

MODULE SPECIFICATION • ELECTIVE

# Causal Machine Learning

This course is an introduction to the principles and practices of causal inference with machine learning methods. It covers the basics of causal inference, including the identification and estimation of causal effects, as well as the applications of causal machine learning in areas such as health, finance and social sciences. The course also includes an introduction to recent methods and algorithms for causal machine learning.

|         |               |               |             |
|---------|---------------|---------------|-------------|
| 10      | 15h           | 85h           | 100h        |
| CREDITS | CONTACT HOURS | PRIVATE STUDY | TOTAL STUDY |

COURSE CONVENOR

NAME      Prof Emmanuel Flachaire

OFFICE    By appointment — please email to arrange a convenient time

COURSE STRUCTURE

Econ 7927 is a 10-credit course and students are expected to input approximately 100 hours of study. The total number of contact hours is 15 hours, leaving 85 hours for private study. Delivery is by lectures — 15 hours across the first three weeks of term, comprising 10 hours of lectures and 5 hours of tutorials. Optional clinics run on the last day of the course.

During private study, balance the course material (the primary source) against the recommended textbooks: think critically about how these fit into the body of knowledge, perform the exercises, complete coursework and revise. You can expect to perform well only by working consistently through the year.

## MODULE PROGRAMME

| LECT. | TOPIC                           | SESSION CONTENT                                                                                                                                                                                |
|-------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 01    | Introduction                    | <ul style="list-style-type: none"> <li>— Simpson's Paradox</li> <li>— Directed Acyclic Graphs (DAG)</li> <li>— Potential Outcomes Causal Model</li> <li>— AB-testing and RCT models</li> </ul> |
| 02    | Standard approaches             | <ul style="list-style-type: none"> <li>— Regression and double orthogonalization</li> <li>— Propensity scores</li> <li>— Doubly robust estimator</li> </ul>                                    |
| 03    | Machine Learning approaches     | <ul style="list-style-type: none"> <li>— High-dimension and variable selection</li> <li>— Post-Lasso and Post-Double-Lasso</li> <li>— Double/debiased machine learning</li> </ul>              |
| 04    | Heterogeneous Treatment Effects | <ul style="list-style-type: none"> <li>— Meta-learners</li> <li>— Causal forest</li> <li>— Generic machine learning</li> </ul>                                                                 |
| 05    | Methods                         | <ul style="list-style-type: none"> <li>— Instrumental variables</li> <li>— Difference-in-differences</li> <li>— Synthetic control</li> </ul>                                                   |

## KEY SKILLS

By the end of this course, students should have some knowledge and understanding of:

- Ability to comprehend concepts and principles of causal inference
- Proficiency in deploying advanced machine learning methods for causal analysis
- Skills to perform rigorous causal analysis using machine learning techniques
- Hands-on experience in deploying advanced ML methods for causal analysis

## DESIRED OUTCOMES

By the end of this course, students should be able to:

- Understand the basics of causal inference and its role in machine learning
- Identify and estimate causal effects using common methods and algorithms
- Apply causal machine learning to real-world problems in areas such as health, finance and social sciences
- Communicate effectively about causal inference and its applications in machine learning

## ASSESSMENT

|            |                                                                                                   |
|------------|---------------------------------------------------------------------------------------------------|
| WEIGHTING  | 100% coursework                                                                                   |
| ISSUED     | End of week 6                                                                                     |
| DUE        | End of week 10 — four weeks for completion                                                        |
| SUBMISSION | Electronically via the Moodle site for this course                                                |
| FEEDBACK   | Returned within 4 weeks of the deadline, as marker's notes appended to the PDF of your coursework |



Marking criteria and penalties are set out in the Economics Undergraduate Handbook and the general course information paper, available via the Current Student page of the university website under Academic Regulations.

#### COURSE TEXT & RECOMMENDED READING

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Book chapters and online material. Copies of the lecture slides are made available on the course web pages, together with additional material and course announcements.

- Angrist, J. and Pischke, J.-S. Mastering Metrics: The Path from Cause to Effect
- Cunningham, S. Causal Inference: The Mixtape
- Facure, M. Causal Inference for the Brave and True
- Gaillac, C. and L'Hour, J. Machine Learning for Econometrics
- Huntington-Klein, N. The Effect: An Introduction to Research Design and Causality