Causal Machine Learning

Freie Universität Berlin — School of Business Economics — Winter Term 2026/27

Lecturers: Prof. Dr. Philipp Bach and Prof. Dr. Jan Marcus

Type

Lecture / Exercise Sessions / Seminar (Language: English)

Credits

12 ECTS

Time and Place

- Lectures Thu 14:00–18:00
- Exercise sessions Wed 16:00–18:00
- Henry-Ford-Bau, Konferenzraum 2

Schedule

The course consists of two integrated parts:

- **Part I (Lecture & Exercises):** The first half of the semester introduces (i) the theoretical foundations of causal inference and the main strategies to identify causal effects, (ii) machine learning methods, and (iii) specific machine learning techniques for causal inference. Lectures are complemented by applied exercise sessions using Python.
- **Part II (Seminar):** In the second half of the semester, students independently work on a topic in causal machine learning. This includes presenting a research paper, implementing selected methods, and writing a seminar paper.

Prerequisites

- Intermediate Econometrics (e.g., Regression Analysis)
- Basic knowledge of causal inference (recommended)

Examination

- Seminar Paper
- Presentation

Active Participation

- Mandatory Test (pass/fail) after the lecture phase

Objectives

After completing the course, students will:

- Understand the foundations of causal inference and the main strategies to identify causal effects
- Apply modern machine learning methods for causal estimation
- Master key approaches in causal machine learning
- Analyse and interpret heterogeneous treatment effects
- Critically evaluate empirical research using causal machine learning methods
- Conduct their own applied empirical project using real or simulated data
- Learn about new methods in causal machine learning independently and present them to their peers

Content

Foundations of Causal Inference

- Potential Outcomes Framework
- Randomised Controlled Trials (RCTs)
- Selection Bias and Identification
- Control Variable Strategies
- Instrumental Variables (IV)
- Difference-in-Differences (DiD)
- Regression Discontinuity Design (RDD)

Machine Learning Methods

- Prediction vs. Causation
- Regularised Regression (Lasso, Ridge)
- Model Selection and Overfitting
- Tree-Based Methods (Regression Trees, Random Forests)

Causal Machine Learning

- Post-Double Selection (PDS)
- Double / Debiased Machine Learning (DML)
- Orthogonalisation and Neyman Orthogonality
- Estimation of Average Treatment Effects (ATE)
- Heterogeneous Treatment Effects
- Simulation-based evaluation of estimators
- Advanced topics in Causal ML (deep learning, auto debiased ML, sensitivity analysis, etc.)

Note

While the course is designed as a 12 ECTS module for students in the Master in Economics and the Master in Public Economics at FU Berlin, it offers flexible participation options for students in other programmes.

In particular, students may choose to complete only one part of the course (6 ECTS each). For students in the Master in Statistics, these correspond to the modules *Neuere Statistische Methoden* (6 ECTS) and *Aktuelle Forschungsfragen der Ökonometrie* (6 ECTS). In this case, the test after the lecture phase constitutes the final exam of *Neuere Statistische Methoden*, while the grade for *Aktuelle Forschungsfragen der Ökonometrie* is based on the presentation and the seminar paper. Similarly, students from other programmes (including the Berlin School of Economics PhD programme and the Master in Bamberg) may enroll in one or both parts of the course.

Participation in the second part is open to students who have participated in the first part or who have acquired equivalent prior knowledge (in particular in advanced causal inference and machine learning).

Literature

Athey, Susan. 2019. "The Impact of Machine Learning on Economics." In *The Economics of Artificial Intelligence*, edited by Ajay Agrawal, Joshua Gans, and Avi Goldfarb. University of Chicago Press. https://www.nber.org/system/files/chapters/c14009/c14009.pdf.

Athey, Susan, and Guido Imbens. 2019. *Machine Learning Methods Economists Should Know about*. arXiv e-prints. https://eurocim2019.bips.eu/fileadmin/EuroCIM2019/AtheyImbens2018_pdf.pdf.

Athey, Susan, and Guido W. Imbens. 2017. "The State of Applied Econometrics: Causality and Policy Evaluation." *Journal of Economic Perspectives* 31 (2): 3–32. https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.31.2.3.

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Cinelli, Carlos, Avi Feller, Guido Imbens, Edward Kennedy, Sara Magliacane, and Jose Zubizarreta. 2025. *Challenges in Statistics: A Dozen Challenges in Causality and Causal Inference*. https://arxiv.org/abs/2508.17099.

Cunningham, Scott. 2021. *Causal Inference: The Mixtape*. Yale University Press. https://mixtape.scunning.com/.

Gaillac, Christophe, and Jérémy L'Hour. 2025. *Machine Learning for Econometrics*. Oxford University Press.

Huber, Martin. 2023. *Causal Analysis: Impact Evaluation and Causal Machine Learning with Applications in R*. MIT Press.

James, Gareth, Daniela Witten, Trevor Hastie, and Robert Tibshirani. 2013. *An Introduction to Statistical Learning: With Applications in R*. Springer.

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