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2021　2023

Evolution, misspecification and equilibrium

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Stochastic Dynamics
and Edmonds' Algorithm   Deep and Shallow Thinking in the Long
Run   Rational beliefs when the truth is not an option

　　　　　The research on decision-making in misspecified environments has advanced
our understanding of economic dynamics under uncertainty. It produced publications including "
Stochastic Dynamics and Edmonds' Algorithm" which investigates cyclic decompositions in economic
dynamics, and "Deep and Shallow Thinking in the Long Run," co-authored with Heinrich Nax in Zurich,
which examines long-term effects of k-level strategic reasoning. Another work, "Rational beliefs
when the truth is not an option," co-authored with Filippo Massari in Bologna, critiques established
models of equilibrium in misspecified environments, proposing a new goal function that optimizes
both log-likelihood and payoffs. This suggests a fundamental reevaluation of economic rationality in
uncertain scenarios, challenging existing orthodoxies and pushing forward new theoretical
frameworks.

Economics

Evolution Misspecification Equilibrium Rationality Cycles

The research commenced with a focus on the implications of decision-making and equilibrium within economic models under the assumption that agents may hold flawed or "misspecified" models of the world. Recognizing that traditional models often incorrectly presume agents have an accurate understanding, the project was inspired by the adage from George E.P. Box that "all models are wrong, but some are useful." The foundational belief that true models might not even be considered by decision makers drove this research, which utilized evolutionary game theory, computer science, and behavioral economics to critically examine economic behavior in misspecified environments. By doing so, the research sought to illuminate how these misspecified models influence real-world economic outcomes and decisions, thereby challenging the conventional wisdom that relies heavily on the assumption of perfect information and rational decision-making. This broader perspective aimed to bring more realism into economic theory and to better understand the nuances and complexities of human decision-making in practical scenarios. Furthermore, it explored the limitations of existing models and the potential for developing new, more robust frameworks that can better accommodate the unpredictability and imperfections inherent in real-world decision-making processes.

The main objective of the research was to investigate how economic decision-making and equilibrium are affected under the influence of misspecified models of the world. The project aimed to explore whether established economic conclusions could withstand the reality of model misspecification and worked on developing new models that better reflect the irrational yet adaptive behaviors observed in such conditions. This was pursued through theoretical modeling, focusing on reevaluating behaviors previously labeled as "irrational" within the framework of evolutionary adaptiveness to misspecification. The overarching goal was to enhance the robustness and applicability of economic theories by incorporating elements of human behavior that have traditionally been overlooked or misunderstood, thus providing a more comprehensive and accurate depiction of economic dynamics. By addressing these gaps, the research sought to contribute to a more nuanced understanding of how individuals and markets operate under less-than-ideal informational conditions. In addition, the project aimed to offer practical insights and tools for policymakers and economists to better navigate and manage economic systems characterized by widespread model misspecification.

The project employed rigorous theoretical modeling as its primary research method. This approach involved integrating mathematical techniques from information theory, computer science, and evolutionary game theory. Collaborative efforts with experts such as Filippo Massari and Heinrich Nax enhanced the depth and scope of the theoretical investigations. The focus was on developing a theoretical framework capable of addressing the complexities of economic behaviors in misspecified settings, which helped to uncover significant insights into the dynamics of economic decision-making under uncertainty. By leveraging these interdisciplinary methods, the research aimed to build a solid foundation for understanding how agents adapt and make decisions when their models of the world are inherently flawed or incomplete. This methodological rigor ensured that the findings were not only theoretically robust but also relevant to practical applications and policy-making. Additionally, the project utilized computational simulations to test and refine the theoretical models, providing empirical support and validation for the proposed frameworks. These simulations helped to illustrate the practical implications of the theoretical findings and demonstrated their applicability to real-world economic scenarios.

The research project on decision-making and equilibrium in misspecified environments has advanced our understanding of economic dynamics under uncertainty. By exploring how agents operate with flawed or incomplete models of their environment, the project has produced several research papers, each addressing different facets of economic theory under the assumption of misspecification. These studies have offered new theoretical frameworks and insights, challenging conventional wisdom in economic decision-making and strategy formulation. Furthermore, the project has provided a deeper understanding of the adaptive nature of economic agents, highlighting how they can still function effectively despite the inherent imperfections in their models. The research has also paved the way for future studies to further explore and refine these concepts, offering a rich foundation for ongoing investigation into the complexities of economic behavior.

In "Stochastic Dynamics and Edmonds' Algorithm" (Journal of Dynamics and Games, 2022), the research explored the application of cyclic decompositions to stochastic dynamics, drawing parallels to the stages of Edmonds' algorithm used in optimization problems. This paper demonstrates how short, medium, and long-term behaviors in economic dynamics can be conceptualized and analyzed through the lens of algorithmic processes, providing a robust mathematical foundation for understanding economic behavior under various types of dynamic and stochastic conditions. This paper was already a work in progress at the start of the grant. It was written together with William Sandholm. Sadly, I had to complete the work on my own following his death. This paper has made significant contributions to the field by linking algorithmic concepts with economic dynamics, offering new tools and perspectives for future research. Moreover, it has opened up new avenues for exploring the intersections between economic theory and computational algorithms, highlighting the potential for cross-disciplinary approaches to enhance our understanding of complex economic phenomena.

The paper "Deep and Shallow Thinking in the Long Run" (Theoretical Economics, 2022), co-authored with Heinrich Nax at the University of Zurich, investigates the long-term effects of cognitive hierarchies on behavior in strategic settings. Despite the significant short-term impact of varying strategic reasoning abilities among players, the study finds that such variations do not persist into the long run. Specifically, when generalized risk-dominant strategy profiles exist, they tend to emerge in the long run, irrespective of the initial strategic reasoning abilities of the players, which may be highly heterogeneous and evolve over time. This paper contributes to the equilibrium analysis in economics by showing that the convergence to risk-dominant equilibria in populations under broad classes of best response dynamics is robust to the level of iterative reasoning employed by the players. This finding has important implications for understanding the stability and evolution of strategic behaviors in economic systems over time. Additionally, it provides valuable insights into how different cognitive strategies can influence long-term outcomes, offering practical implications for both theoretical research and policy-making.

The paper titled "Rational beliefs when the truth is not an option," co-authored with Filippo Massari at the University of Bologna, considers decision-making processes within misspecified environments and frames popular models of misspecification like Berk-Nash Equilibrium (BNE) as finding an equilibrium of a two-player game internal to an individual where one 'player' selects strategies to maximize expected payoffs and another chooses models to maximize expected log-likelihood. The paper argues that this often fails to maximize both log-likelihood and realized payoffs. By introducing an innovative goal function and a corresponding learning algorithm, the paper demonstrates how agents can achieve better outcomes by selecting models and strategies from the Pareto frontier of these objectives. This approach allows for higher payoffs and greater model accuracy, suggesting a significant rethinking of how rationality is understood and applied in economic theory, especially under conditions of uncertainty and misspecification. This paper is very hard to publish as it challenges existing orthodoxy. We are continuing in our efforts to publish it. This ongoing effort underscores the importance of challenging established norms and continuously pushing the boundaries of economic research. Additionally, it highlights the potential for innovative approaches to reshape our understanding of rationality and decision-making in economics, providing a more realistic and adaptive framework for analyzing economic

behavior in complex and uncertain environments.

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Stochastic dynamics and Edmond's algorithm				2022
Journal of Dynamics and Games				529-546
DOI 10.3934/jdg.2021029				

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Deep and shallow thinking in the long run				2022
Theoretical Economics				1501-1527
DOI 10.3982/TE4824				

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What should economic agents learn in misspecified environments?		
University of Sydney		
2022		

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What should economic agents learn in misspecified environments?		
National University of Singapore		
2022		

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Evolution of collaboration	
Learning & Evolution in Games (LEG2022)	
2022	

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Overview of asymmetry	
Economics & Management in the era of Data Science workshop (EMbeDS2022)	
2022	

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Good biases in misspecified learning	
Learning & Evolution in Games (LEG2023)	
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Rational beliefs when the truth is not an option	
University of Tokyo workshop on misspecified learning	
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Evolution of collaboration	
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