

Statement on Research Yonghong An

My research spans two closely related fields: empirical analysis of game-theoretic models and econometric methodologies on measurement error models. Game-theoretic models describe prevalent market mechanisms in our society, such as bilateral contracts and auctions, where agents interact strategically to maximize their returns. My research infers the preferences of those agents from their decisions and uses those preferences to predict the impact of policy changes. By exploiting a previously overlooked link implied by various structural models between *multiple* decisions of agents and their preferences, I study agents' subjective beliefs and their strategic behavior in contracts, auctions, and market competition. Measurement error models deal with economic analysis of data contaminated with measurement errors. My research provides econometric methods to deliver correct estimation for such models, considering that ignoring measurement errors would cause misunderstanding of economic phenomenon and thereby be detrimental to policy evaluation. My studies show that these two literatures are closely related, and methods developed to address measurement error are crucial in the empirical analysis of game-theoretical models. I have completed 20 papers on these two subjects; 14 have been published; two are under review (one under revision at *Journal of Econometrics*); and four are being prepared for submission. My research has gained widespread recognition: it has been applied in different fields of economics, included in course syllabi of graduate courses at top schools, and discussed in review articles, handbooks, and books in economics and computer science.

The empirical analysis of game-theoretic models. In this theme of my search, I study environments where there is information that impacts the agents, but is unknown to researchers and must be inferred, if possible, from the behavior and decisions of those agents.

1. Subjective beliefs in structural models. Decision-making under uncertainty is prominent in economics. The beliefs held by decision-makers about the uncertainty are therefore crucial in economic analyses. Unfortunately, economists typically do not observe beliefs, they rather impose a ubiquitous assumption called "rational expectations", i.e., beliefs about the uncertainty coincide with the distribution of ex-post realized outcomes. Nevertheless, empirical evidence show that such an assumption may be violated. In such a case, one dominating approach is to solicit beliefs and then to study decisions under those beliefs. However, collecting data on beliefs is costly or even impossible in some important datasets. Without relying on data of beliefs, my main contribution is to develop methodologies to study decision-making by relaxing the assumption of rational expectations. In "*Dynamic Decisions under Subjective Beliefs: A Structural Analysis*" (with Yingyao Hu and Ruli Xiao, *Journal of Econometrics*, 2021), we study dynamic discrete choice models in which forward-looking individuals make dynamic decisions. If individuals lack the information to correctly predict the future values of variables that determine their decisions, we show that both preferences and beliefs of individuals can be recovered from their choices and the observed value of the variables. Our approach relies mainly on variations of variables affecting agent decisions but being excluded from beliefs and preferences. An application of our methodology to the labor force participation choices of women illustrates the existence of systematic differences between workers' beliefs about the distribution of future household incomes and its realized counterpart. This finding implies that decision-makers' beliefs need to be addressed prior to any policy interventions. In "*Identification of First-Price Auctions with Non-Equilibrium Beliefs: A Measurement Error Approach*" (*Journal of Econometrics*, 2017), I propose a new approach to analyzing auctions with bidders not having "perfect foresight" of their opponents' behavior. In an empirical analysis of the United States Forest Service (USFS) timber auctions, I illustrate that bidders are less sophisticated than rational expectations. This suggests that the current mechanism of the USFS, based on rational expectations of bidders, is not efficient. I argue that the efficiency could be improved by changing the design of the auction, e.g., increasing the lowest acceptable bid. In "*Estimating Private Provision of Public Goods with Heterogenous Participants: A Structural Analysis*" (with Yingyao Hu and Pengfei Liu, *Journal of Economic Behavior & Organization*, 2018), we analyze a model of public goods contributions. The public good is provided only if the aggregated contribution of a group of individuals is not less than a predetermined cost; otherwise, the contributions are returned. We show that individuals' unobserved contributing strategies can be recovered without assuming perfect expectations about the contributions of

other members. Applying the results to experimental data, we find that individuals adjust their contributing strategies based on the history of provision outcomes. This finding can help policymakers to predict a provision outcome and to adjust the group size or provision cost to improve the successful rate.

2. Structural analysis of contracts. Economic agents enter contracts almost every day to coordinate their activities. Understanding the strategic behavior of such agents is necessary to evaluate the efficiency of the contracts. My studies investigate contract parties' strategic behavior and conduct welfare analysis. In "A Structural Analysis of Simple Contracts" (with Shengjie Hong and Daiqiang Zhang, working paper, revise and resubmit at *Journal of Econometrics*), we provide one of the first econometric frameworks for analyses of simple contracts that specify the payment scheme only as a function of the agent's observed cost, or even as a constant. We first propose to test the widely assumed linearity of cost function, and then to show that agents' costs, disutility functions, and bargaining power against the principal all can be recovered. In an application to transportation procurement contracts in France, we show that the linearity assumption of cost is rejected, and we provide a welfare analysis of simple contracts using the recovered model primitives. We find that incorrectly assuming linearity leads to a 65% overestimate of contract cost. These results are useful for policymakers to evaluate the efficiency of simple contracts. In "Specification and Negotiation in Incomplete Contracts" (with Xun Tang, *RAND Journal of Economics*, 2019), we address the issue of incompleteness in procurement contracts: both sides agree that the initial specification may be replaced by a new one if it leads to incremental surplus. In such cases, additional transfers are negotiated between the two parties. Studying contracts held by the California Department of Transportation, we find that firms have higher bargaining power against the government and on average and the holdup on the buyer due to contractual incompleteness is about 20% of project costs. In "Simple Menus of Cost-based Contracts with General Cost Structures" (with Daiqiang Zhang, *Journal of Public Economic Theory*, 2018), we prove theoretically that the specification of cost is crucial to evaluating the efficiency of a simple contract. In "Assurance Contract in Threshold Public Goods Provision with Incomplete Information" (with Zhi Li and Pengfei Liu, working paper), we propose a new contracting method for public goods provision that would greatly improve the provision rate.

3. Empirical analysis of auctions. Auctions have long been one of the most important market mechanisms in our society. Many government projects are procured through auctions; property is forfeited and used cars are sold using auctions; numerous products are auctioned off on eBay, etc. My research focuses on investigating the major factors that affect bidders' strategic behavior and on answering important policy questions using those factors. In "Government Procurement, Market Power and Consumer Welfare: Empirical Evidence from the Infant Formula Market" (with David Davis, Rui Huang, Yizao Liu, and Ruli Xiao, working paper), we examine the impact of government purchasing via procurement auctions in the US infant formula market on firms' strategic interactions and consumer welfare. Over 50% of total volume sales in this market are made to the Women, Infants, and Children (WIC) program sponsored by the USDA. We show that using procurement auctions to purchase the infant formula for WIC participants contains the overall cost paid by the program because manufacturers bid aggressively to win an exclusive contract. Such costs are then passed on to the non-WIC consumers. Our results are vital to evaluating the overall effectiveness of the program. In "Specification and Negotiation in Incomplete Contracts" (with Xun Tang, *RAND Journal of Economics*, 2019), we empirically demonstrate that the efficiency of government procurement auctions is negatively affected by ex post modifications of the project. Moreover, changing the contracting format to cost-plus (that is, buyer reimburses contractors for actual costs incurred plus a profit margin that is negotiated ex ante), frequently used in government procurement, does not alleviate the problem of extra cost caused by ex post modifications. Thus, a new mechanism is needed to reduce the costs imposed by ex post modifications. In "Identification of First-Price Auctions with Non-Equilibrium Beliefs: A Measurement Error Approach" (*Journal of Econometrics*, 2017), I show that first-price sealed-bid auctions with non-sophisticated bidders can be identified using a measurement error approach. In "Estimating First-price Auctions with an Unknown Number of Bidders: A Misclassification Approach" (with Yingyao Hu and Matt Shum, *Journal of Econometrics*, 2010), we propose a method for analyzing bidders' behavior without information about unrecorded bidders. We apply this method to construction auctions held by the New Jersey Department of

Transportation. We find that a bidder's profit margin can be underestimated by as much as 50% if one does not use our method.

4. Merger evaluation. In antitrust practice a fundamental question is how to evaluate the impact of mergers on consumer welfare. A merger can lessen competition and harm consumers, but it can also bring efficiencies that reduce costs, e.g., by generating economies of scale in production. My research tries to understand how firms' strategic behavior affects merger analysis in both online and off-line markets. In "*Dynamic Efficiencies of the 1997 Boeing-McDonnell Douglas Merger*" (with Wei Zhao, *RAND Journal of Economics*, 2019), we provide empirical evidence that firms' forward-looking behavior (learning-by-doing) is crucial to evaluating the welfare effects of a merger. Our analysis of the 1997 Boeing-McDonnell Douglas merger shows that it increases consumer surplus by \$5.14 billion because of the lower costs brought about by learning-by-doing (productivity increasing over time with accumulated production), while not using our method would predict a \$0.92 billion loss of consumer welfare, thus leading to erroneous policy conclusions for antitrust agencies. In "*Identification and Estimation of Online Price Competition with an Unknown Number of Firms*" (with Michael Baye, Yingyao Hu, John Morgan and Matthew Shum, *Journal of Applied Econometrics*, 2017), we address one issue regarding antitrust practice in the online market: the relevant number of competitors is often unobserved by researchers. We propose a methodology for quantifying the competitive effects of changes in the number of firms, which is unobserved by researchers. Our analysis of the personal digital assistant market in the UK illustrates, that the effects on consumers of changing the number of online firms are similar to those of an offline market with homogenous products, even though the price variation of a product in an e-retail market is much larger. This result is helpful for antitrust agencies when dealing with cases of online competition.

Measurement error models. Measurement errors in observed data are prevalent in economic analysis. On the one hand, many analyses rely on survey data which are known to be inaccurate because they are self-reported. On the other hand, some economic concepts---such as ability and human capital---are abstract and thus hard to measure accurately. The existence of measurement errors may lead to incorrect economic analysis and thus be detrimental to policy evaluation. My work focuses on providing econometric methods for correct estimation while directly dealing with measurement errors in the data. In "*Eliciting Information from Sensitive Survey Questions*" (with Pengfei Liu, 2020, under review), we develop a formal test for the assumptions of list experiments, a leading method in the experimental literature on sensitive questions. The result implies that the method may be problematic. Next, we propose a survey method for inferring unobserved sensitive information from inaccurate responses of subjects. Applying this method provides empirical results on how misreporting on sexual orientation and Lesbian, Gay, Bisexual, and Transgender - related sentiment depends on subjects' age, race, gender, and political attitudes. Such results cannot be recovered using list experiments. In "*A Nonparametric Nonclassical Measurement Error Approach to Estimating Intergenerational Mobility Elasticities*" (with Le Wang and Ruli Xiao, forthcoming, *Journal of Business and Economic Statistics*, 2020), we focus on intergenerational mobility elasticities (IGE) of child permanent income with respect to parental permanent income. We address two methodological issues: (1) permanent income is unobserved and not immediately operational, whereas only its imperfect measures – annual incomes – are observable; (2) IGEs may be different across parental income. Applying our method to Panel Studies of Income Dynamics data, we find that despite the considerable degree of mobility within America's broadly defined middle class, children of high-income parents are more likely to become high-income adults. In "*Identifying Models of Committee Decisions with Heterogeneous Tastes and Ideological Bias*" (with Xun Tang, *Journal of Business & Economic Statistics*, 2017), we focus on committee decision-making process where members' discrepancies are rationalized by two unobserved types according to how they weigh different sources of information and their tastes for multiple objectives in the policy target. We show that the distribution of types can be recovered from the members' choices by exploiting the structural link between the unobserved types and members' multiple decisions. Analyzing the interest rate decisions by the Monetary Policy Committee at the Bank of England, we show that external members are less strategic than internal members. In "*Well-posedness on Measurement Error Models for Self-Reported Data*" (with Yingyao Hu, *Journal of Econometrics*, 2012), we find that if survey respondents always report true values

with a positive probability, then we can accurately recover the distribution of an unobservable from survey data. This solves a long-standing problem in the literature.

Summary. I intend to continue to develop practical methodologies for applied economists and to apply my own or others' methods to important empirical problems, e.g., dynamic decisions in health market, value of reputation in informal-lending market, and publishers' decisions in setting prices of academic journals, etc.