RESULTS 2018

Many areas of economics use subjective data, gathered from respondents with traditional surveys as well as through new web-based information exchanges and markets. For example, prediction markets, which have been attracting increasing attention recently, rely on data from participants who provide probabilistic estimates of market-related and other events. Economic forecasting is another area that relies on subjective data, where "hard" data such as unemployment figures, actual consumer spending, exports etc., are often supplemented by qualitative judgments and surveys. Economic indexes such as Consumer Confidence Index and Happiness Index are used by economists to evaluate policy effects and plan future actions, while Labor Survey and Community Innovation Survey are just two examples of government surveys that are used to develop indicators and evaluate policies.

Subjective data is important for the private sector as much as for the public sector. Reliable and simple methods of eliciting data are especially important for small and medium enterprises that have very limited resources for market research. In use of subjective data the crucial question is its overall quality. More precisely, the key issue is how much confidence one can have in truthfulness of our respondents' answers and consequently in the findings derived from them. Subjective data is known to pose reliability problems, although this may not necessarily be a result of intention to deceive. One solution to this problem is presented by Bayesian Truth Serum (BTS), developed by Drazen Prelec (*Science*, 2004). This is a game-theoretic scoring system that provides incentives for honest reporting of private judgments. The method assigns a score to each of the respondents according to their answers, their predictions of how other people will respond, and on the actual answers by the other respondents. An important feature of the BTS method is that respondents are rewarded not only for their knowledge of the topic, but also for how well they know their peers, i.e. for their meta-knowledge.

Innovation development relies crucially on input elicited from potential innovation adopters. Regardless whether in private or public sphere, innovation is inherently an expensive and risky activity. To minimize the risk and improve chances for success, innovation developers aim to get information from the stakeholders into the development process starting at the beginning and continuing throughout the process. By improving the quality and reliability of subjective data, the BTS method opens up completely new possibilities for subjective judgment to be incorporated into economic research, most notably innovation research.

The aim of this project was to show how BTS could be incorporated in existing methodologies for innovation development to create improvements and deliver new value. Conjoint analysis was chosen as a test bed for this approach, being a very popular methodology within innovation development. Conjoint analysis is actually a set of methodologies with a predominantly statistical content that originated from mathematical psychology. It is an experimental approach for measuring consumer's preferences about a product, service, project or policy, and has been widely used in social and applied sciences. Although consumer measurement was recognized as a serious problem of this

method due to wear-out, self-perception biases, and other phenomena, no solution was offered yet.

Since choice based conjoint analysis involves a series of repeated choices, this project started with the study of how BTS can be incorporated in modeling of one choice event where people choose between two alternatives. An example for such an event is purchase intention survey, which asks subjects whether they want to buy a product or not. Purchase intention survey is often used for early sales forecasting and elimination of potentially failing concepts, although it is known that there is a systematic discrepancy between stated purchase intentions and purchase incidence. This is usually corrected by use of sophisticated statistical models, which require large quantities of respondent and product related data. A novel explanation for this discrepancy is recognizing that those respondents who are not sufficiently knowledgeable about the product report unreliable purchase intentions. Consequently, in order to improve forecasting precision, only the data from the knowledgeable respondents should be used for forecasting. So instead of collecting additional product and respondent specific data, the new approach championed in the BayInno project is to identify "high quality" data and discard the rest. The problem lies in the inability to recognize the knowledgeable respondents ex ante, as their understanding is usually tacit. A theoretical model is developed and an algorithm is produced that shows how to identify the tacit knowledge holders from their meta-predictions only. At the same time the intervention in data collection is minimal, as only one question needs to be added to the questionnaire. The algorithm was tested in three online experiments.

Having resolved the incorporation of BTS in one choice set, the ground was set for consideration of BTS and repeated choices. The resulting new hybrid methodology is called predicted preference conjoint analysis. A theoretical argument mathematically demonstrates that replacing the own choice (the alternative that the respondent would choose for him/herself) with the predicted choice (the alternative the respondent thinks will be chosen by majority of others) yields a more accurate estimate of personal utilities and more precise forecast of preference shares for the alternatives. In addition, it is shown that these results remain valid even when the information from respondents' social circles is biased, provided that the net bias across individuals is zero. These theoretical results are confirmed in three online experiments.

The advantage of both methods (purchase intentions with BTS and predicted preference conjoint analysis) is that engaging respondents' meta-knowledge employs the information contained in their social circle. This enlarges the actual sample, as predictions involve the members of all social circles. Also, in preference predicted conjoint it is possible to use online non-representative inexpensive samples as long as they are large enough so that the various biases cancel out. This makes conjoint analysis more accessible to small businesses, individual innovators, public sector entities, and anyone else who wants to forecast adoption of an innovation but has no budget to hire professional market research agencies.

The project has produced four working papers. Titles and abstracts are listed below.

WORKING PAPERS

- Cvitanic, Jaksa; Prelec, Drazen; Radas, Sonja, and Hrvoje Sikic; *Incentive Compatible Surveys via Posterior Probabilities.*

Abstract: We consider the problem of eliciting truthful responses to a survey question, when the re- spondents share a common prior about which the survey planner is agnostic. The planner would therefore like to have a universal mechanism, which would induce honest answers for all possible priors. If the planner also requires a locality condition that ensures that the mechanism payoffs are determined by the respondents' posterior probabilities of the true state of nature, we prove that, under additional smoothness and sensitivity conditions, the payoff in the truth-telling equi- librium must be the logarithmic function of the posterior probabilities. Moreover, the players are necessarily ranked according to those probabilities. Finally, we discuss implementation issues.

- Cvitanic, Jaksa; Prelec, Drazen; Radas, Sonja, and Hrvoje Sikic; *Bayesian Truth Serum and Information Theory: The Game of Duels.*

Abstract—This paper aims to develop insights into Bayesian truth serum (BTS) mechanism by postulating a sequence of seven natural conditions reminiscent of axioms in information theory. The condition that reduces a larger family of mechanisms to BTS is additivity, akin to the axiomatic development of entropy. The seven conditions identify BTS as the unique scoring rule for ranking respondents in situations in which respondents are asked to choose an alternative from a finite set and provide predictions of their peers' propensities to choose, for finite or infinite sets of respondents.

- Drazen Prelec and Sonja Radas; *Uncovering Hidden Knowledge in Stated Purchase Intentions: Application of Bayesian Truth Serum.*

Abstract - Purchase intention survey is often used for early sales forecasting and elimination of potentially failing concepts. It is a well-known fact that there is a systematic discrepancy between stated purchase intentions and purchase incidence, resulting from both temporal and non-temporal causes. These are usually corrected by use of sophisticated statistical models, which require large quantities of respondent and product related data. In this paper we offer a new explanation for this discrepancy: we suggest that some respondents are of "lower quality", either because they cannot understand the task or because they do not pay attention. So in order to improve forecasting precision, we propose to identify those respondents who are of "higher quality" and use only their data while disregarding the information the others. We address this issue by building a theoretical model and test it experimentally.

- Sonja Radas and Drazen Prelec, *Predicted Preference Conjoint Analysis*.

Abstract: In this paper we propose a new method of eliciting market research information. Instead of asking respondents for their personal choices and preferences, we ask respondents to predict the choices of other respondents to the survey. Such predictions incorporate respondents' knowledge of their peers, which presumably reflects their social network. The effectiveness of this approach has already been demonstrated in context of political polling. Here we extend it to market research, specifically, to conjoint analysis. A theoretical argument demonstrates that predictions should yield utility estimates that are more accurate, and less noisy than estimates based on own stated preferences. In addition, we show that our results remain valid even when the information from social circles is biased, provided that the net bias across individuals is zero. These theoretical results are confirmed in three online experiments.