MIT Economics

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DOCTORAL STUDIES

Massachusetts Institute of Technology (MIT)
PhD, Economics and Statistics, Completed June 2023
DISSERTATION: "*Essays on Algorithmic Learning and Uncertainty Quantification*"

DISSERTATION COMMITTEE AND REFERENCES

Professor Victor Chernozhukov
MIT Department of Economics
77 Massachusetts Avenue, E52-524
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Professor Anna Mikusheva
MIT Department of Economics
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Professor Alberto Abadie
MIT Department of Economics
77 Massachusetts Avenue, E52-546
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PRIOR EDUCATION

University of Cambridge — 2017
MASt, Mathematics and Mathematical Statistics, *first class*

Massachusetts Institute of Technology
BS in Theoretical Mathematics — 2016

CITIZENSHIP United States **GENDER:** Male (he/him)

LANGUAGES English, Tamil, French (limited)

FIELDS Primary Fields: Econometrics

Secondary Fields: Statistics, Machine Learning

TEACHING EXPERIENCE

Graduate of MIT's Kauffman Teaching Certificate Program	2019
14.380 Statistical Methods in Economics (UG, median rating 6/7) Teaching Assistant to Prof. Tetsuya Kaji	2022
14.32 Econometrics (UG, median rating 6/7) Teaching Assistant to Prof. Tetsuya Kaji	2022
14.388 Inference on Causal and Structural Parameters Using ML and AI (G) Curriculum Consultant to Prof. Victor Chernozhukov	2020
14.385 Nonlinear Econometrics (G) Teaching Assistant to Profs. Whitney Newey and Alberto Abadie	2020
14.15 Networks (UG, joint w/ Computer Science) Teaching Assistant to Prof. Alexander Wolitzky	2019-20
6.042 Introduction to Mathematics for Computer Science Teaching Assistant to Prof. Albert Meyer (as undergraduate)	2015

RELEVANT POSITIONS

Amazon Science Post-Doc (with Profs. Guido Imbens and Thomas Richardson). Topic: Experimental Design in Marketplaces	2022-23
Graduate Research Assistant for Blueprint Labs (with Profs. Joshua Angrist and Parag Pathak). Topic: School Evaluation in Centralized Matching Markets	2019-21
Amazon Applied Science Intern (with Prof. Victor Chernozhukov). Topic: Neural Networks for Hedonic Demand Modeling	2019-20
Pre-Doctoral Research Assistant to Profs. Joshua Angrist, Pierre Azoulay, and Glenn Ellison	2016-17
Pre-Doctoral Research Assistant to Prof. Frank Schilbach	2016
Software Engineer Intern, Applied Predictive Technologies	2015

FELLOWSHIPS, HONORS, AND AWARDS

MIT James A. Berkovec Graduate Student Fellowship
MIT Jerry A. Hausman Graduate Dissertation Fellowship

PROFESSIONAL ACTIVITIES

Invited Talks/Presentations: Topics in Neural Information Processing Systems Conference (2x), MIT Conference on Digital Experimentation (2x), Symposium on the Foundations of Responsible Computing.

Invited participant: University of Chicago Center for Applied AI, Machine Learning in Economics Summer Institute, University of Bocconi High-Dimensional Statistics Summer School (Topic: Random Graphs and Statistical Inference in Networks)

Reviewer, 23rd International Conference on Artificial Intelligence and Statistics

Co-coordinator, High Dimensional Probability & Statistics Reading Group, MIT

PUBLICATIONS

"Synthetic Combinations: A Causal Inference Framework for Combinatorial Interventions," ***To appear in Proceedings of the 37th Conference on Neural Information Processing Systems*** **(NeurIPS, 2023).** (with Abhineet Agarwal and Anish Agarwal)

"Can Calibration and Equal Error Rates be Reconciled?" ***Proceedings of the 2nd Symposium on Foundations of Responsible Computing*** **(FORC 2021).** (with Claire Lazar-Reich)

"Localization, Convexity and Star Aggregation," ***Proceedings of the 35th Conference on Neural Information Processing Systems*** **(NeurIPS, 2021).**

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"Higher Bruhat Orders in Type B," ***Electronic Journal of Combinatorics, 23(3), 13th ser.,*** **2017. (**with Seth Shelley-Abrahamson)

RESEARCH PAPERS

"Kernel Ridge Regression Inference, with Applications to Preference Data" (Job Market Paper) (with Rahul Singh)

We provide uniform inference and confidence bands for kernel ridge regression (KRR), a widely-used non-parametric regression estimator for general data including rankings, images, and graphs. Despite the prevalence of these data—e.g., ranked preference lists in school assignment—the inferential theory of KRR is not fully known, limiting use in economics and other scientific domains. We construct sharp, uniform confidence sets for KRR, which shrink at nearly the minimax rate, for general regressors. To conduct inference, we develop an efficient bootstrap procedure that uses symmetrization to cancel bias and limit computational overhead. To justify the procedure, we derive finite-sample, uniform Gaussian and bootstrap couplings for partial sums in a reproducing kernel Hilbert space (RKHS), implying strong approximation for empirical processes indexed by the RKHS unit ball with logarithmic dependence on the covering number. Simulations verify coverage. We use our procedure to construct a novel test for match effects in school assignment, an important question in education economics with consequences for school choice.

"Hedonic Prices and Quality-Adjusted Price Indices Powered by AI" (with Pat Bajari, Victor Chernozhukov, Ramon Huerta, Manoj Manukonda, and Jin Wang) *arxiv:2305.00044,* 2023. *Submitted.*

We build empirical models that can process large amounts of unstructured product data (text, images, prices, quantities) and output accurate hedonic price estimates and derived indices. To accomplish this, we generate abstract product attributes (a.k.a. embeddings) from text descriptions and images using deep neural networks. We then use these attributes to estimate the hedonic price

function. To demonstrate performance, we apply the models to Amazon's data for first-party apparel sales and estimate hedonic prices. The resulting models have a very high out-of-sample predictive accuracy, with R^2 ranging from 80-90%. Finally, we construct the AI-based hedonic Fisher price index, chained at the year-over-year frequency, and contrast the it with the CPI and other indices.

"Frank Wolfe Meets Metric Entropy: Domain-specific Lower Bounds for Conditional Gradient Algorithms" *arXiv:2205.08634,* 2022. *Submitted.*

The Frank-Wolfe algorithm is widely used for its ability to efficiently solve constrained optimization problems in machine learning and high-dimensional statistics. To study its limitations, we establish domain specific and easy-to-estimate lower bounds for Frank-Wolfe and its variants using the metric entropy of the domain. Notably, we show that a dimension-free linear upper bound must fail not only in the worst case, but in the average case: for Gaussian or spherical random polytopes in $\mathbf{R}^d$ with poly(d) vertices, Frank-Wolfe requires up to $\Omega(d)$ iterations to achieve a O(1/d) error bound, with high probability. We also establish this phenomenon for the nuclear norm ball.

RESEARCH IN PROGRESS

"Stability and Efficiency of Random Serial Dictatorship"
arXiv:2110.07024, 2021.

Parsimonious "cutoff" representations of matching markets are widely used in market design theory and in empirical work on school effectiveness. However, many real-world school choice markets have a number of schools that is roughly the square root of the number of students, which is not captured by existing theory. I establish validity of the cutoff representation for the random serial dictatorship (RSD) mechanism in markets where the number of schools is rapidly growing and student preferences are arbitrary, with quantitative bounds. Unlike prior work, which considers replica economies or stable preference distributions, I derive results for arbitrary—even adversarial—sets of preferences, using tools from randomized algorithms and discrete probability. In ongoing work, I study implications for the (ex-ante) efficiency of RSD in large markets.

"Improving Precision in Clustered Randomization Designs" (with Guido Imbens, Lorenzo Masoero, James McQueen, and Thomas Richardson)

"Discrete Choice, Sparse Recovery, and Latent Nested Logit" (with Francesca Molinari and Devavrat Shah)

"Plug-in Empirical Welfare Maximization" (with Liyang Sun)

"Combining Models by Alternating Estimation" (with Victor Chernozhukov)