



The Leverhulme Trust

Network Grant

MANCHESTER
1824

The University of Manchester

Bayesian Adaptive Survey Design Network

Ref: IN-2014-046

Annual Report

12 January 2016 – 11 January 2017

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University of Manchester

**The Leverhulme Trust International Network Grant: Bayesian Adaptive
Survey Designs (BADEN) Ref: IN-2014-046**

**Annual Progress Report
12 January 2016 – 11 January 2017**

Natalie Shlomo, University of Manchester

Network members

University of Manchester (Natalie Shlomo, PI)
University of Southampton (Gabi Durrant)
University of Michigan (James Wagner)
Central Bureau of Statistics (CBS) Netherlands (Barry Schouten)
United States Census Bureau (Stephanie Coffey)
Statistics Sweden (Peter Lundquist)
RTI International, USA (Dan Pratt)

Introduction

The activities for the second year of the Leverhulme Trust International Network Grant: Bayesian Adaptive Survey Design (BADEN) (Ref: IN-2014-046) were according to the original work plan as set out in the grant application with an additional bilateral meeting.

The network partners have made progress on the selected case studies for the application of adaptive survey designs. Statistics Netherlands has taken the lead in developing the theoretical approach on the introduction of prior distributions and their corresponding posterior distributions in models for the estimation of response propensities, design parameters and proxy measures of non-response error. They have also written R-codes for the derivation of these posterior distributions which will be used on the selected case studies. A first theoretical paper from the network has been drafted. In the final year of the grant, we will move beyond the design parameters and investigate the intervention and optimisation of adaptive survey within the Bayesian framework.

The website for the project is hosted by the University of Manchester:
www.badennetwork.com.

Below are details of the network events and meetings with a brief summary.

Network activities, events and meetings

As a reminder, the events in the first year of the grant: January 12th 2015 – January 12th 2016 were:

- The **Kick-start meeting** was held at the United States Census Bureau in Washington DC (26-27 February 2015).
- A **Bi-lateral meeting** between CBS Netherlands, University of Manchester and Statistics Sweden was held in the Netherlands (28 - 29 May 2015).
- The **Intermediary meeting** with all partners was held at Statistics Sweden in Stockholm (10 – 11 September 2015).
- October, 2015: The PI successfully proposed an **invited panel session** to the 71st Annual American Association of Public Opinion Research (AAPOR) conference, Austin Texas, May 12-15, 2016.
- **4th International Workshop: Advances in Adaptive and Responsive Survey Design** at the University of Manchester (9 - 10 November 2015)

The events in the second year of the grant: 12 January 2016 - 11 January 2017 are as follows:

- **Bilateral meeting** between the University of Manchester, Statistics Netherlands, University of Michigan and the US Census Bureau was held at the US Census Bureau in Washington DC (21 – 22 March 2016).

At this meeting, each country reported on their case studies and we received updates from each partner institution. These informed further discussions on what we will present at the 71st Annual AAPOR Conference, Austin Texas in May 2016 (see below). We held extensive discussions on the first theoretical network paper led by Statistics Netherlands on the general Bayesian framework paper: A Bayesian Analysis of Design Parameters in Survey Data Collection. The University of Michigan also presented their work on response propensity modelling for daily survey response monitoring under a Bayesian framework. Whilst visiting at the US Census Bureau, we also heard talks from members of staff on adaptive design applications for both the Survey of Income and Program Participation (SIPP) and for the US Decennial Census. It was very interesting to hear about some of the problems encountered when transforming research to practice.

- The **intermediary network meeting and presentations** at the 71st Annual AAPOR Conference, Austin Texas (12 – 15 May 2016).

The topic of the discussion at the intermediary meeting was to review and coordinate all presentations for the invited session and to discuss progress on case studies. The invited session was held on May 15th, 2016. The session was well-attended and a great success with positive feedback from the conference participants. The presentations

from the invited session are available at:

<http://www.cmist.manchester.ac.uk/research/projects/baden/documents/>

- An extra **bilateral meeting** between Statistics Netherlands, University of Southampton, Statistics Sweden and the University of Manchester was held at Statistics Netherlands (20 - 21 September 2016).

At the meeting, the Statistics Netherlands team demonstrated the software application in 'R' for the Bayesian estimation of design parameters which will be used for each case study, starting with the implementation on the case study of Statistics Sweden based on the Swedish Labour Force Survey. We also obtained updates on the first theoretical network paper from Statistics Netherlands. We held extensive discussions on the case study from the University of Southampton based on the longitudinal dataset Understanding Society where Bayesian modelling is applied for estimating response propensities using information from previous waves.

- October, 2016: The PI successfully proposed an invited **panel session** to the 2017 Joint Statistical Meetings (JSM) which will be held in Baltimore, Maryland July 29-Aug 3 2017. The submitted papers and abstracts are in Appendix 1.
- The **intermediary network meeting** was held at the University of Southampton (14-15 November 2016).

At the meeting we obtained updates on country case studies and discussed some initial results and findings from the first stage of estimating design parameters under the Bayesian framework: how to identify and weight the prior distributions for estimating the design parameters and the influence of the prior distributions on the posterior distributions. We are moving to the next stage of research which is on the optimization and prioritization of adaptive survey designs under the Bayesian framework. A draft outline of the second network paper was written by Statistics Netherlands and distributed to the network partners. We also discussed the planning of the 5th International Workshop on Advances in Adaptive and Responsive Survey (ASD) to be held at the University of Michigan on November 6-7, 2017 and the development of software tools in 'R' with a manual as one of the key outcomes of the project.

The events planned for the third year of the grant are as follows:

- **29 July-3 August 2017:** JSM session (29 July – 3 August 2017) in Baltimore MD and BADEN network meeting to discuss presentation of papers in the invited session and future planning.
- **6-7 November 2017:** 5th International Workshop Advances in Adaptive and Responsive Survey held at the University of Michigan with a network follow-on meeting to be held on

8 November 2018. The BADEN network will present a summary paper with conclusions and recommendations on the optimisation and prioritization in Bayesian adaptive survey designs.

- January 2018: end of grant

Outputs from 12 January 2016 - 11 January 2017:

Journal Articles/ Book Chapters

Schouten, B., F. Cobben, P. Lundquist and J. Wagner (2016). Does More Balanced Survey Response Imply Less Non-response Bias? *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 179(3): 727-748.

Calinescu, M. and Schouten, B. (2016). Adaptive Survey Designs for Non-response and Measurement Error in Multi-purpose Surveys. *Survey Research Methods*, 10 (1), 35-47.

Burger, J., Perryck, K. and Schouten, B. (submitted 2016). Robustness of Adaptive Survey Designs to Inaccuracy of Design Parameters. Submitted to *Journal of Official Statistics*.

Bethlehem, J. and Schouten, B. (2016). Nonresponse Bias: Detection and Correction. *Chapter 38 in Handbook of Survey Methodology*, Eds C. Wolf, D. Joye, T.W. Smith, Y.C. Fu, SAGE.

Bianchi, A., Shlomo, N. Schouten, B., Da Silva, D. and Skinner, C. (2016). Estimation of response propensities and indicators of representative response using population-Level information. Submitted to *Annals of Applied Statistics* and also Discussion paper 2016-21, CBS, Den Haag, The Netherlands.

Plewis, I. and Shlomo, N. (2016). Using Response Propensities to Improve the Quality of Response in Longitudinal Studies. Submitted to *Journal of Official Statistics*.

Nishimura, R., J. Wagner and M. Elliott (2016). Alternative Indicators for the Risk of Non-response Bias: A Simulation Study. *International Statistical Review* 84(1): 43-62.

Laflamme, F. and J. Wagner (2016). Responsive and Adaptive Designs. *The SAGE Handbook of Survey Methodology*. Eds. C. Wolf, D. Joye, T. W. Smith and Y.-c. Fu. London, Sage.

Särndal, C.E. and Lundquist, P. (2016). Inconsistent Regression and Nonresponse Bias: Exploring their Relationship as a Function of Response Imbalance. Submitted to *Journal of Official Statistics*.

Online articles

Klausch, L.T. and Schouten, B. (2016). Mixed-mode Surveys. Wiley StatsRef, Statistics Reference Online,

<http://onlinelibrary.wiley.com/doi/10.1002/9781118445112.stat07869/full>

Books

Schouten, B., Peytchev, A. and Wagner, J. (2016). *Adaptive Survey Design*, Series on Statistics Handbooks. Chapman and Hall/CRC. Submitted and Under Review.

Conference Presentations

Pratt, D., Rosen, J., Wilson, D., Cominole, M., Copello, E., Duprey, M. and Andrey Peytchev, A. (2016). Examination of Interventions during Data Collection to Increase Response and Sample Representativeness: A Field Test Experiment and Simulation. Presented at the 71st Annual AAPOR Conference, Austin Texas, 12 – 15 May 2016.

Wagner J. (2016). Using Bayesian Methods to Estimate Response Propensity Models During Data Collection. Presented at the 71st Annual AAPOR Conference, Austin Texas, 12 – 15 May 2016.

Wagner J. (2016). Estimating Response Propensity Models During Data Collection: Challenges and New Approaches. Invited paper presented at the Washington Statistical Society Mini-Conference on Paradata.

Bruin, L., Mushkudiani, N. and Schouten, B.(2016). A Bayesian Analysis of Survey Design Parameters. Presented at the Statistics Canada Methodology Symposium, March 22 – 24, Ottawa, Canada.

Mushkudiani, N., Bruin, L. and Schouten, B. (2016). A Bayesian Analysis of Mixed-mode Data Collection, Presented at the International Workshop on Household Survey Nonresponse, Aug 31 – Sept 2, Oslo, Norway.

Schouten, B., Bruin, L. and Mushkudiani, N. (2016). A Bayesian Analysis of Mixed-mode Data Collection. Presented at the 71st Annual AAPOR Conference, Austin Texas, 12 – 15 May 2016.

Johansson, A., Lundquist, P. and Durrant, G.B. (2016). Stopping Rules in a Longitudinal Survey – Impact on Cost and Survey Quality. Presented at the 71st Annual AAPOR Conference, Austin Texas, 12 – 15 May 2016.

Lindblom, A. Lundquist, P. and Ståhl, O. (2016). Use of Nonresponse Indicators in the Turnover in the Service Sector Survey. Presented at the Fifth International Conference on Establishment Surveys (ICES-V), Geneva, 20-23 June, 2016.

Liang, Y., Lundquist, P. and Olsson, F. (2016). A Simulation Tool for Data Collection. Presented at Nordiskt Statistiker möte, Stockholm, 22-24 August 2016.

Tolliver, K. (2016). Selecting Cases Effectively for the Current Population Survey. Presented at the Joint Statistical Methods, Chicago, July 30-Aug 4, 2016.

Miller, P. V. (2016). Adaptive Survey Design: A Progress Report. Invited Paper to the Joint Statistical Methods, Chicago, July 30-Aug 4, 2016.

Miller, Peter V. (2016). Alternative Goals for Adaptive Survey Design. Roundtable Discussion at the Joint Statistical Meetings, Chicago, July 30-Aug 4, 2016.

Coffey, S. (2016). Case Prioritization: Value is Not Enough. Presented at the 71st Annual AAPOR Conference, Austin Texas, 12 – 15 May 2016.

Coffey, S. (2016). Case Prioritization in the National Health Interview Survey. Presentation of Interim Results to NCHS leadership and the NHIS Sample Redesign Team, September 2016.

Working/Draft Papers

Bruin, L., Schouten, B. Mushkudiani, N., Shlomo, N., Coffey, S., Durrant, G., Lundquist, P., Pratt, D., Wagner, J. (2016). A Bayesian Analysis of Design Parameters in Survey Data Collection. Discussion paper 2017-xx, CBS, Den Haag, The Netherlands.

Kibuchi, E., Durrant, G.B., Sturgis, P. and Maslovskaya, O. (2016). An Assessment of the Utility of a Bayesian Modelling Framework to Improve Response Propensity Modelling.

Johansson, A., Lundquist, P., Durrant, G.B. (2016) Stopping Rules in a Longitudinal Survey – Impact on Cost and Survey Quality.

US Census Bureau (2015). Implementing Multimode Dynamic Adaptive Design at the Census Bureau: An Operational Proof of Concept. To be submitted to Survey Practice.

US Census Bureau (2015). Incentive Targeting Using Static Adaptive Design: Results from an Incentive Timing Experiment. To be submitted to the Journal of Survey Statistics and Methodology.

US Census Bureau (2015). Expanding the Use of Dynamic Design in a Multimode Survey: Larger Sample Sizes and Larger Interventions. To be submitted to Journal of Official Statistics or another appropriate journal.

Grant funding

Wagner, J. and West, B. (Principle Investigators) Short courses on using Responsive and Adaptive Survey Designs. Funded by the US National Institutes of Health, from 2017 (many of the network members will be instructors for these courses).

Appendix 1

JSM 2017 Invited Session - Session Number: 213867

Sponsor: Survey Research Methods Section

Session Title: Bayesian Adaptive Survey Designs

Session Description.

Adaptive survey designs employ different strategies or design features to different population strata. The strata are identified by auxiliary data from administrative data and/or from paradata. The employment of the strategies may take place in the form of interventions during data collection and/or through the optimization of design in between waves of the survey. The interventions and optimization are based on estimated design parameters such as stratum contact propensities, stratum participation propensities, stratum mode coverage propensities and stratum costs parameters. These parameters are estimated using a combination of expert knowledge, prior data and current data. As a consequence, the estimated parameters are subject to inaccuracy. Furthermore, the parameters will, generally, change gradually in time. A Bayesian approach towards interventions and optimization is natural as it is a tractable and convenient way to mix and weight expert knowledge, prior data and current data, to account for the resulting uncertainty in the design parameters, and to allow for gradual change. The Bayesian component to adaptive survey design consists of 1) prior distributions to parameters in models for nonresponse and measurement and 2) decision rules in interventions and optimization of design. The Bayesian Adaptive Survey Design Network (BADEN) funded by the Leverhulme trust in the United Kingdom consists of the Universities of Manchester (network coordinator), Michigan and Southampton, the National Statistical Institutes of the Netherlands and Sweden, RTI international, and the US Census Bureau. The invited session will highlight research carried out under BADEN and will focus on case studies with an emphasis on monitoring and optimizing data collection using a Bayesian perspective to inform adaptive survey designs.

Paper 1: Title: Optimization of adaptive survey design from a Bayesian perspective. Two case studies

Barry Schouten jg.schouten@cbs.nl, Joep Burger and Nino Mushkudiani n.mushkudiani@cbs.nl, Statistics Netherlands

Abstract: A Bayesian analysis of survey data collection may be profitable when expert knowledge and/or historic survey data from the same or similar surveys are available. This knowledge and data may then be employed to set informative prior distributions to coefficients in regression models for survey design parameters, e.g. contact propensities, eligibility propensities, participation propensities, costs per sample unit and survey variable outcomes. During or after data collection posterior distributions may be derived for the same parameters, but also for overall quality and cost measures. Even when survey design parameters change gradually in time or change from one survey to the other, the posterior distributions during or after data collection may be more informative than without the prior

knowledge. In earlier papers, we demonstrated how a Bayesian analysis may be implemented and analyzed in monitoring survey data collection. In the current paper, we discuss the optimization and adaptation of survey design using the posterior distributions for survey design parameters, and quality and cost measures. We do so using two case studies. In the studies the choice of survey modes plays an important role.

Paper 2: Title: Test of adaptive survey design from a Bayesian perspective in a longitudinal survey

Anton Johansson Anton.Johansson@scb.se Peter Lundquist peter.lundquist@scb.se
Statistics Sweden and Gabriele Durrant G.Durrant@soton.ac.uk University of Southampton

Abstract: It has been demonstrated that it is possible to reduce unproductive calls in CATI-surveys by using information from previous waves in longitudinal surveys. In the Swedish Labour Force Survey have data from both registers and paradata been used to build nonresponse models. The models are used to formulate strategies to support the survey agency in the data collection work with the ambition to reduce costs but at the same time maintain the survey quality. In this paper we will investigate if a Bayesian analysis could be an option in monitoring the data collection. Different strategies based on the previous nonresponse models are tested.

Paper 3: Title: Using Bayesian Methods to Rank Cases Based on Response Propensity During Data Collection

James Wagner jameswag@umich.edu University of Michigan

Abstract: Rankings of cases based on estimated response propensities have been used to create inputs to adaptive survey designs. These inputs may be needed during data collection as triggers for design decisions. Cases above or below a certain threshold may receive a special recruitment protocol. However, Wagner and Hubbard (2014) showed that estimates of response propensity models can be biased when fit on a daily basis during data collection using the incoming data. These biases may lead to inaccurate ranking of cases, which, in turn, leads to inefficient or even counterproductive interventions. The use of informative priors in Bayesian logistic regression is explored. The goal is to identify a method for developing priors from other surveys and expert opinion that reduces or eliminates any potential biases in the rankings of cases.

Paper 4: Title: Modeling nonresponse bias likelihood and response propensity: the design and implementation of statistical models to identify cases for interventions during data collection

Daniel Pratt dip@rti.org , Jeffrey Rosen jrosen@rti.org, Michael Duprey mduprey@rti.org, and Jamie Wescott jwescott@rti.org, RTI International

Abstract: Longitudinal studies benefit from prior information to inform data collection strategies. The presentation describes two models used together during data collection of a US/ED National Center for Education Statistics study to identify cases for interventions. The presentation describes a response likelihood model used to identify, in advance of data collection, likelihood of cases to participate. Using prior data/paradata, we fit a model predicting prior-round response. We used coefficients associated with predictors to estimate response likelihood. The response likelihood model informed decisions about inclusion/exclusion of cases for interventions to control costs. The presentation describes a bias likelihood model used to select cases for interventions. The bias likelihood model was used to identify cases most unlike cases that had already responded at the time the model was run. The model used key survey and frame variables as predictors to identify nonrespondents most likely to cause bias in key survey variables if they did not respond. The model was run multiple times during data collection to identify cases for various interventions (e.g., incentives; field data collection).

Paper 5: Title: Can a Bayesian Modelling approach improve response propensity modelling? An application to a longitudinal survey using prior wave data

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Abstract: Response propensity models are widely used in survey research to predict response outcomes. However, standard models suffer from low predictive power, which may hinder their effective application in adaptive and responsive survey designs. In recent years a number of ways have been explored how to improve prediction, for example by including paradata, information from a previous wave or from previous calls to a sample unit. In particular, improved response propensity models with higher predictive power would be beneficial when aiming to predict response outcomes before or during data collection. This paper explores the use of a Bayesian modelling approach. The models are implemented in a longitudinal context, which allows the conditioning on prior wave information. The models also condition on available paradata from the previous and current waves. Here, the outcomes of the previous wave are used to form informative prior distributions which are included in subsequent wave analyses, a process known as Bayesian updating. A range of measures are employed to assess the performance of the models. The study uses data from Understanding Society, a large scale UK longitudinal survey.

Paper 6: Title: More Information is Better! Where Do We Get It and How Do We Use It?

Stephanie Coffey stephmcoffey@gmail.com, U.S. Census Bureau and Joint Program in Survey Methodology, University of Maryland

Abstract: One factor that is often overlooked in dynamic adaptive designs is whether a certain data collection strategy is "worth it", with respect to reaching data collection goals. Ideally, we would not send that expensive field interviewer to attempt a case that will not respond to either a telephone attempt or a personal visit, as resources could be better spent on other similar cases. Alternatively, perhaps a small incentive would convince a sample individual to respond. To use this type of information, we need to look at the response propensity of a case (and how it is affected by different data collection features) in addition to its value to the data collection goal. This is difficult, as we do not know in advance the effect of different combinations of features on survey response – we cannot tell the future. As a result we rely on models, but early in data collection, when a decision could have a large impact at reducing cost and burden, response propensities are often unreliable, shown by Wagner. This talk will illustrate how poor estimates of response propensity can affect data collection decisions, the potential benefits of external information, and how to integrate that data.