Princeton University **Spring 2023**
Department of Economics **ECO 519**

Advanced Econometrics: Nonlinear Models

Syllabus: Version 3d (March 2, 2023)

Instructors:	Mikkel Plagborg-Moller, mikkelpm@princeton.edu Bo Honoré, honore@princeton.edu
Lectures:	Tue/Thu 10.40am–12.10pm, Friend Center 111
Office hours:	Thu 1.35–2.30 pm, JRR 282 (first half)
Website:	`https://princeton.instructure.com/courses/9823`

Description. This is half of the second-year sequence in econometric methodology (ECO 513 is the other). The course covers nonlinear and high-dimensional statistical models for the analysis of cross-sectional and panel data. It is intended both for students specializing in econometric theory and for students interested in applying statistical methods to economic data. Topics covered include large-sample theory for nonlinear estimators, partial identification, statistical decision theory, shrinkage estimation, semiparametric estimation and machine learning, and weak identification.

Prerequisites. ECO 517 and 518, or equivalent. Students from outside the Economics PhD program should contact the instructors to obtain permission to take the course.

Material. There is no required textbook for the course. Handouts will be made available on the website. Attached to this syllabus is a list of optional readings that are useful for a deeper understanding of the material in the first half of the course.

Homework. Problem sets will be posted on the course website approximately every one or two weeks. Students are encouraged to collaborate on the problem sets, but answers and computer code must be typed up independently. The problem sets will be graded coarsely, i.e., a full score will be given as long as the work demonstrates dedication and thoughtfulness. We reserve the right to subtract points for sloppy exposition, including unreadable code. If you find a grading error, please resubmit your problem set along with a one-paragraph explanation; we reserve the right to re-grade the entire problem set.

Paper presentation. In lieu of a midterm and final exam, students will present a paper in the final week of each half of the course. Students may choose to collaborate in groups of two. The paper may be original work, an in-depth critical assessment of an existing paper from the literature, or somewhere in between. Students should receive prior approval from the instructors of their choice of paper topic.

Grading. The final course grade will be a monotonic function of the simple average of the point scores in each half of the course. In the first half of the course, the point score is given by a weighted average of (i) the average problem set score (50% weight) and (ii) the paper presentation score (50% weight).

Code of conduct. All course activities, including class meetings and homework assignments, are subject to the university's academic code and code of conduct as detailed in the "Rights, Rules, Responsibilities" publication.

Accommodations for students with disabilities. Students must register with the Office of Disability Services (ODS) (ods@princeton.edu; 258-8840) for disability verification and determination of eligibility for reasonable academic accommodations. Requests for academic accommodations for this course need to be made at the beginning of the semester, or as soon as possible for newly approved students, and again at least two weeks in advance of any needed accommodations in order to make arrangements to implement the accommodations. Please make an appointment to meet with the instructor in order to maintain confidentiality in addressing your needs. No accommodations will be given without authorization from ODS, or without advance notice.

Important dates. These dates are preliminary. Changes will be announced via course email.

Jan 31 (Tue): First class with M. Plagborg-Moller

Mar 9 (Thu): Last class with M. Plagborg-Moller

Mar 14 (Tue) and 16 (Thu): No class due to Spring Recess

Mar 21 (Tue): First class with B. Honoré

Apr 27 (Thu): Last class with B. Honoré

Course outline: Jan 31 – Mar 9. The following outline is preliminary and may change without warning.

1. Decision-theoretic justifications for conventional maximum likelihood procedures
   - i) Gaussian limit experiment
   - ii) Squared error loss, admissibility, unbiasedness, invariance, minimax
   - iii) Testing
   - iv) Uniformity
2. Shrinkage estimation
   - i) Empirical Bayes, random effects, penalization
   - ii) Compound decision problems
   - iii) Linear and non-linear shrinkage, James-Stein estimator
   - iv) Soft thresholding, sparse and dense models
   - v) Nonparametric empirical Bayes
   - vi) Empirical implementation with covariates and heteroskedasticity
   - vii) Other decision problems
3. Non-standard confidence sets
   - i) Empirical Bayes confidence intervals
   - ii) Shrinkage confidence balls
4. Nonparametric estimation
   - i) Upper and lower risk bounds
   - ii) Honest inference
5. Semiparametric estimation and machine learning
   - i) Efficiency bounds
   - ii) Double robustness, double machine learning
6. Weak identification (time permitting)

Optional reading list

Where available, introductory readings are listed first and marked with a star (*). Original contributions are not always cited when good handbook/textbook references are available. The reading list is preliminary and may change without warning.

The following textbooks appear frequently below.

Hansen, B. E. (2022). *Econometrics*. Princeton University Press.

Johnstone, I. M. (2019). *Gaussian Estimation: Sequence and Wavelet Models*. `https://statweb.stanford.edu/~imj/GE_09_16_19.pdf`

1 Decision-theoretic justifications for conventional maximum likelihood procedures

* Ferguson, T. S. (1967). *Mathematical Statistics: A Decision Theoretic Approach*. Academic Press Inc. Chapters 1-5.

Johnstone, Chapters 2, 4.

Lehmann, E. L., and J. P. Romano (2005). *Testing Statistical Hypotheses*, 3rd ed. Springer. Chapters 3-6, 13.

van der Vaart, A. W. (1998). *Asymptotic Statistics*. Cambridge University Press. Chapters 6-9.

Cheng, X., D. W. K. Andrews, and P. Guggenberger (2020). "Generic Results for Establishing the Asymptotic Size of Confidence Sets and Tests." *Journal of Econometrics* 218(2): 496-531.

Elliott, G., U. K. Müller, and M. W. Watson (2015). "Nearly Optimal Tests When a Nuisance Parameter Is Present Under the Null Hypothesis." *Econometrica* 83(2): 771-811.

Leeb, H., and B. M. Pötscher (2005). "Model Selection and Inference: Facts and Fiction." *Econometric Theory* 21(01): 21-59.

2 Shrinkage estimation

* Efron, B. (2010). *Large-scale Inference: Empirical Bayes Methods for Estimation, Testing, and Prediction.* Cambridge University Press.

* Gu, J., and C. R. Walters (2022). "Empirical Bayes Methods: Theory and Applications." NBER Summer Institute Methods Lectures. `https://www.nber.org/conferences/si-2022-methods-lectures-empirical-bayes-methods-theory-and-application`

Hansen, Chapter 28.

Johnstone, Chapters 2, 4, 5.

Carlin, B. P., and T. A. Louis (2000). *Bayes and Empirical Bayes Methods for Data Analysis*, 2nd ed. Chapman & Hall/CRC.

Hastie, T., R. Tibshirani, and J. Friedman (2009). *The Elements of Statistical Learning*, 2nd ed. Springer. Chapters 3, 5.

Abadie, A., and M. Kasy (2019). "Choosing among Regularized Estimators in Empirical Economics: The Risk of Machine Learning." *Review of Economics and Statistics* 101(5): 743-762.

Chen, J. (2022). "Gaussian Heteroskedastic Empirical Bayes without Independence." arXiv:2212.14444.

Efron, B. (2016). "Empirical Bayes deconvolution estimates." *Biometrika* 103(1): 1-20.

Efron, B. (2019). "Bayes, Oracle Bayes and Empirical Bayes." *Statistical Science* 34(2): 177-201.

Gu, J., and R. Koenker (2022). "Invidious Comparisons: Ranking and Selection as Compound Decisions." *Econometrica*, forthcoming.

Hansen, B. E. (2016). "Efficient Shrinkage in Parametric Models." *Journal of Econometrics* 190(1): 115-132.

Jiang, W., and C.-H. Zhang (2009). "General Maximum Likelihood Empirical Bayes Estimation of Normal Means." *Annals of Statistics* 37(4): 1647-1684.

Kline, P., R. Saggio, and M. Sølvsten (2020). "Leave-Out Estimation of Variance Components." *Econometrica* 88(5): 1859-1898.

Kline, P., and Walters, C. (2021). "Reasonable Doubt: Experimental Detection of Job-Level Employment Discrimination." *Econometrica* 89(2): 765-792.

Koenker, R., and I. Mizera (2014). "Convex Optimization, Shape Constraints, Compound Decisions, and Empirical Bayes Rules." *Journal of the American Statistical Association* 109(506): 674-685.

Liu, L., H. R. Moon, and F. Schorfheide (2020). "Forecasting With Dynamic Panel Data Models." *Econometrica* 88(1): 171-201.

Xie, X., S. C. Kou, and L. D. Brown (2012). "SURE Estimates for a Heteroscedastic Hierarchical Model." *Journal of the American Statistical Association* 107(500): 1465-1479.

Zhang, C. H. (2003). "Compound decision theory and empirical Bayes methods." *Annals of Statistics* 31(2): 379-390.

3 Non-standard confidence sets

Carlin and Louis, Chapter 3.5.

Armstrong, T. B., M. Kolesár, and M. Plagborg-Møller (2022). "Robust Empirical Bayes Confidence Intervals." *Econometrica* 90(6): 2567-2602.

Casella, G., and J. T. G. Hwang (2012). "Shrinkage Confidence Procedures." *Statistical Science* 27(1): 51-60.

Ignatiadis, N. & S. Wager (2022). "Confidence Intervals for Nonparametric Empirical Bayes Analysis." *Journal of the American Statistical Association* 117(539): 1149-1166.

Pratt, J. W. (1961). "Length of Confidence Intervals." *Journal of the American Statistical Association* 56(295): 549-567.

4 Nonparametric estimation

* Hansen, Chapters 19-20.

Johnstone, Chapters 1, 3-6.

Li, Q., and J. S. Racine. (2006). *Nonparametric Econometrics: Theory and Practice.* Princeton University Press.

Tsybakov, A. B. (2009). *Introduction to Nonparametric Estimation.* Springer.

Wasserman, L. (2006). *All of Nonparametric Statistics.* Springer.

Armstrong, T. B., and M. Kolesár (2018). "Optimal Inference in a Class of Regression Models." *Econometrica* 86(2): 655-683.

Chen, X. (2007). "Large Sample Sieve Estimation of Semi-Nonparametric Models." In *Handbook of Econometrics*, Vol. 6B, edited by J. J. Heckman and E. E. Leamer, Chapter 76: 5549-5632. Elsevier.

Ichimura, H., and P. E. Todd (2007). "Implementing Nonparametric and Semiparametric Estimators." In *Handbook of Econometrics*, Vol. 6B, edited by J. J. Heckman and E. E. Leamer, Chapter 74: 5369-5468. Elsevier.

5 Semiparametric estimation and machine learning

* Newey, W. K. (1990). "Semiparametric Efficiency Bounds." *Journal of Applied Econometrics* 5(2): 99-135.

Hansen, Chapter 29.

Tsiatis, A. A. (2006). *Semiparametric Theory and Missing Data.* Springer.

Chamberlain, G. (1987). "Asymptotic Efficiency in Estimation with Conditional Moment Restrictions." *Journal of Econometrics* 34(3): 305-334.

Chernozhukov, V., D. Chetverikov, M. Demirer, E. Duflo, C. Hansen, W. Newey, and J. Robins (2018). "Double/Debiased Machine Learning for Treatment and Structural Parameters." *Econometrics Journal* 21(1): C1-C68.

Hahn, J. (1998). "On the Role of the Propensity Score in Efficient Semiparametric Estimation of Average Treatment Effects." *Econometrica* 66(2): 315-331.

Hirano, K., G. W. Imbens, and G. Ridder (2003). "Efficient Estimation of Average Treatment Effects Using the Estimated Propensity Score." *Econometrica* 71(4): 1161-1189.

Newey, W. K. (1994) “The Asymptotic Variance of Semiparametric Estimators.” *Econometrica* 62(6): 1349-1382.

6 Weak identification

* Andrews, I., J. H. Stock, and L. Sun (2019). “Weak Instruments in Instrumental Variables Regression: Theory and Practice.” *Annual Review of Economics* 11: 727-753.

* Stock, J. H, J. H. Wright, and M. Yogo (2002). “A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments.” *Journal of Business & Economic Statistics* 20(4): 518-529.

Andrews, I., and A. Mikusheva (2014). “Weak Identification in Maximum Likelihood: A Question of Information.” *American Economic Review: Papers & Proceedings* 104(5): 195-199.

Moreira, M. J. (2003). “A Conditional Likelihood Ratio Test for Structural Models.” *Econometrica* 71(4): 1027-1048.