Machine Learning and Causal Inference

Fall Term - 3 ECTS

Mandatory Course

Overview and Objectives

Prediction requires assumptions. Predicting the impact of a new business decision or public policy requires causal assumptions. In this course, we will bring together ideas from machine learning and econometrics to formalize, verify, and uncover the assumptions needed to measure and predict effects of any form of intervention.

In the first part of the course, students will learn to model causal systems via Directed Acyclic Graphs (DAGs) and their underlying structural causal models. We will then learn about graph recovery algorithms and how statistical dependences associated with causal assumptions can be tested and recovered directly from data. Finally, we will use DAGs to characterize the transportability of causal relationships from one context to another.

In the second part of the course students will be introduced to data analysis using structural models. They will learn basic models and estimation techniques commonly applied in academia, business and government policy analysis. There will be opportunities to gain practical experience in homework assignments. Students will understand the advantages and disadvantages of a structural approach and the extent to which it complements other methods.

Prerequisite Requirements

Good Knowledge of STATA and Python.

Course Outline

Part I.

a. Hume's Problem of Induction and the Challenge of Prediction.
b. DAGs and Structural Causal Models
c. Graph Recovery Algorithms.

Part II.

a. Discrete Choice Models

b. Maximum Likelihood and GMM Estimation
c. Models of Self-Selection and Heterogeneous Treatment Effects
d. Counterfactual Estimation

Part III.

a. Discrete Choice Models as DAGs.
b. Complementarity of Structural and Regression-Based Methods

Required Activities

Students will work on individual and group exercises throughout the term and submit a final project where they will be required to apply the ideas from the course.

Evaluation

Exercises (50%) and Final Project (50%)

Materials

Recommended Books:

Peters, Jonas, Dominik Janzing, and Bernhard Schölkopf. Elements of causal inference. The MIT Press, 2017.

Morgan, Stephen L., and Christopher Winship. Counterfactuals and causal inference. Second edition. Cambridge University Press, 2015.

Keane, Michael, Todd, Petra and Wolpin, Kenneth I., The Structural Estimation of Behavioral Models: Discrete Choice Dynamic Programming Methods and Applications, Ch. 04, p. 331-461 in Handbook of Labor Economics, Ashenfelter, O. and Card, D. eds., (2011) Elsevier

Manski, Charles F. and McFadden, Daniel L., Structural Analysis of Discrete Data and Econometric Applications, Cambridge: The MIT Press, 1981 (Freely Available Online)

Recommended Articles:

Cunha, Flavio., and Heckman, James, “A New Framework for the Analysis of Inequality”, Macroeconomic Dynamics, 12(2), 2011, 315-354.

Eckstein, Zvi and Wolpin, Kenneth I., “The Specification and Estimation of Dynamic Stochastic Discrete Choice Models: A Survey,” Journal of Human Resources, 1989, 24 (4), 562–598.

Heckman, James, “Sample Selection Bias and Specification Error”, Econometrica, 1979, 47, 153-161.

Low, Hamish and Meghir, Costas, “The Use of Structural Models in Econometrics”, Journal of Economic Perspectives, 31(2), 2017, 33-58.