Perils of Quantification Lecture	**Individual Quiz 4 Due**
Tu		
W - Th	**Attend:** Synchronous Session	
F		

Week 14 Learning objectives:
- Learn the concepts: Prediction, Adaptation
- Definitions: deep parameter, equilibrium behavior, studying the wrong outcomes, adaptation driven bias

"Week 15"

During this week and possibly over break I will be holding additional office hours and optional review sessions. More to follow.