# Adaptive Experimentation and Data-driven Decision Making

*NBER Digitalization Tutorial Application*

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## 1 Applicant Information

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## 2 Graduate Course of Study

My course of study during my Ph.D. in Information Systems has focused on intersectional topics between microeconomics and machine learning. I am the recipient of the NSF GRFP award in economics for my application on algorithmic pricing collusion. In 2023-2024, I was a research fellow at the United Nations. Substantial courses have included "No-regret Learning in Games," "Reinforcement Learning," "Digital Economics," and "Advanced Data-driven Decision Making" (Specialized Bandit Algorithms). These are built atop standard foundational classes of "Real Analysis," "Causal Inference," "Stochastic Processes," and "Foundations of Machine Learning and Sequential Decision Making." These courses represent a partial listing of my graduate coursework. I have also served as a teaching fellow at NYU for various graduate-level data science courses along with undergraduate microeconomics. Additional details can be found in my CV.

## 3 Research Interests

My Ph.D. work centers on a conviction that algorithmic decision-makers will fundamentally change the social and economic institutions that underpin today's society. I chose to pursue a Ph.D. at NYU's Stern School of Business because of its focus on technology and its strong connection to the departments of economics and data science. Just as behavioral economics has become a topic of great interest over the past few decades, I believe the study of algorithmic agents will be a vital

perspective within the quantitative social sciences in the coming years. My goal as a researcher is to better establish models of these interactions and help continue to lay the foundation for the economic study of algorithmic agents. A dual side of this agenda is in constructing better algorithmic decision making methods with an explicit integration of the economic and social contexts in which they are used. Specifically, my work has focused largely on data-driven decision-making and adaptive experimentation. I am actively pursuing a few streams of work, outlined below.

**Algorithmic Pricing Collusion** The first stream of my research is in algorithmic pricing collusion. Here, I am studying the effects of what we call *naive collusion* whereby pricing agents are unwitting to the multi-agent nature of the market environment. This work differs from the Calvano et al. (2020) work in that we study bandit learners (which store no state of the environment) and that we focus primarily on theoretical analyses. Here, we have developed an analytical model to study the interaction between multi-armed bandit learners performing online pricing experiments with no underlying knowledge of game structure or opponent actions. We have found that the use of different, standard bandit learning algorithms can lead to starkly different collusion results. Moreover, we prove that symmetry between agents increases the likelihood of collusion being reached, which speaks directly to a form of "hub and spoke" algorithmic collusion in which a central firm distributes pricing software to multiple sellers in the same market. I am looking to improve this work analytically, by characterizing the effect of symmetry and determinism in broader market settings. With this, I am in the process of characterizing collusive cycles in addition to our extant analysis of long-run collusive behavior. In addition to these theoretical analyses, however, I am especially interested in identifying ways of studying algorithmic pricing collusion empirically.

**Misinformation Detection** The second topic I am actively studying is how to identify and characterize online misinformation. This project has spun out from work done while I was a research fellow at the United Nations in the Department of Peace Operations. In completed work, I have developed a better method for classifying narratives by fine-tuning sentence embedding models via LLM feedback and learning a clustering algorithm on these embeddings. This system is useful not only for real-time monitoring but also potentially as a tool for empirical studies of social media behavior, including in the identification of coordinated behavior, topic drift, and influence networks. The results of using this method so far are promising, and the system is currently being implemented by analysts at the UN. I am in the process of extending this to an online learning setting so that this method can be used for real-time sequential content monitoring. I also plan to extend this method to empirical work described in section 4.

# 4 Interest in NBER Digitalization Tutorial for Future Work

Beyond garnering feedback on my current streams of work, I hope to join the NBER digitalization tutorial and workshop to enhance my skill set in empirical economics. My work thus far has been largely in developing analytical models and computational methods for studying social and economic phenomena. As I look to ensure regulatory impact, however, I intend to pursue more empirical work going forward. With sufficient data access, I hope to perform empirical analyses of pricing behavior to find stronger evidence of collusive behavior via supra-competitive pricing. Specific to my "naive collusion" work, I am interested in learning about what approaches exist (or can be applied) to model algorithmic learning behavior from observations of an agent's actions. A central challenge I have been trying to address is in devising a statistical test to identify an agent's learning algorithm from observations of actions it has taken. This is a critical but unsolved step in identifying the

potential for algorithmic collusion to arise in specific online markets given observations of sequential pricing decisions.

Tying this stream into my interest in misinformation, a central reason I hope to attend this tutorial and associated meeting is to learn about current work on platform regulation. Here, I am interested in how price visibility decisions by platforms can affect collusion potential. Regarding information integrity, I am interested in how changes to recommendation systems can affect the spread of misinformation and hate speech online. I believe the method I've been developing to identify narratives, which leverages recent advances in natural language processing, may be paired with more established techniques of information diffusion to garner novel insights on the relationship between platform policies and information integrity. In sum, I hope to use this tutorial to better understand recent advances in empirical methodology and how they can be leveraged to study the collective impacts of algorithmic decision-makers and their effect on social welfare.