

## Professor(s)

Prof. Emilio Calvano (Tor Vergata University of Rome)

## Overview and Objectives

The course introduces the recent Economics literature on Artificial Intelligence with particular emphasis on competition policy issues. The course will be a mixed bag of (i.) tools (imported from the Computer Science literature), (ii.) theoretical results (from the Economics literature) and (iii.) empirical evidence (from the marketing literature). The course integrates the study of key algorithms used in digital marketplaces as well as the study of theoretical models that employing a stylized approach. Emphasis will be given to two popular applications that sparked an articulated policy debate: algorithmic pricing and recommender systems.

Basic knowledge of calculus and linear algebra are required for the technical sessions

## Course Outline

1. What is AI?
2. A Helicopter tour of the Economics of AI
  - a. Econ of AI: a research Agenda
  - b. What can AI “learn” and what does this mean for the economy
  - c. AI as a GPT: productivity boost?
  - d. Machine Learning and Economics
  - e. Will AI steal our jobs?
3. Under the hood: Reinforcement Learning algorithms
  - a. Elements of Reinforcement Learning
  - b. Temporal Difference Learning: basics
4. Pricing algorithms and collusion
  - a. Theory: do algorithms lead to higher prices?
  - b. Experimental evidence: do algorithms learn to collude in the lab?
  - c. Empirical Evidence: do they learn to collude in the wild?
  - d. Policy implications and market design
5. Artificial Intelligence, Algorithmic Bidding and Collusion in Online Advertising
  - a. Online advertising markets
  - b. Generalized second price auctions
  - c. Algorithmic Bidding
6. An introduction to Recommender Systems and collaborative filtering
  - a. The spectrum of applications
  - b. Do recommender systems affect what we read, listen to, watch or purchase online?  
Existing systematic evidence
7. Under the hood: Collaborative filtering.
  - a. Neighborhood-Based Collaborative Filtering
  - b. Model Based Collaborative Filtering (latent factor models).
8. The economics of recommender systems
  - a. Theories of biased advice
  - b. Experimental evidence: do RS distort consumption choices?

c. Empirical evidence: field experiments

9. Public Policy

## Schedule and allocation of hours

TBD

## References and material

### On AI and on the Economics of AI

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\*Acemoglu, D., & Restrepo, P. (2019). Automation and New Tasks: How Technology Displaces and Reinstates Labor. *The Journal of Economic Perspectives: A Journal of the American Economic Association*, 33(2), 3–30. <https://doi.org/10.1257/jep.33.2.3>

\*Brynjolfsson, E., Mitchell, T., & Rock, D. (2018). What Can Machines Learn, and What Does It Mean for Occupations and the Economy? *AEA Papers and Proceedings*, 108, 43–47. <https://doi.org/10.1257/pandp.20181019>

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Goldfarb, A., & Tucker, C. (2019). Digital Economics. *Journal of Economic Literature*, 57(1), 3–43. <https://doi.org/10.1257/jel.20171452>

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Mullainathan, S., & Spiess, J. (2017). Machine Learning: An Applied Econometric Approach. *The Journal of Economic Perspectives: A Journal of the American Economic Association*, 31(2), 87–106. <https://doi.org/10.1257/jep.31.2.87>

## Reinforcement Learning

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## Pricing Algorithms

Assad, S., Clark, R., Ershov, D., & Xu, L. (2020). Algorithmic Pricing and Competition: Empirical Evidence from the German Retail Gasoline Market. <https://papers.ssrn.com/abstract=3682021>

Brown, Z., & MacKay, A. (2021). *Competition in Pricing Algorithms*, SSRN working paper. <https://doi.org/10.2139/ssrn.3485024>

Calvano, E., Calzolari, G., Denicolò, V., & Pastorello, S. (2020). Artificial Intelligence, Algorithmic Pricing, and Collusion. *The American Economic Review*, 110(10), 3267–3297. <https://doi.org/10.1257/aer.20190623>

Calvano, E., Calzolari, G., Denicolò, V., & Pastorello, S. (2021). Algorithmic collusion with imperfect monitoring. *International Journal of Industrial Organization*, 102712. <https://doi.org/10.1016/j.ijindorg.2021.102712>

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## Recommender Systems

Aggarwal, C. C. (2016). *Recommender Systems: The Textbook*. Springer, Cham. <https://doi.org/10.1007/978-3-319-29659-3> (sections of chapters 2, 3).

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### Auctions and algorithmic bidding

F. Decarolis and G. Rovigatti “From Mad Men to Maths Men: Concentration and Buyer Power in Online Advertising,” CEPR Discussion Paper 13897, 2019, *American Economic Review*, forthcoming.

F. Decarolis, M. Goldmanis and A. Penta “Marketing Agencies and Collusive Bidding in Online Ad Auctions,” *Management Science*, 2020, 66(10), pp. 4359-4919.

B. Edelman, M. Ostrovsky and M. Schwarz "Michael Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords" *American Economic Review* 97 1 242-259 2007 . <https://doi.org/10.3386/w11765>

### Algorithmic Bias and fairness

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### Policy

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