Modern Sampling Methods: Design and Inference

Draft Syllabus (last updated: December 8, 2021)

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Course Description:

The way that data are collected can have important implications for their subsequent use in model estimation and evaluation, parameter inference, and policy choice. Complex experimental schemes are gaining increasing interest in economics and many other fields. In this course we examine the interplay between data design, and statistical inference and decisions. We will examine classic sampling and experimental designs, but also alternatives such as adaptive randomization designs and multi-armed bandits which raise the possibility of improving inference and decisions at lower cost. Some key themes we will examine include: the connection between design and identification; statistical efficiency considerations; and alternative objectives for data analysis beyond point estimation and classical statistical inference.

Outline of Topics:

1. Introduction: Examples and Key Issues; Random Samples for Population Inference
2. Randomized Experiments
3. Publication Bias and Preanalysis Plans
4. Treatment and Policy Choice
5. Multi-Wave Experiments
6. Covariate-Adaptive Randomization
7. Bandit Algorithms and Response-Adaptive Experiments
8. Applications of Bandits and Adaptive Designs
9. Statistical Inference with Adaptively Generated Data
10. Window Choice in Time Series

Topics and Readings:

Especially useful readings, recommended to read before the lecture, are marked with a "*". Additional references and readings will be added as this syllabus is revised.

1. Examples and Background

2. Randomized Experiments

   - Athey, S., and Imbens, G. W., (2017), "The Econometrics of Randomized Experiments," in *Handbook of Economic Field Experiments*, Volume 1, Elsevier.

   * Imbens, G. W., and Rubin, Donald B., (2015), *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction*, Cambridge University Press. (Ch. 4-6.)

   - Rosenberger, W. F., and Lachin, J. M., (2016), *Randomization in Clinical Trials*, 2nd ed., Wiley. (Ch. 2,3,6,7.)

   - Rubin, D. B., (2008), "For Objective Causal Inference, Design Trumps Analysis," *The Annals of Applied Statistics* 2(3), 808-840.

   * Holland, P. W., (1986), "Statistics and Causal Inference" (with comments and rejoinder), *Journal of the American Statistical Association* 81: 945-970.

3. Publication Bias and Preanalysis Plans

   - Andrews, I., and Kasy, M., (2019), "Identification of and Correction for Publication Bias," *American Economic Review* 109(8), 2766-2794.

   - Camerer, C., et al, (2016), "Evaluating Replicability of Laboratory Experiments in Economics," *Science* 351(6280): 1433-1436.

   - Christensen, G., and Miguel, E., (2018) "Transparency, Reproducibility, and the Credibility of Economics Research," *Journal of Economic Literature* 56(3): 920-980.

   * Duflo, E., Banerjee, A., Finkelstein, A., Katz, L. F., Olken, B. A., and Sautmann, A., (2020), "In Praise of Moderation: Suggestions for the Scope and Use of Pre-Analysis Plans for RCTs," NBER Working Paper No. 26993.

   - Ioannidis, J. P. A., (2009), "Why Most Discovered True Associations are Inflated," *Epidemiology* 19(5): 640-648.

   - Ludwig, J., and Mullainathan, S., and Spiess, J., (2019), "Augmenting Pre-Analysis Plans with Machine Learning," *AEA Papers and Proceedings* 109: 71-76.

   - McCrary, J., Christensen, G., and Fanelli, D., (2016), "Conservative Tests under Satisficing Models of Publication Bias," *PLoS ONE* 11(2): e0149590.

   - Spiess, J., (2018), "Optimal Estimation when Researcher and Social Preferences are Misaligned," working paper.
     https://gsb-faculty.stanford.edu/jann-spiess/files/2021/01/alignedestimation.pdf

   - Tetenov, A., (2016), "An Economic Theory of Statistical Testing," working paper.
     https://tetenov.com/Tetenov_hypothesis_testing.pdf

4. Treatment and Policy Choice

- Athey, S., and Wager, S., (2021), "Policy Learning with Observational Data," *Econometrica* 89(1): 133-161.
- Chamberlain, G., (2011), "Bayesian Aspects of Treatment Choice," in *The Oxford Handbook of Bayesian Econometrics*, ed. by J. Geweke, G. Koop, and H. van Dijk, Oxford University Press.
- Dehejia, R., (2005), "Program Evaluation as a Decision Problem," *Journal of Econometrics* 125, 141-173.
- Hirano, K., and Porter, J. R., (2009), "Asymptotics for Statistical Treatment Rules," *Econometrica* 77, 1683-1701.
- Hirano, K., and Porter, J., (2020), "Asymptotic Analysis of Statistical Decision Rules in Econometrics," in *Handbook of Econometrics* vol 7A, eds. S. N. Durlauf, L. P. Hansen, J. J. Heckman, and R. Matzkin, Elsevier.

* Kitagawa, T., and Tetenov, A., (2018), "Who Should Be Treated? Empirical Welfare Maximization Methods for Treatment Choice," *Econometrica* 86, 591-616..

* Manski, C. F., (2004), "Statistical Treatment Rules for Heterogeneous Populations," *Econometrica* 72, 1221-1246.

- Stoye, J., (2009), "Minimax Regret Treatment Choice with Finite Samples," *Journal of Econometrics* 151, 70-81.

5. Multi-Wave Experiments

* Hahn, J., Hirano, K., and Karlan, D., (2011), "Adaptive Experimental Design Using the Propensity Score," *Journal of Business and Economic Statistics* 29(1): 96-108.

- Jennison, C., and Turnbull, B. W., (2000), *Group Sequential Methods with Applications to Clinical Trials*, CRC Press.
- Tabord-Meehan, M., (2021), "Stratification Trees for Adaptive Randomization in Randomized Controlled Trials," working paper.

6. Covariate-Adaptive Randomization

* Bugni, F. A., Canay, I. A., and Shaikh, A. M., (2018): "Inference under Covariate Adaptive Randomization," *Journal of the American Statistical Association* 113 (524), 1784-1796.

- Bugni, F.A., Canay, I. A., Shaikh, A. M., (2019): "Inference under Covariate Adaptive Randomization with Multiple Treatments," *Quantitative Economics* 10(4) 1747-1785.

7-8. Response-Adaptive Experiments and Multi-Armed Bandits

- Caria, A. S., Gordon, G., Kasy, M., Quinn, S., Shami, S., and Teytelboym, A., (2021), "An Adaptive Targeted Field Experiment: Job Search Assistance for Refugees in Jordan," working paper. https://maxkasy.github.io/home/files/papers/RefugeesWork.pdf
- Food and Drug Administration, 2019, "Adaptive Designs for Clinical Trials of Drugs and Biologics: Guidance for Industry." https://www.fda.gov/media/78495/download

- Flournoy, N., and Rosenberger, W. F., 1995, "Adaptive Designs," IMS Lecture Notes - Monograph Series, volume 25.
- Hu, F., and Rosenberger, W. F., (2006), *The Theory of Response-Adaptive Randomization in Clinical Trials*, Wiley.
* Lattimore, T., and Szepesvári, C., (2020), *Bandit Algorithms*, Cambridge University Press. (especially Ch. 4, 6, 7.) https://tor-lattimore.com/downloads/book/book.pdf
- Perchet, V., Rigollet, P., Chassang, S., and Snowberg, E., (2016), "Batched Bandit Problems," *The Annals of Statistics* 44(2): 660-681.

9. Statistical Inference with Data from Bandits

- Dimakopoulou, M., Zhou, Z., Athey, S., and Imbens, G., "Estimation Considerations in Contextual Bandits," working paper. https://arxiv.org/abs/1711.07077
- Hadad, V., Hirshberg, D. A., Zhan, R., Wager, S., and Athey, S., (2021), "Confidence Intervals for Policy Evaluation in Adaptive Experiments," *Proceedings of the National Academy of Sciences* vol. 118 no. 15. https://doi.org/10.1073/pnas.2014602118
- Zhang, K. W., Janson, L., and Murphy, S. A., (2020), "Inference for Batched Bandits," working paper. https://arxiv.org/abs/2002.03217

10. Window Choice in Time Series (if time permits)

- Andrews, D. W. K., (1993), "Tests for Parameter Instability and Structural Change with Unknown Change Point," *Econometrica* 61(4): 821-856.
- Bai, J., and Perron, P., (1998), "Estimating and Testing Linear Models with Multiple Structural Changes," *Econometrica* 66(1): 47-78.
* Hirano, K., and Wright, J., (2022), "Analyzing Cross-Validation for Forecasting with Structural Instability," *Journal of Econometrics* 226(1): 139-154.
- Inoue, A., Jin, L, and Rossi, B., (2017), "Rolling Window Selection for Out-of-sample Forecasting with Time-Varying Parameters," *Journal of Econometrics* 196(1), 55-67.
- Koo, B., and Seo, M. H., (2015), "Structural-break Models under Mis-specification: Implications for Forecasting," *Journal of Econometrics* 188(1): 166-181.
- Pesaran, M. H., Pick, A., and Pranovich, M., (2013), "Optimal Forecasts in the Presence of Structural Breaks," *Journal of Econometrics* 177(2): 134-152.
- Pesaran, M. H., and Timmermann, A., (2007), "Selection of Estimation Window in the Presence of Breaks," *Journal of Econometrics* 137(1): 134-161.

T. Additional Technical Background

- Berger, J. O., (1985), *Statistical Decision Theory and Bayesian Analysis*, 2nd ed., Springer.
- Ferguson, T. S., (1967), *Mathematical Statistics: A Decision Theoretic Approach*, Academic Press.
- Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., and Rubin, D. B., (2013), *Bayesian Data Analysis*, 3rd ed., CRC Press.

- Hansen, B., (2021), *Econometrics*. https://www.ssc.wisc.edu/ bhansen/econometrics/
- Newey, W. K., and McFadden, D., (1994), "Large Sample Estimation and Hypothesis Testing," in *Handbook of Econometrics* vol. 4, ed. by R. F. Engle and D. McFadden, Elsevier.
- Thompson, S. K., (2012), *Sampling*, 3rd ed., Wiley.
- van der Vaart, A. W., (1998), *Asymptotic Statistics*, Cambridge University Press.
- Vershynin, R., (2018), *High-Dimensional Probabilty: An Introduction with Applications in Data Science*, Cambridge University Press.
- Wasserman, L., *All of Statistics*, Springer.