

**Institute of Service Science, College of Technology Management,  
National Tsing Hua University**

**Course Syllabus  
Experiments and Causal Inference**

*Course Duration:* Feb 2023 – Jul 2023

*Class Time:* Thursday, 14:20 pm- 17:20 pm

*Classroom:* TSMC Bldg. R406

*Instructor:* Jaewon Yoo ([jaewon.yoo@iss.nthu.edu.tw](mailto:jaewon.yoo@iss.nthu.edu.tw))

*TA:* Yi-Chun (Jean) Liu ([jean.liu@gapp.nthu.edu.tw](mailto:jean.liu@gapp.nthu.edu.tw))

**COURSE DESCRIPTION:**

This course introduces experimental methods for causal inference that are widely used in a broad array of domains such as marketing and information systems. The focus of the course is on delivering a breadth of substantive topics and methodological considerations that emerge in utilizing the identification-oriented methods. Throughout the course, we will discuss topics that are related to methods such as randomized controlled trials (RCT), difference-in-differences (DiD), matching methods such as propensity score matching (PSM) and coarsened exact matching (CEM), and more advanced topics such as regression discontinuity designs (RDD) and synthetic control methods (SCM). To foster learning experiences, students will review relevant research papers on each topic and be asked to actively engage in presentations and discussions about the nature of causation and alternative means of inferring causal relationships.

Students will also carry out a collaborative group project for which they will design an experiment and associated plan of analysis in an attempt to draw business insights. Leading tech companies such as Netflix, Microsoft, and Amazon are growingly paying attention to the importance of business experimentation and causal inference to enhance their decision making, and are hiring employees that are equipped with such analytical tools/mindsets (e.g., watch [a recent video](#) highlighting this by causal inference science team at Netflix). In line with this growing trend, this course also caters to those that are interested in joining the industry after graduation with one condition: a willingness to work hard on possibly unfamiliar materials.

**COURSE GOALS:**

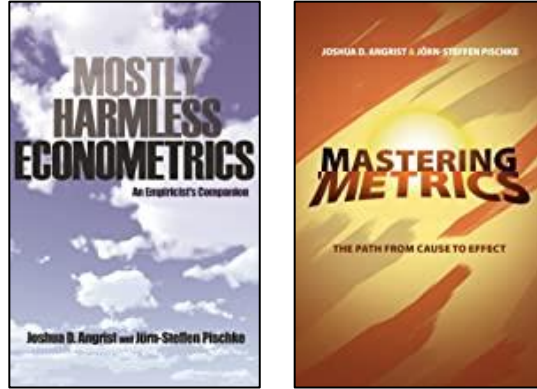
- Learn how to determine which methods and results best support empirical inference questions.
- Be familiar with causal inference methods that are widely used for business analytics.
- Understand the trade-offs in the design, analysis, and reporting of field/quasi/natural experiment methods.

**PREREQUISITES:**

- **Math:** undergraduate-level probability and statistics; some experiences with regression analysis/econometrics will be helpful.
- **Programming:** Knowledge of statistical programming (e.g., R and Python)

**TEXTBOOK:**

1. **[TX1] Mostly Harmless Econometrics: an empiricist's companion** by J. D. Angrist and Jorn-Steffen Pischke, Princeton University Press, 2008.
2. **[TX2] Mastering 'metrics: The path from cause to effect** by J. D. Angrist and Jorn-Steffen Pischke, Princeton University Press, 2015.



Students can choose to purchase either the hard copy or the e-book for both textbooks 1 and 2, but please be prepared to have the textbooks ready before the beginning of the semester. Students can order the hard copy textbooks directly at <https://bookdepository.com/> (provides free shipping worldwide). Be aware that it might take time for the textbooks to be delivered so if you plan to take the course, please make sure to place your order early enough so the books arrive in time.

**OTHER RECOMMENDED BOOKS:**

The following books are optional but may prove useful for additional coverage of some of the course topics.

- Imbens, Guido W., and Donald B. Rubin. 2015. Causal Inference for Statistics, Social, and Biomedical Sciences. Cambridge University Press.
- Cunningham, S. Causal Inference: The Mixtape. Yale University Press, 2021.
- Hernán, Miguel A., and James M. Robins. 2020. Causal inference: What If. CRC Press. Taylor and Francis Group. (Opensource PDF version provided by the authors [here.](#))
- Morgan, Stephen L., and Christopher Winship. 2015. Counterfactuals and Causal Inference, Second Edition. Cambridge University Press.
- Pearl, Judea. 2000. Causality: Models, Reasoning, and Inference. New York: Cambridge University Press.
- Wooldridge, Jeffrey M. 2010. Econometric Analysis of Cross Section and Panel Data, Second Edition. MIT Press.

**COURSE EVALUATION:**

**Grading Policy**

Project Reports & Presentation (Peer-reviewed)	45%
Journal Article Review	35%
Attitude/Participation	10%
Attendance	10%
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Total	100%

## Course Requirements

1. **Academic Honesty and Plagiarism\*:** All work submitted for academic evaluation must be the student's own. The penalty for violation of academic integrity will result in a zero for that assignment for the first time. Subsequent violation(s) will result in a failing grade for the course. Plagiarism will also not be tolerated.

Academic dishonesty comprises of, but is not limited to, the following:

- Cheating: Copying from other students' quizzes and assignments or allowing others to copy from one's own.
- Plagiarism: Using other people's original work without giving appropriate credit or acknowledgment to the authors or sources.
- Self-plagiarism: Submitting a piece of work in more than one course without the explicit permission of the instructors involved.
- Misrepresentation of authorship: Submitting work as one's own, which has been prepared by or purchased from others.

Students will be asked to upload their submission materials to Turnitin.com, an online plagiarism checker, to ensure academic integrity. Read more about online submission on <http://learning.site.nthu.edu.tw/p/412-1319-7120.php?Lang=en>.

2. **Attendance:** All students are expected to attend every class. Please bring your own hard copy of the course materials, which will be distributed by the instructor before class. If you have any urgent reason to miss a class, you are still responsible for the materials covered during the class and are expected to complete the required work. Attendance will be taken on a regular basis and will count towards your participation score (10%). Class missing will cause about 1% loss of final grade. Students who miss a class should inform me or the TA prior to the class via email or phone call.
3. **Attitude/Participation:** In class, the most important thing for the students is to stay active and engaged about the topic being discussed. Positive contributions to class discussions will increase your score towards attitude. When we discuss a topic in class, effective discussions are only possible if everyone is well prepared. Please, be prepared to open and engage in discussions with your opinions and thoughts.
4. **Journal Article Review**
  - a. **One-Page Summaries:** Before class starts, every student should submit 1-page summary of the assigned papers which will be discussed in class. A guideline will be distributed for students to use when summarizing the papers.
  - b. **Paper Introduction Presentations (Peer-Reviewed):** Throughout the semester, students will be reading academic publications/papers that utilize different causal inference methods. Students will be asked to present the papers they reviewed each week (reading list will be distributed) by taking turns. The contents to be necessarily included are the value of the topic and motivational story. Other audience should also read the paper prior to the class for discussion. The presentations will be peer-reviewed.
5. **Student Projects:** In lieu of a final exam, this course requires students to write a short paper applying or extending the causal inference methods we learn in this class. It should be no longer than 20 double-spaced pages and focus on the research design, data, methodology, results, and analysis. Co-authored projects are strongly encouraged and working as an individual requires

approval. Working with collaborators will be the cornerstone of your career from now on, so it's crucial to get to know this process sooner rather than later.

- a. **Progress Report & Project Presentation (Peer-Reviewed):** Students will generate a potential research idea based on what we will discuss and suggest how to collect data and what causal inference methods/models can be used to carry out the research. The final project presentation will be peer-reviewed.

Here is a brief timetable for the projects:

- b. **By Week 2:** Find a collaborator or obtain permission from the instructor to work on an individual project.
- c. **By Week 5:** Submit a short (half-page) description of your proposed project and a feasible plan for carrying out the research.
- d. **By Week 10:** Submit a brief (no longer than 5 page) page memo of your main results, including tables, figures, and brief analysis. For methodological projects, this should include a description of the method and any analytical/simulation results. You will be required to give feedback on another group's project, which will be counted toward the overall grade based on attentiveness and usefulness of the feedback provided.
- e. **By Week 18:** Submit your final version of the project.

**COURSE SCHEDULE:**

Week	Topics
1	<p><b>Introduction to Causal Inference:</b> Potential outcomes and the fundamental problem of causal inference.</p> <p>Group forming &amp; Ice breaking activities.</p>
2	<p><b>Randomization Inference:</b> Randomized experiments and Fisher's approach to inference.</p> <p><u>Find a collaborator for the group project.</u></p>
3	<p><b>Inference for the Average Treatment Effect:</b> Neyman's approach to inference for the ATE. Sampling variance and confidence intervals.</p> <p><u>Students' Paper Introduction Presentations: 1.1. and 1.2.</u></p>
4	<p><b>Linear Regression and Randomized Experiments:</b> Simple linear regression in experiments. Covariate adjustment in experiments with regression.</p> <p><u>Students' Paper Introduction Presentations: 1.3. and 1.4.</u></p>

5	<p>In-Class Group Project Meetings (30 minutes per group): The purpose of the meetings is to help each group materialize their ideas/topics for the group project.</p> <p><u>Submit a half-page description of your proposed project &amp; plan.</u></p>
6	<p><b>Observational Studies I:</b> Selection on observables. Regression for observational data.</p>
7	<p><b>Observational Studies II:</b> DAGs and the back-door criterion.</p> <p><u>Construct a DAG for your own research project!</u></p>
8	<p><b>Observational Studies III:</b> Sensitivity analysis</p> <p><b>Instrumental Variables I:</b> Noncompliance in randomized experiments. Instrumental variables in observational studies.</p> <p><u>Students' Paper Introduction Presentations: 2.1. and 2.2.</u></p>
9	<p><b>Instrumental Variables II:</b> Two-stage least squares. Review of IV applications.</p> <p><u>Submit a progress report.</u> <u>Students' Paper Introduction Presentations: 2.3. and 2.4.</u></p>
10	<p><b>Panel Data, Fixed Effects, and Difference-in-Differences:</b> Fixed effects and first differences. Difference-in-differences.</p> <p><u>Students' Paper Introduction Presentations: 3.1. and 3.2.</u></p>
11	<p><b>Difference-in-Differences Cont.:</b> Applications of difference-in-differences.</p> <p><u>Students' Paper Introduction Presentations: 3.3. and 3.4.</u></p>
12	<p><b>Matching and Weighting Estimators:</b> Propensity scores, matching, and weighting.</p> <p><u>Students' Paper Introduction Presentations: 4.1. and 4.2.</u></p>

13	<p><b>Regression Discontinuity Designs:</b>  Sharp RD designs, identification.  Estimation and bandwidth selection.</p> <p><u>Students' Paper Introduction Presentations: 4.3. and 4.4.</u></p>
14	<p><b>Regression Discontinuity Designs Cont.:</b>  Fuzzy RD designs.  Applications of RDDs.</p> <p><u>Students' Paper Introduction Presentations: 5.1. and 5.2.</u></p>
15	<p><i>(No Class)</i> Preparation for Group Presentations:  Please meet individually with your group members to prepare a draft of the final presentation. As you do this, please also try to come up with questions you would like to have answered during our meeting on Week 16.</p>
16	<p>In-Class Group Meetings:  Q&amp;A regarding group presentations for each group</p> <p><u>Students' Paper Introduction Presentations: 5.3. and 5.4.</u></p>
17	<p><b>Final Group Project Presentations (I)</b></p>
18	<p><b>Final Group Project Presentations (II)</b></p> <p><u>Submit a final project report.</u></p>

*Notes:* The course schedule is **subject to change if necessary.**

## READING ASSIGNMENTS:

### 1. Reading Materials for Field Experiments:

- 1) *Chapter 2. The Experimental Ideal* in Joshua D. Angrist & Jörn-Steffen Pischke, 2009. "Mostly Harmless Econometrics: An Empiricist's Companion," Economics Books, Princeton University Press, edition 1, number 8769.
- 2) Elisa Montaguti, Scott A. Neslin, Sara Valentini (2016) Can Marketing Campaigns Induce Multichannel Buying and More Profitable Customers? A Field Experiment. *Marketing Science* 35(2):201-217.
- 3) Navdeep S. Sahni, Dan Zou, Pradeep K. Chintagunta (2017) Do Targeted Discount Offers Serve as Advertising? Evidence from 70 Field Experiments. *Management Science* 63(8):2688-2705.
- 4) Bapna, Ravi, Jui Ramaprasad, Galit Shmueli, and Akhmed Umyarov. "One-way mirrors in online dating: A randomized field experiment." *Management Science* 62, no. 11 (2016): 3100-3122.

- 5) *Chapter 1. Experiments and Generalized Causal Inference* in Cook, Thomas D., Donald Thomas Campbell, and William Shadish. *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin, 2002.

## 2. Reading Materials for Instrumental Variables (IVs):

- 1) *Chapter 4. Instrumental Variables in Action: Sometimes You Get What You Need* in Joshua D. Angrist & Jörn-Steffen Pischke, 2009. "Mostly Harmless Econometrics: An Empiricist's Companion," Economics Books, Princeton University Press, edition 1, number 8769.
- 2) Angrist, Imbens, G. W., & Rubin, D. B. (1996). Identification of Causal Effects Using Instrumental Variables. *Journal of the American Statistical Association*, 91(434), 444–455.
- 3) Florian Zettelmeyer, Fiona Scott Morton, & Jorge Silva-Risso. (2006). How the Internet Lowers Prices: Evidence from Matched Survey and Automobile Transaction Data. *Journal of Marketing Research*, 43(2), 168–181.
- 4) Dewan S, Ramaprasad J (2012) Research Note—Music Blogging, Online Sampling, and the Long Tail. *Inf. Syst. Res.* 23(3-part-2):1056–1067.
- 5) Barron, Kyle, Edward Kung, and Davide Proserpio. "The effect of home-sharing on house prices and rents: Evidence from Airbnb." *Marketing Science* 40.1 (2021): 23-47.

## 3. Reading Materials for Difference in Differences (DiD):

- 1) *Chapter 5. Parallel Worlds: Fixed Effects, Difference-in-Differences, and Panel Data* in Joshua D. Angrist & Jörn-Steffen Pischke, 2009. "Mostly Harmless Econometrics: An Empiricist's Companion," Economics Books, Princeton University Press, edition 1, number 8769.
- 2) Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. "How much should we trust differences-in-differences estimates?" *The Quarterly journal of economics* 119.1 (2004): 249-275.
- 3) Dranove, David, et al. "Is more information better? The effects of "report cards" on health care providers." *Journal of political Economy* 111.3 (2003): 555-588.
- 4) Goldfarb, Avi, and Catherine E. Tucker. "Conducting research with quasi-experiments: A guide for marketers." *Rotman School of Management Working Paper 2420920* (2014).
- 5) Foerderer, Jens, Nele Lueker, and Armin Heinzl. "And the Winner Is...? The Desirable and Undesirable Effects of Platform Awards." *Information Systems Research* 32, no. 4 (2021): 1155-1172.

## 4. Reading Materials for Matching Methods:

- 1) Gordon, Brett R., et al. "A comparison of approaches to advertising measurement: Evidence from big field experiments at Facebook." *Marketing Science* 38.2 (2019): 193-225.
- 2) Xu, Kaiquan, Jason Chan, Anindya Ghose, and Sang Pil Han. "Battle of the channels: The impact of tablets on digital commerce." *Management Science* 63, no. 5 (2017): 1469-1492.

- 3) Adamopoulos, Panagiotis, Vilma Todri, and Anindya Ghose. "Demand effects of the Internet-of-things sales channel: Evidence from automating the purchase process." *Information Systems Research* 32.1 (2020): 238-267.
- 4) Kim, Jun Hyung, et al. "Home-tutoring services assisted with technology: Investigating the role of artificial intelligence using a randomized field experiment." *Journal of Marketing Research* (2021): 00222437211050351.
- 5) Son, Yoonseock, Wonseok Oh, Sang Pil Han, and Sungho Park. "When loyalty goes mobile: Effects of mobile loyalty apps on purchase, redemption, and competition." *Information Systems Research* 31, no. 3 (2020): 835-847.

### 5. Reading Materials for Regression Discontinuity Design (RDD):

- 1) *Chapter 6. Getting a Little Jumpy: Regression Discontinuity Designs* in Joshua D. Angrist & Jörn-Steffen Pischke, 2009. "Mostly Harmless Econometrics: An Empiricist's Companion," Economics Books, Princeton University Press, edition 1, number 8769.
- 2) Caroline Flammer (2015) Does Corporate Social Responsibility Lead to Superior Financial Performance? A Regression Discontinuity Approach. *Management Science* 61(11):2549-2568.
- 3) Wesley Hartmann, Harikesh S. Nair, Sridhar Narayanan, (2011) Identifying Causal Marketing Mix Effects Using a Regression Discontinuity Design. *Marketing Science* 30(6):1079-1097.
- 4) Jo, Wooyong, et al. "Protecting consumers from themselves: Assessing consequences of usage restriction laws on online game usage and spending." *Marketing Science* 39.1 (2020): 117-133.
- 5) Flammer, Caroline, and Pratima Bansal. "Does a long-term orientation create value? Evidence from a regression discontinuity." *Strategic Management Journal* 38, no. 9 (2017): 1827-1847.

### **ADDITIONAL READING MATERIALS:**

- Holland, Paul W. "Statistics and causal inference." *Journal of the American statistical Association* 81, no. 396 (1986): 945-960.
- Lin, Winston. "Agnostic notes on regression adjustments to experimental data: Reexamining Freedman's critique." *The Annals of Applied Statistics* 7, no. 1 (2013): 295-318.
- Freedman, David A. "On regression adjustments to experimental data." *Advances in Applied Mathematics* 40, no. 2 (2008): 180-193.
- Stuart, Elizabeth A. "Matching methods for causal inference: A review and a look forward." *Statistical science: a review journal of the Institute of Mathematical Statistics* 25, no. 1 (2010): 1-21.
- Imai, Kosuke, and In Song Kim. "When should we use unit fixed effects regression models for causal inference with longitudinal data?" *American Journal of Political Science* 63, no. 2 (2019): 467-490.
- Baker, Andrew C., David F. Larcker, and Charles CY Wang. "How much should we trust staggered difference-in-differences estimates?" *Journal of Financial Economics* 144, no. 2 (2022): 370-395.