Introduction to the *Handbook of Experimental Game Theory*

C. Mónica Capra, Rachel T.A. Croson, Mary L. Rigdon and
Tanya S. Rosenblat

As for all sciences, economics continues to advance and evolve. It started as a subfield of philosophy and went through various phases influenced, in part, by advances in other disciplines. Economics in the late nineteenth century morphed from philosophy to its neoclassical phase, led by Alfred Marshall. Marshall wished to improve the mathematical rigor of economics and transform it into a more scientific profession. He was successful at this endeavor, and his book, *Principles of Economics* (1890), was the dominant economic textbook in England for many years, able to influence generations of economists throughout much of the twentieth century. With a solid scientific framework to organize economic thinking, the evolution of economics into an empirical science was inevitable.

In 1944, John von Neumann and Oskar Morgenstern published *Theory of Games and Economic Behavior*. This groundbreaking book introduced a new paradigm of thinking about economic interactions, and completely transformed the way economists analyzed behaviors. Its influence reached into every sub-discipline, from industrial organization to labor economics to trade and development. Game theory inspired Leonid Hurwicz. Hurwicz (1945, 1960) developed the theory of mechanism design. Mechanism design has been useful for modeling voting, bargaining, taxation, auctions and other economic institutions. Almost contemporaneously, Vernon Smith (1962, 1976) started thinking of ways to empirically assess the performance of economic institutions.

The dominant view in the 1970s was that economics was an observational science. It was believed that, unlike chemists or physicists, economists could not test theories in controlled environments. Peer-reviewed articles using the methodology of experimental economics were almost nonexistent until the mid-1960s. Vernon Smith challenged this view. Soon after Smith's publications found themselves on economists' desks, a large and growing community of researchers realized that controlled experiments represented a fruitful way to test propositions that were previously thought untestable. The effect of experimentation in economics, however, quickly went well beyond testing propositions. Indeed, experiments created a paradigm shift. In Vernon Smith's (1989, p. 152) own words: '[e]xperimentation changes the way you think about economics ... economics begins to represent concepts and propositions capable of being or failing to be demonstrated.' Smith shared the 2002 Nobel Prize in economics with Daniel Kahneman, one of the founding fathers of behavioral economics. The twenty-first century started with the recognition that experimental economics methods are important tools for advancing economics as a science.

The aims of this *Handbook* are twofold: to educate and to inspire. It is meant for researchers and graduate students who want to learn from leading experts in the field and who are interested in taking a scientific approach to the study of game theory. Educators and students of economics will find the *Handbook* useful as a companion book to conventional upper-level

game theory textbooks. Researchers and non-specialists will find in this *Handbook* valuable examples of laboratory and field experiments that test game-theoretic propositions and suggest new ways of modeling strategic behavior.

The *Handbook's* 16 chapters are organized into three main parts: methodological considerations (Chapters 1–5), games of complete information (Chapters 6–12), and games of incomplete information (Chapters 13–16). This structure allows the *Handbook* to be used alongside a traditional game theory texts such as *Game Theory* by Fudenberg and Tirole (1991), which is organized in a similar way, or as a stand-alone volume. Each part includes chapters that offer new directions and cutting-edge topics of research in experimental game theory. We next briefly describe each part and the individual chapters within them.

Part I addresses a sampling of methodological innovations in measurement of strategic behavior using experimental methods. It also includes advice on how to address the challenges inherent in those innovations. This part is of particular interest to game theorists who are interested in designing experiments and analyzing experimental data as well as experimentalists who are new to game theory.

One of the main challenges facing experimenters interested in testing game-theoretic predictions is that typical participants in experiments are not as rational as the standard model assumes. In Chapter 1, ‘Stochastic game theory for social science: a primer on quantal response equilibrium’, Jacob K. Goeree, Charles A. Holt and Thomas R. Palfrey describe their path-breaking methodology to make sense of experimental data by acknowledging that participants are likely to make mistakes. Quantal response equilibrium (QRE) replaces the sharp responses of standard game theory with smoothed quantal responses. The authors focus on applying QRE to explain intuitive deviations from Nash equilibrium predictions. They walk the reader through standard applications, including simple matrix games, multiplayer games, games with continuous strategy spaces, multistage games in extensive form and Bayesian games.

Economic theorists have acknowledged frequent departures from Nash equilibrium prediction seen in experimental games by developing theories of bounded rationality. A class of models that has received a great deal of attention involves some or all players acting rationally on incorrect beliefs concerning the strategies of others. Since beliefs are notoriously difficult to measure in an incentive-compatible way, many of the advances in measurement have focused on classifying players into different types and deducing their beliefs from choice data. Econometric finite mixture models offer statistical tools to separate subjects into different types. Chapter 2, ‘The experimetrics of depth-of-reasoning models’ by Peter G. Moffatt, explores econometric issues related to estimating player types based on choice data in several contexts, including much studied levels of reasoning analysis of beauty contest games, the 11–20 money request game, hide-and-seek games and belief-based reasoning in auctions.

Chapter 3, ‘The process of choice in games’ by Giorgio Coricelli, Luca Polonio and Alexander Vostroknutov, describes techniques used to unpack the black box of decision-making by collecting auxiliary data on the decision process itself. The authors provide practical insights on how choice process data, such as reaction time, mouse movements and eye tracking, can be integrated into the analysis of participants’ choices. This chapter introduces readers to the cutting-edge methodology which takes a step back from focusing on the final reported choices by studying mechanisms of how these choices come about. These methods will be of interest to game theorists who want to understand the biological foundations of behavior, experimental and behavioral economists who want to unpack

decision-making processes in other possibly non-strategic settings, and neuroscientists who can use these data to motivate even deeper explorations of the brain activity.

In Chapter 4, ‘Games with continuous-time experimental protocols’, Alexander L. Brown and Daniel G. Stephenson describe the benefits of continuous-time protocols where subjects receive real-time feedback on their actions and some of the important results gleaned from the methodology. They categorize the types of potential protocols and the results obtained from each of their uses, while also describing how the behavioral results obtained are similar or different from the more standard protocols.

Chapter 5, ‘Bargaining in the field’ by Marco Castillo and Ragan Petrie, deals with an important concern regarding external validity of laboratory experiments by providing a detailed example of a field study designed to address a specific set of bargaining models. The chapter shows how to conduct theory-motivated field experiments in a naturally occurring bargaining setting – a taxi market in Peru which predates proliferation of ride-sharing platforms.

Taken together these chapters highlight complementary approaches to measurement that experimental economists have pursued in understanding strategic behavior in the laboratory and in the field: by modifying solution concepts to account for participants’ mistakes, using insights from econometrics to infer player types, tracing the decision-making process by collecting choice process data, and adding generalizability by conducting naturalistic studies in field settings.

Part II can be used to supplement the standard game theory treatment of static and dynamic games of complete information. This part looks at familiar contexts such as coordination games, games of cooperation including prisoner’s dilemma and public goods games as well as equilibrium selection and enforcement mechanisms, such as social norms and punishment.

Chapter 6, ‘Recent advances in experimental coordination games’ by David J. Cooper and Roberto A. Weber, explores new developments in the experimental literature on coordination games. Coordination games are particularly suitable for exploration in the laboratory because theory is usually agnostic about equilibrium selection in multiple equilibria settings. The authors direct readers to many existing review papers on coordination games and focus on two recent avenues for exploration: pure-matching (or Schelling) coordination games and weak-link games. Most of the exciting work on pure coordination games has been exploring the role of salience in strategy labeling and in payoffs. Salience appears to be a robust coordination device across numerous types of games and populations. Weak-link games have garnered a lot of attention owing to the basic underlying conflict between payoff dominance and safety. The authors review recent results on the role of increased incentives, communication, leadership, and endogenous group formation in achieving coordination on more efficient equilibria.

In Chapter 7, ‘Public goods, norms and cooperation’, Marie Claire Villeval reviews a large experimental literature on cooperation with non-kin group members in public goods games. She first examines how the heterogeneity of social preferences and norms in groups can explain the dynamics of cooperation over time. She then reviews various institutional arrangements that sustain the norm of cooperation and enable self-governance. Specifically, she explores the role of punishment of norm violators and reward of cooperators, and mechanisms based on communication, leadership and assortative matching.

In Chapter 8, ‘Cooperation among strangers with and without a monetary system’, Maria Bigoni, Gabriele Camera and Marco Casari look at a specific case of coordination on efficient equilibria in cooperation games in which money emerges as an institution that reduces

strategic uncertainty. Their contribution highlights that game-theoretic modeling can help understand macroeconomic phenomena, such as monetary exchange. Since natural data is not readily available to test theories of money, experiments provide a perfect sandbox to explore why money exists and how it impacts allocations.

In Chapter 9, ‘Game-theoretic accounts of social norms: the role of normative expectations’, Cristina Bicchieri and Alessandro Sontuoso look at social norms as informal group-specific solutions to strategic problems. They define social norms as behavioral regularities that emerge in social dilemma games. Norms emerge through preferences for conformity and endogenous sets of beliefs and expectations. The chapter provides valuable insights on both the measurement of social norms using experiments and explaining norm-driven behavior in important social science contexts.

In Chapter 10, ‘Strategies used by non-human primates in dynamic games’, Mackenzie F. Smith, Julia Watzek and Sarah F. Brosnan provide an overview of research on human and non-human primates across a wide-variety of experimental games, including the stag hunt game, matching pennies, and the ultimatum game, utilizing a comparative methodology. Through this research, we learn important similarities and differences in our cognitive mechanisms with other animals and something about the role evolutionary history has played in shaping our strategies.

Together, these chapters demonstrate transformative behavioral research focused on classic topics in game theory: cooperation and coordination games. We learn about mechanisms for sustaining cooperation in repeated games, equilibrium selection in games with multiple equilibria, and applications to such diverse phenomena as monetary exchange and social norms. These foundational topics are at the core of any course in applied game theory. They also highlight the nuance that experiments have delivered to our understanding of strategic interactions among decision makers, be they human or non-human primates.

Experimental research has consistently found that many individuals do not act to maximize their monetary payoffs even in very simple and easy-to-understand social interactions. Both theorists and experimentalists have to grapple with the fact that payoffs modeled in games are expressed in terms of utility, while payoffs presented to participants in the laboratory have to be in dollars or experimental currency units that convert to dollars. A great deal of the research in experimental game theory has been focused on trying to explain these deviations by enriching game-theoretic models to take into account distributional preferences and psychological states of decision makers. In Chapter 11, ‘Reciprocity in games with unknown types’, Garret Ridinger and Michael McBride provide a critical review of the several classes of models that have been used to explain theoretically puzzling reciprocal behavior in one-shot interactions. These models can be broadly classified as models with preferences over distributional outcomes (models of social preferences), models with utility from beliefs about others’ intentions (psychological game theory), models with utility from adherence to norms, and models that incorporate emotion and cognition of players. This chapter highlights these different strands of research used to explain seemingly irrational behavior in one-shot games, and it provides a conceptual framework for deeper explorations by instructors of game theory and researchers in the field.

Chapter 12, ‘Behavioral rules’ by Carlos Alós-Ferrer and Johannes Buckenmaier, provides an overview of the literature on stochastic learning in coordination games, when agents interact on a network, and when firms compete (for example, oligopolies) by first presenting theoretical results and then reviewing laboratory experiments. They begin by outlining a

general model that incorporates behavioral rules, for example, myopia and social learning. Experimental testing of the framework generally examines the nature of long-run convergence and what factors help determine convergence. They conclude with a discussion of a second type of experiment that attempts to identify the behavioral rules from the observed behavior. This chapter also serves as a natural transition to Part III, which focuses on static and dynamic games of incomplete information.

Part III includes four chapters. In Chapter 13, ‘Strategic information transmission: a survey of experiments and theoretical foundations’, Andreas Blume, Ernest K. Lai and Wooyoung Lim survey the experimental literature on communication of private information via cheap-talk messages. Some players have private information that is relevant to the decisions made by others. The informed players have the option to send the messages before decisions are made. Messages are named ‘cheap talk’ because they do not directly affect payoffs but can link decisions to information. The authors focus on a class of games termed ‘sender–receiver games’ in which there are routinely multiple Bayesian Nash and perfect Bayesian equilibria. They review how language can help with equilibrium selection by focusing on the themes of available language, payoff structure and the compositions of the sets of communicating players. They leave the reader inspired to contribute new work to a field they name ‘communication design’.

Voting games and other collective decision situations often pose challenges for game theory predictions owing to multiplicity of equilibria. In Chapter 14, ‘Communication and information in games of collective decision: a survey of experimental results’, César Martinelli and Thomas R. Palfrey survey laboratory experiments on the role of communication (including cheap talk) and other pre-play activities for equilibrium selection. Specifically, they look at the release of information about realized preferences of voters, public messages about voting intentions such as pre-election polls, free-form communication, costly messages such as campaigns, advertising, or costly entry, sequential decisions in which some voters can observe the choices of others, and information acquisition activities. Some of these environments involve cheap talk and therefore do not change the set of possible equilibria, while others involve a change in the game form, which reflects plausible real-world scenarios.

In Chapter 15, ‘Voting game experiments with incomplete information: a survey’, Jens Großer provides a thorough overview of voting game experiments where there is incomplete information about voters’ opinions on what the best course of action may be as well as their characteristics, especially their private costs and benefits related to decision making and group affiliation (that is, which candidate or alternative they support). The literature discussed consists of two lines of research: (1) within the common value framework developed by Condorcet (1785), providing an understanding of how relaxing the assumptions of the jury theorem matters to voter choice; and (2) within the voter participation game of Palfrey and Rosenthal (1983, 1985), providing an understanding of factors that matter to voter turnout.

In our final chapter, Chapter 16 ‘Experiments in market design’, Siqi Pan focuses on two strands of literature in market design: auctions and matching. This literature focuses on thin markets, and studies the mechanisms that can generate a price (auction) or allocates without price (matching). On auctions, it covers the literature exploring the revenue-equivalence theorem in private-value auctions, the winner’s curse prominent in common-value auctions, and the various mechanisms developed and used in multi-unit auctions. On matching, it details

several frameworks, proposed solutions to the problem and experimental results in the various settings.

We are confident that this *Handbook* will be useful to a diverse group of readers. Educators and students of economics will find the *Handbook* useful as a companion book to conventional upper-level game theory textbooks. The *Handbook* provides non-specialists with a critical review of work completed to date and it can help specialists set an agenda for future research. Thus, the *Handbook* helps those looking to gain a broader understanding of experimental game theory and those looking for ideas to contribute to its advancement.

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