Christopher Zosh

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Education

Ph.D. in Economics, Binghamton University, May 2025
Committee: **Andreas Pape** (Advisor), **Hiroki Sayama**, and **Ozlem Tonguc**

- Advanced Graduate Workshop in Computational Social Science, Santa Fe Institute (with John Miller and Scott Page), Summer 2024
- Graduate Workshop in Computational Social Science, Santa Fe Institute (with John Miller and Scott Page), Summer 2023
- Complex Systems Summer School, Santa Fe Institute, Summer 2022
- Behavioral Macro and Complexity course, Tinbergen Institute (with Cars Hommes), Summer 2021

B.A. in Mathematics and Economics (Dual Major), University at Buffalo, Spring 2018

Teaching Areas

- Microeconomic Theory (all levels), Principles of Macroeconomics (undergraduate), Game Theory (all levels), Behavioral Economics (all levels), and an interest course in Computational Modeling in Python.

Teaching Experience

- As **Instructor**:
  - Intro Microeconomics (Undergraduate), Fall 2022 (x2) at Ithaca College
- As **Teaching Assistant**:
  - Intro Microeconomics (Undergraduate), Fall 2019, Spring 2020 at Binghamton University
  - Macroeconomic Theory (PhD), Fall 2020, Fall 2021 at Binghamton University

  - Agent-Based Policy Modeling (in Python) (Masters/PhD), Spring 2023 at Binghamton University

- As **Department-Hired Tutor**:

  - Microeconomic Theory: Game Theory (PhD) Comprehensive Exam Review, Summer2021 at Binghamton University
  - Macroeconomic Theory (PhD) Comprehensive Exam Review, Summer2022 at Binghamton University

All student evaluations can be found here.

Research Fields

Computational Modeling, Behavioral Economics, Game Theory, Microeconomic Theory, Complex Systems, Learning Models and Optimization

Job Market Paper

- **A Case for Simulated Self-Play in Decision Models with Learning**
  Abstract: While there is an extensive history of bringing decision theories with learning to lab data, such models have been plagued with inadequate assumptions about the information players know before the first round of play. To solve this problem, I discuss the notion of Simulated Self-Play (SSP), in which agents play simulated rounds of the game against themselves to develop intuition about the nature of the game before the first round of play. Although some existing models of artificial intelligence have utilized self-play to achieve high performing solutions to some fairly complex problems (e.g. Alpha Zero playing Chess and Go), its exploration as a cognitive parameter when modeling human behavior has been relatively unexplored. First, I make the case that SSP improves theoretical coherence by discussing a number of common alternative assumptions (uniform / no priors, fitted priors, and burned-in priors), some of their a priori issues, and how Simulated Self-Play addresses many of them in a parsimonious way. Next, I evaluate the empirical value of SSP by implementing a simple learning model using priors formed via SSP and the alternatives and then compare their performance at predicting out-of-sample play in variations of the Beauty Contest game. I find that Simulated Self-Play performs as well or better than all of the aforementioned alternatives.

Working Papers

- **Evolving Sustainable Institutions in Agent-Based Simulations with Learning** with Andreas Pape, Todd Guilfoos, and Peter DiCola.

In revise & resubmit status at JEBO, first submitted June 2024

Abstract: Elinor Ostrom identified eight design principles for the management of common-pool resources across hundreds of case studies. We develop a novel computational model in which learning agents intentionally explore the action space in a common resource game under different policy regimes to test the conditions in which one of Ostrom's design principles, graduated sanctions, emerges. We characterize the long-run policies that emerge top-down via a computational social planner and bottom-up via democracy, modeled as an endogenous self-governance process.

First, we find that graduated sanctions emerge top-down via a social planner who utilizes a fine-based policy without redistribution, but only when agents utilize similarity in their decision-making process. Next, we find that, when policy makers are able to redistribute fines, draconian-style sanctions emerge. We also demonstrate that implementing the theoretical solution for rational agents who fully understand the game can forgo substantial potential gains in social welfare. Finally, we observe that, when agents participate in "democracy" (a bottom-up policy selection mechanism via voting for representatives) they are able to solve the commons problem fairly well, though we do not observe graduated sanction emerge in this context.

- **Monte-Carlo Tests for Identification of Stochastic Agent-Based Models** with Nency Dhameja, Yixin Ren, and Andreas Pape.

  Abstract: Agent-based models (ABMs) are increasingly used for formal estimation and inference, but their complexity and algorithmic nature pose persistent challenges for the formal assessment of estimator properties.

  This paper highlights the indispensable role that Monte Carlo simulations (MCS) can play in addressing these challenges. We show that MCS can systematically evaluate whether parameters of an ABM can be reliably estimated, as well as how estimate accuracy and precision depend on factors such as search algorithm choice and the number of model runs conducted. We also introduce a novel Monte Carlo test that disentangles imprecision due to the stochasticity of the model and estimation process itself versus that sourced by sampling variation.

  We apply these techniques to two example applications: first, a repeated prisoner's dilemma model with learning agents and second, a model of information diffusion over a network. Our results demonstrate that, while the parameters of these models can be identified in principle, estimator performance can be highly sensitive to choice of hyper-parameters used in the es-

timation process and to features of the model itself. These findings underscore the practical importance of applying MCS-based diagnostics before drawing substantive conclusions from estimated ABM parameters.

- **A Guide for Estimating Agent-Based Model Parameters, their Confidence Intervals, and Establishing Estimator Properties using AgentCarlo** with Nency Dhameja, Yixin Ren, and Andreas Pape.

  Abstract: Although many agent-based models (ABMs) have traditionally served as tools for demonstrating proof-of-principle findings, it is increasingly common and desirable for such models to be used directly for empirical estimation across a range of disciplines. This shift underscores the need for accessible and econometrically sound estimation methods tailored to ABMs.

  This paper presents a practical and broadly applicable approach for bringing agent-based model to panel data paired details on how such methods can be easily used via our new Python package AgentCarlo. We explain how to estimate best-fitting parameters via the Simulated Method of Moments, covering the summarization and aggregation of model output, construction of a fitness function, and selection of an optimization algorithm. We also cover how to obtain critical values using block bootstrapping, including the interpretation of confidence intervals and hypothesis testing in this context. Finally, we also briefly cover the suite of Monte Carlo simulations (as detailed in our companion methodological paper "Monte-Carlo Tests for Identification of Stochastic Agent-Based Models") which can be used to evaluate key properties of the estimation procedure.

- **On the Preservation of Input/Output Directed Graph Informativeness under Crossover** with Andreas Pape, J. David Schaffer, and Hiroki Sayama.

  Under review at Complexity, submitted April 2025
  Abstract: There exists a broad class of networks that connect inputs to outputs. These networks include chemical transformation networks, electrical circuits, municipal water systems, and neural networks. The goals of this paper are to provide a theoretical foundation for evolutionary crossover on this class of graphs and connect crossover to *informativeness*, a measure of the connectedness of inputs to outputs. Informativeness is defined as: a *partially informative* graph has at least one path from an input to some output, a *very informative* graph has a path from every input to some output, and a *fully informative* graph has a path from every input to every output. If a neural network with non-zero weights and any number of layers is fully informative. As links are removed (assigned zero weight), it may become very, partially,

or not informative. (The complement of informativeness is *actionability*, which is a measure of how connected outputs are from inputs.)

We define a crossover operation on IOD Graphs in which we find subgraphs with matching sets of forward and backward directed links to "swap." With this operation, IOD Graphs can be subject to evolutionary computation methods. We show that fully informative parents may yield a non-informative child. We also show that under certain conditions, crossover compatible, partially informative parents yield partially informative children, and very informative input parents with partially informative output parents yield very informative children. However, even under these conditions, full informativeness may not be retained. Similar results hold for actionability.

Presentations

- "A Case for Simulated Self-Play in Decision Models with Learning"
  Eastern Economic Association Computational Economics & Complexity Workshop, NY, NY February 2025
- "Evolving Sustainable Institutions In Agent Based Simulations With Learning"
  Eastern Economic Association Computational Economics & Complexity Workshop, Boston, MA February 2024
- "Evolving Sustainable Institutions In Agent Based Simulations With Learning"
  Commons, Commoning, and Social Change Workshop (School for Environment and Sustainability - University of Michigan), Ann Arbor, MI, Fall 2023
- "Evolving the Commons" Graduate Workshop in Computational Social Science, Santa Fe Institute (with John Miller and Scott Page), Santa Fe, NM, June 2023
- "Evolving the Commons" Complex Systems Summer School, Santa Fe Institute, Santa Fe, NM, July 2022

Skills

- Coding: Python (proficient), Stata and R (some experience)
- Development Tools: Git, GitHub, VS Code, Jupyter, Git Bash, Claude, ChatGPT
- Software: Excel, LaTeX, AutoCAD, Revit, Inventor
- Quantitative Skills: Computational modeling, structural estimation, causal inference (IV, RDD, Diff-in-Diff), stochastic optimization, behavioral modeling, experience using LLMs (e.g., ChatGPT, Claude) to streamline coding and analysis

- Other: Teaching, project management, strong quantitative foundation, independent problem-solving, effective communication of complex ideas, tech-savvy, collaborative, proactive

Other

- President of the Graduate Student Organization for the Economics Department, Fall 2020 - Summer 2021
- Student coordinator for the Fourth Northeast Regional Conference on Complex Systems, Binghamton University, Spring 2021
- Peer advisor to Weiwen Zou, Spring 2023 - Present

References

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