

QTM 510: Reasoning I

Contact Hours: Two 1.25-hour or one 2.5-hour session weekly, plus 4.5 hours of regular, out-of-class work required as preparation for in-class work

Credit Hours: 3

Prerequisites: None

| | |
|-------------------------|-----------|
| Instructor: | Xxx |
| Semester | Fall 20xx |
| Meeting Time and Place: | xxx |
| Office: | xxx |
| Office Hours: | xxx |
| Email/Contact: | xxx |
| Course Website: | xxx |
| TA: | xxx |

COURSE OBJECTIVES

This class will provide a logical and intuitive introduction to quantitative analysis from first principles. Much of the class is devoted to learning about causal effects from data and answering questions from observational and experimental data. The course provides an introduction to critical, quantitative thinking in general and an introduction to basic decision theory. Students will be introduced to the basic toolkit of quantitative analysis including sampling, hypothesis testing, Bayesian inference, regression, experiments, instrumental variables, differences in differences, and regression discontinuity. The course takes a critical approach emphasizing limits and ethical considerations when discussing techniques. The course is designed to be taken simultaneously with QTM 520 and QTM 530 where students will also learn how to use a statistical software program to organize and analyze data and how to apply the techniques here in statistical models. More importantly, students will learn the principles of critical thinking essential for careful and credible policy analysis.

CLASS REQUIREMENTS

Grades will be based on

- homework assignments (25 %)
- 2 midterm exams (20 % each)
- a final exam (30 %)
- Class Participation (5%)

HOMEWORK

The homework assignments will consist of 2 analytical problem sets and 2 writing-based problem sets. Each assignment will have its due date indicated and should be submitted through Canvas. Usually it would be due before the class (11:30 am). Any assignment submitted after the due date/time will be considered 0 points. To accommodate unexpected circumstances, your lowest homework grade will be automatically dropped at the end of the semester. Working together on the homework assignments is encouraged, but you must write your own answers. It is highly recommended that you make your solo effort on all the problems before consulting others.

Problem Set 1: Writing Assignment

Identify one recent case where a claim is made about a correlation but there is no variation in either the dependent or independent variable. It should come from a news article, academic article, or related source and it should not be any of the examples discussed in class or in the readings. Summarize the argument made and discuss the inferential problem. What alternative analysis could the author have conducted instead to make a more informative comparison? Your write-up should be less than 1,000 words.

Problem Set 2: Analytic Problem Set

Problem Set 3: Writing Assignment

We will discuss why comparisons and correlations may not be informative about causal relationships. Find an example of a researcher, journalist, policymaker, etc. who makes an error by wrongly interpreting a correlation as causal. As before, your example should not be closely related to any example discussed in class or in the readings. Explain the evidence presented, and explain why you think this correlation is not informative about the effect of interest. Furthermore, propose an alternative research design that would provide more credible causal evidence on this particular question. Your proposed design should be feasible, meaning that a real researcher or organization with resources (but not endless resources) could actually implement it. Again, your write-up should be no more than 1,000 words.

EXAMS

The 2 midterms and the final will be in-class exams. **No collaboration is allowed on the exams.**

Important Dates

Problem Set 1: Week 3

Midterm 1: Week 5

Problem Set 2: Week 7

Midterm 2: Week 10

Problem Set 3: Week 11

Problem Set 4: Week 15

Final: TBD

HONOR CODE

All students enrolled at Emory are expected to abide by the Emory College Honor Code. Any type of academic misconduct is not allowed which includes 1) receiving or giving information about the content or conduct of an examination knowing that the release of such information is not allowed and 2) plagiarizing, whether intentionally or unintentionally, in any assignment. For the activities that are considered to be academically dishonest, refer to the Honor Code: <http://catalog.college.emory.edu/academic/policies-regulations/honor-code.html>.

DISABILITY ACCOMMODATIONS

If you are seeking classroom accommodations or academic adjustments under the Americans with Disabilities Act, you are required to register with Office of Accessibility Services (<http://accessibility.emory.edu>). To receive academic accommodations for this class, please obtain the relevant letter and meet with me at the beginning of the semester. Students are expected to give two weeks notice of the need for accommodations.

REQUIRED TEXTBOOK

- [P] Page, Scott. The Model Thinker, Basic Books [W]
- [BDM-F] Bueno de Mesquita, Ethan and Anthony Fowler. Thinking Clearly in a Data-Driven World. Book manuscript
- [MM] Angrist, Joshua D. and Jörn-Steffen Pischke. 2014. Mastering ‘Metrics: The Path from Cause to Effect. Princeton University Press.
- [PMT] Ellenberg, Jordan. 2014. How Not to Be Wrong: The Power of Mathematical Thinking. Penguin Books.

SUPPLEMENTAL TEXTBOOK

- [MHE] Joshua D. Angrist and Jörn-Steffen Pischke, Mostly Harmless Econometrics, Princeton University Press
- As indicated on syllabus. Available on Canvas.

Part 1: Fundamentals of Data Informed Decisions

Week 1

Topics:

Logic

- Necessary and Sufficient Conditions
- Implications

Description

- Correlation
- Sample Statistics
- Prediction
- Bias-Variance Trade-off
- Overfitting
- Limits to Prediction for Decision Making Decision Theory

Measurement

- Scales
- Reliability and Validity
- Quantification and Normative Values [Ethics Component]

Reading:

[BDM-F], Chapter 1, 2 and 3

[P], Intro, Chapter 1 and 4

*[MM] Angrist and Pischke, Introduction

*[PMT] Ellenberg, Introduction (When Am I Going to Use This?). Chapter 1 and 2

Case Study: Value of Statistical Life

Banzhaf, H. Spencer. "Retrospectives: the Cold-War origins of the value of statistical life." *Journal of Economic Perspectives* 28, no. 4 (2014): 213-26.

León, Gianmarco, and Edward Miguel. "Risky transportation choices and the value of a statistical life." *American Economic Journal: Applied Economics* 9, no. 1 (2017): 202-28.

Week 2

Topics:

Signal and Noise (First Look)

- Reversion to the mean
- Variation
 - Selecting on Dependent

Causal Inference

- Definition of Causality
- Neyman-Rubin Model
- Fundamental Problem of Causal Inference
- Answerable and Non-Answerable Questions [Ethics Component]

Reading:

[BDM-F], Chapter 3, 4, 5 8

[P], Chapter 15

Case Study: Skill versus Luck [Ethics Component]

Selections from: Frank, Robert H. *Success and luck: Good fortune and the myth of meritocracy*. Princeton University Press, 2016.

Watts, D.J., 2017. Should social science be more solution-oriented?. *Nature Human Behaviour*, 1(1), p.0015

Part 2: Threats to Causal Inference

Week 3

Topics:

Confounding

- Common cause confounding
- Confounding versus noise
- Complex confounding

Reverse Causality

- Cross sectional models
- Longitudinal models

Reading:

[BDM-F], Chapter 9 and 10

Selections from: Pearl, Judea. *Causality*. Cambridge university press, 2009.

Selections from: Pearl, Judea, and Dana Mackenzie. *The book of why: the new science of cause and effect*. Basic Books, 2018.

Part 3 Research Methods

Week 4 and 5

Topics:

Experiments

- Bernoulli and completely randomized designs
- Clustered treatment assignment
- Blocked randomized designs

Threats to Experiments:

- Non-Compliance and Instrumental Variables
- Interference
- Attrition

Ethics of Experiments [Ethics Component]

- Internal and External Validity
- Cost
- Compassionate Use
- Deception
- Informed Consent
- Omission/Commission

Reading:

[BDM-F], Chapter 11

[MM] Chapter 1 and 3

Selections from: Gerber, Alan S., and Donald P. Green. *Field experiments: Design, analysis, and interpretation*. WW Norton, 2012.

Case Study: Moving to Opportunity Program [Ethics Component]

All Read/Listen to:

Planet Money: Moving To Opportunity?

<https://www.npr.org/2019/09/06/758426760/planet-money-moving-to-opportunity>

Groups Assigned to read one of the following:

Leventhal, Tama, and Jeanne Brooks-Gunn. "Moving to opportunity: an experimental study of neighborhood effects on mental health." *American journal of public health* 93, no. 9 (2003): 1576-1582.

Sanbonmatsu, Lisa, Lawrence F. Katz, Jens Ludwig, Lisa A. Gennetian, Greg J. Duncan, Ronald C. Kessler, Emma K. Adam, Thomas McDade, and Stacy T. Lindau. "Moving to opportunity for fair housing demonstration program: Final impacts evaluation." (2011).

Katz, Lawrence F., Jeffrey R. Kling, and Jeffrey B. Liebman. "Moving to opportunity in Boston: Early results of a randomized mobility experiment." *The Quarterly Journal of Economics* 116, no. 2 (2001): 607-654.

Chetty, Raj, Nathaniel Hendren, and Lawrence F. Katz. "The effects of exposure to better neighborhoods on children: New evidence from the Moving to Opportunity experiment." *American Economic Review* 106, no. 4 (2016): 855-902.

Week 6 and 7

Topics:

Regression and Matching

- Interpreting Regression
- Selection on observables
- Saturated models
- Regression in unsaturated models
- Matching in unsaturated models

Reading:

[BDM-F] Chapter 9 and 10

[P] Chapter 6

[MM] Chapter 2

Week 8 and 9

Topics:

Difference in Difference

- Cross sectional versus time series comparison
- Parallel trends
- Linear models
- Nonlinear models

Regression Discontinuity Design

- Linear RDD
- Nonlinear RDD
- Fuzzy RDD

Reading:

[BDM-F] Chapter 12

[MM] Chapter 4 and 5

Part 4: Learning and Interpreting

Week 10 and 11

Topics:

Hypothesis Testing and Multiple Testing

- Exploratory Analysis
- Testing Theories
- Analytic versus Computational Methods
- Multiple Testing and Adjustment [Ethics Component]
- P-Hacking and Forking Paths [Ethics Component]

Reading:

[BDM-F], Chapter 6, 7

[PMT] Chapter 6,7 and 9

[P] Chapter 26

Case Study: Replication Crisis in Psychology [Ethics Component]

Groups assigned to read two of the following:

Munafò, Marcus R., Brian A. Nosek, Dorothy VM Bishop, Katherine S. Button, Christopher D. Chambers, Nathalie Percie Du Sert, Uri Simonsohn, Eric-Jan Wagenmakers, Jennifer J. Ware, and John PA Ioannidis.

"A manifesto for reproducible science." *Nature human behaviour* 1, no. 1 (2017): 1-9.

Button, Katherine S., John PA Ioannidis, Claire Mokrysz, Brian A. Nosek, Jonathan Flint, Emma SJ Robinson, and Marcus R. Munafò. "Power failure: why small sample size undermines the reliability of neuroscience." *Nature Reviews Neuroscience* 14, no. 5 (2013): 365-376.

Simonsohn, Uri, Leif D. Nelson, and Joseph P. Simmons. "P-curve: a key to the file-drawer." *Journal of experimental psychology: General* 143, no. 2 (2014): 534.

Miguel, Edward, Colin Camerer, Katherine Casey, Joshua Cohen, Kevin M. Esterling, Alan Gerber, Rachel Glennerster et al. "Promoting transparency in social science research." *Science* 343, no. 6166 (2014): 30-31.

Ioannidis, John PA. "Why most published research findings are false." *PLoS med* 2, no. 8 (2005): e124.

Week 12

Topics:

Signal to Noise Revisited

- Internal versus External Validity and Bias
- Regression to Mean
- Hard and Easy Prediction Problems
- Feedback Loops
- Machine Learning for Prediction
- Manipulation and Adaption

Reading:

[BDM-F], Chapter 8

[P] Chapter 12

Selections from:

Silver, Nate. *The signal and the noise: why so many predictions fail--but some don't*. Penguin, 2012.

Mauboussin, M.J., 2012. *The success equation: Untangling skill and luck in business, sports, and investing*.
Harvard Business Review Press.

Week 12

Topics:

Bayesian Reasoning

- Bayes Rule
- Beta priors for binomial distributions
- False Positives and False Negatives
- Base Rates
- Prior Elicitation

Reading:

[BDM-F], Chapter 14

[PMT] Chapter 10

Part 5: The problems of Datafication

Week 13 and 14

Topics:

Quantifiable versus non-quantifiable Problems [Ethics Component]

- Measurement scales
- Uniqueness and meaningfulness

Normative Standards [Ethics Component]

- Loss functions
- Risk
- Bounding
- Advice

Reading:

[BDM-F], Chapter 14, 15 and 16

[PMT] Chapter 4-5

Week 15: Catch-up and Review