Harvard University, fall 2016
Syllabus for Economics 2110 - Foundations of Econometrics

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Overview and Objectives

Econ 2110 covers the foundations of econometrics. Knowledge of probability at the level of Harvard **Statistics 110 or equivalent is a prerequisite** of this class.

The first part of this class is going to be a review of **probability theory**. You are expected to already know this material but I am still going to review it to make sure everybody is on the same page.

After this review, we will discuss **causality and identification**. Identification is about mapping population distributions of observed variables into statements about underlying structures or causal effects. We will introduce the potential outcomes framework, and discuss standard approaches to causal inference – randomized experiments, instrumental variables, controlling for covariates.

The third part of this class covers **statistical decision theory**. Statistical decision theory evaluates decision procedures such as estimators, tests, and confidence regions based on expected loss. This framework is very similar to (expected) utility maximization in economic theory.

The last part of Econ 2110 will provide an introduction to **asymptotic theory**. Often we cannot evaluate the exact behavior of decision procedures in finite samples, since it depends on various unknown features of the data generating process. We can, however, approximate the behavior of such procedures in large samples using asymptotic theory. This allows us to evaluate the performance of estimators, tests, and confidence regions in more complicated models.

Classes will mainly consist of lectures. You are asked to actively participate, however! The more questions you ask, the better. I have posted slides for all lectures. Any feedback about typos, comprehensibility etc. is very much appreciated.

I plan to dedicate a few minutes in every class to small exercises which you should try to solve on your own, before I (or a volunteer among you) will present the solution on the board. After each section of class, I will review and repeat some of the material covered. These reviews are good occasions for you to ask any questions that have not been answered, yet.

Assignments

Your grade for Econ 2110 will be determined as follows:

1. Two **Matlab problem-sets**, posted on the class webpage (5% of grade each). Due by October 3 and November 14.

2. Four **regular problem-sets**, posted on the class webpage (5% of grade each). Due by September 26, October 11, November 7 and November 21.

3. Two **summaries of empirical papers**, applying material discussed in class (5% of grade each). Due by October 7 and October 26.

4. An in-class **midterm** exam on **October 19** (25% of grade).

5. An in-class **final** exam on **November 30** (25% of grade).

6. **Presentations** of the empirical papers (10% of grade), on October 5 and October 24.

   If you did not get a presentation slot, you may instead hand in two additional summaries, and earn the same amount of points.

Remarks:

- All assignments except for exams are to be submitted online on the class homepage.
- Exams will be similar to the regular problem-sets. You should therefore make sure you understand these well.
- You are welcome, and in fact encouraged, to collaborate on any of these assignments (exams excluded). However, every one of you has to produce a separate write-up of your problem-set solutions and summaries. Identical write-ups will receive zero points.
- If you volunteer to present one of the empirical papers (in groups of up to 3), you can earn 10% credit for your grade. This will help making sure everybody knows these papers and we can use them as examples later.
- Whoever signs up first for presentations gets to present. You can sign up on the class homepage, by clicking on "scheduler" in the calendar view. If you did not get a presentation slot, you may instead hand in two additional summaries, and earn the same amount of points.

To help me improve the course, I will ask you to give me anonymous feedback at some point, writing what you like about the class and what you think I should change.
I encourage you to come to my office hours with any questions. I will not answer emails with questions on the material.
If you need any special accommodations for physical or medical reasons, please see me after class or send me an email.

Course outline

We will cover the following topics in Econ 2110.

1. **Review of probability theory**
   (a) Elementary Probability Theory
   (b) Conditional Probability, Independence
   (c) Random Variables, Distribution Functions, Functions of Random Variables
   (d) Expectations

(e) Special Distributions

(f) Joint Distributions, Conditional Distributions, Independence of Random Variables

2. **Causality and identification**

   (a) Basic concepts

   (b) Historical origins: Linear systems of structural equations

   (c) Potential outcomes and treatment effects

   (d) Instrumental variables, local average treatment effects

   (e) Conditional independence, reweighting and regression with controls

3. **Applications**

   (a) Estimating top income shares

   (b) Testing for labor market discrimination

   (c) Displacement effects of active labor market programs

   (d) The effect of juvenile incarceration on future education and crime

4. **Statistical decision theory**

   (a) loss, risk function, Bayes risk

   (b) admissible, minimax, and Bayes decision functions

   (c) complete class theorem

   (d) testing, Neyman Pearson lemma

5. **Asymptotic theory**

   (a) Convergence, Laws of Large Numbers, Central Limit Theorems

   (b) Delta method

   (c) M-estimators: consistency, asymptotic normality

   (d) Tests and confidence regions

   (e) Ordinary Least Squares

   (f) Maximum Likelihood

Readings

There is no required textbook for this class. I have posted lecture slides as well as scanned copies of some textbook chapters on the class website. You are required to know everything on the lecture slides for the exam. The textbook chapters are more technical, and contain optional material, but are well worth your time.

1. Review of probability theory

   Casella, G. and Berger, R. (2001). *Statistical inference*. Duxbury Press, chapters 1 through 4.

2. Causality and identification

   Angrist, J. D. and Pischke, J. S. (2009). *Mostly harmless econometrics: an empiricist's companion*. Princeton Univ Pr, chapters 2, 3, and 4.

   Manski, C. (2003). *Partial identification of probability distributions*. Springer Verlag, chapters 2 and 7

   Imbens, G. W. and Rubin, D. B. (2015). *Causal inference in statistics, social, and biomedical sciences*. Cambridge University Press

   Angrist, J., Imbens, G., and Rubin, D. (1996). Identification of causal effects using instrumental variables. *Journal of the American Statistical Association*, 91(434):444–455

3. Statistical decision theory

   Robert, C. (2007). *The Bayesian choice: from decision-theoretic foundations to computational implementation*. Springer Verlag, chapter 2.

4. Asymptotic theory

   van der Vaart, A. (2000). *Asymptotic statistics*. Cambridge University Press, sections 2.1, 2.2, 3.1, 5.1, 5.2, 5.3, and 5.5.

5. Empirical papers (preliminary list)

Atkinson, A. B., Piketty, T., and Saez, E. (2011). Top incomes in the long run of history. *Journal of Economic Literature*, 49(1):3–71.

Bertrand, M. and Mullainathan, S. (2004). Are Emily and Greg More Employable Than Lakisha and Jamal? A Field Experiment on Labor Market Discrimination. *American Economic Review*, 94(4):991–1013

Crépon, B., Duflo, E., Gurgand, M., Rathelot, R., and Zamora, P. (2013). Do labor market policies have displacement effects? evidence from a clustered randomized experiment. *The Quarterly Journal of Economics*, 128(2):531–580.

Aizer, A. and Doyle, J. J. (2015). Juvenile incarceration, human capital, and future crime: Evidence from randomly assigned judges. *The Quarterly Journal of Economics*, 130(2):759–803.