An expert elicitation tool to capture probabilistic estimates of future demographic indicators

2019 Annual meeting of the Population Association of America

Extended abstract

Patrice Dion
Nora Galbraith
Elham Sirag

Most statistical agencies perform some kind of consultation with experts when designing their demographic projection assumptions. Among UNECE countries, 29 of 31 countries undertook some form of consultations in their recent projections, with 19 of them documenting the results (UNECE 2018). The intensity and the format of these consultations vary considerably, from merely seeking approval from higher levels in the organization to a formal process where a committee of experts has the last word about the final assumptions or methods that will be used.

Expert knowledge elicitation can be defined as the "process of formulating a person's knowledge and beliefs about one or more uncertain quantities into a (joint) probability distribution for those quantities" (Garthwaite et al. 2005). Expert elicitation has been used to inform decision-makers about numerous critical societal issues such as the likelihood of climate change, of health impacts caused by pollution or the consequences of introducing new technologies (Morgan 2014) and is expected to play a greater role in the future in a context where the range of choices, the availability of data and the demands for accountability are increasing (Dias et al. 2018).

There is a clear role for expert knowledge elicitation in demographic projections given the inherent uncertainty associated with the future. While it has been shown that simple models tend to outperform subjective judgment in prediction performance (e.g., Meehl 1954, Tetlock and Gardner 2015), expert elicitation can be valuable when there is a lack of good data, insufficient knowledge about the underlying causal mechanisms or apparent randomness of the trends. Expert elicitation is also informative about the degree of consensus about the future path of a given component of demographic growth. Finally, compared with conventional statistical techniques, expert elicitation may also offer greater transparency (Knol et al 2010).

In demography, expert elicitation has been used to inform the development of demographic projections assumptions (e.g., Lutz 2009, Billari et al. 2012, Wilson et al. 2011, Bijak and Wisniowski 2010). In their 2013-based demographic projections,

Statistics Canada undertook a pilot survey of Canadian demography experts to support the process of building the various projection scenario assumptions. Following its successful pilot project in 2013, the demographic projections team at Statistics Canada undertook a thorough evaluation of best practices in the field of elicitation. This review reiterated the importance of designing the survey in a manner so as to avoid various cognitive biases and heuristics such as anchoring bias, confirmation bias, hindsight bias and motivation bias (Hora 2007; Kynn 2008; O'Hagan et al 2006; Speirs-Bridge et al 2010; Tversky and Kahneman 1974). This review also revealed the importance of providing visual feedback tools to the respondent in order to allow them to review and revise their responses (Allan et al 2010; Garthwaite et al 2005; Goldstein and Rothschild 2014; Morgan and Henrion 1990; Sperber et al 2013). Since the pilot survey was rolled out, the projections team has also been investigating the possibility of producing probabilistic population projections in the future. As a result, it was also considered necessary to obtain expert estimates in a format that could be utilized in the production of said projections. For instance, it would be necessary to combine the probability distributions from individual experts in some way; several different approaches (behavioural, axiomatic, Bayesian) are possible.

Taking into account these numerous demanding requirements, Statistics Canada recently launched a new tool to elicit the opinions and quantitative probabilistic estimates of demography experts regarding the likely future values of various demographic indicators. In addition to incorporating several best practices in elicitation, this survey meets several practical considerations: it is low cost, user-friendly, self-administered and has relatively low respondent burden. It also offers several innovative features which represent a step forward towards the better characterization of uncertainty in population projections. Using a small number of quantitative estimates provided by the expert, the elicitation tool produces a detailed and flexible probability distribution which can be asymmetric, non-parametric or unbounded in nature. The tool also offers the respondent a graphical validation of their inputs, taking advantage of the recent development of the *metalog* distributions by Keelin (2016). Critically, the tool allows experts to provide feedback on the elicitation exercise to ensure that their knowledge is captured accurately (Gosling 2014). Taken together, the features of this new elicitation tool offer a more scientifically sound approach to combining the views of multiple experts, which can be applied to any question about which there is considerable uncertainty. Figures 1, 2, and 3 below provide snapshots of selected portions of the new Microsoft Excel-based expert elicitation tool.

In the fall of 2018, a survey of Canadian demography experts will be completed using this new and improved tool, eliciting their views about the future levels of fertility, mortality, immigration and non-permanent residents in Canada. Results of this elicitation exercise and lessons learned will be available by March 2019.

Figure 1: Excerpt (1) from the 2018 Survey of Experts on Future Demographic Trends

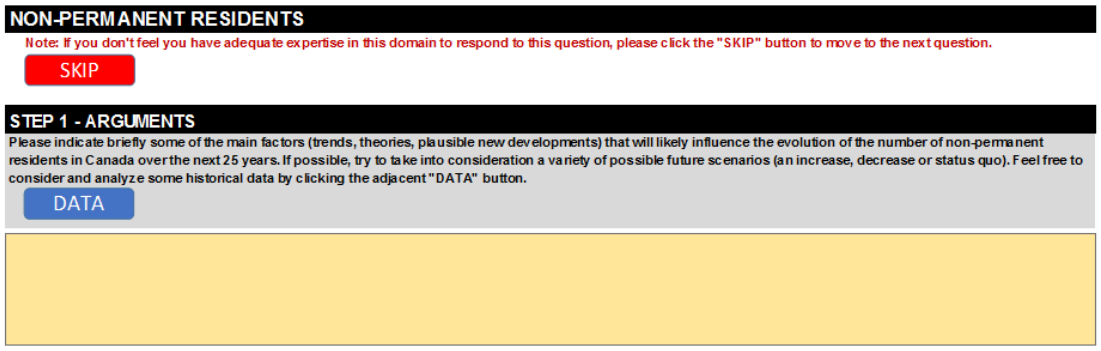


Figure 2: Excerpt (2) from the 2018 Survey of Experts on Future Demographic Trends

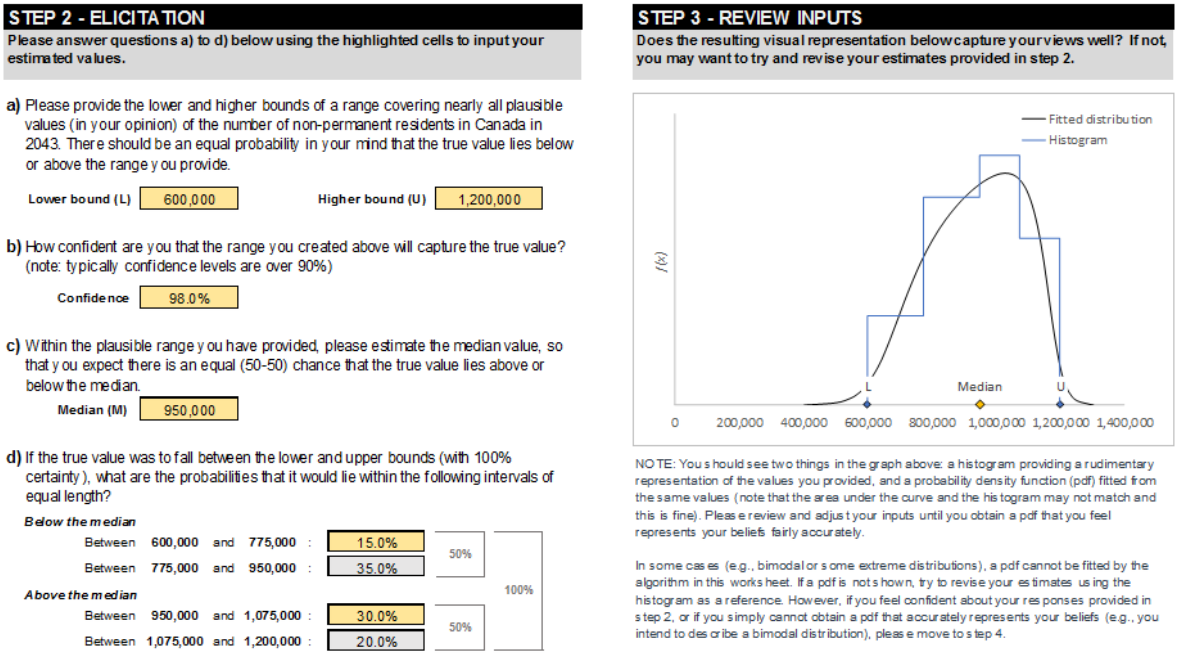
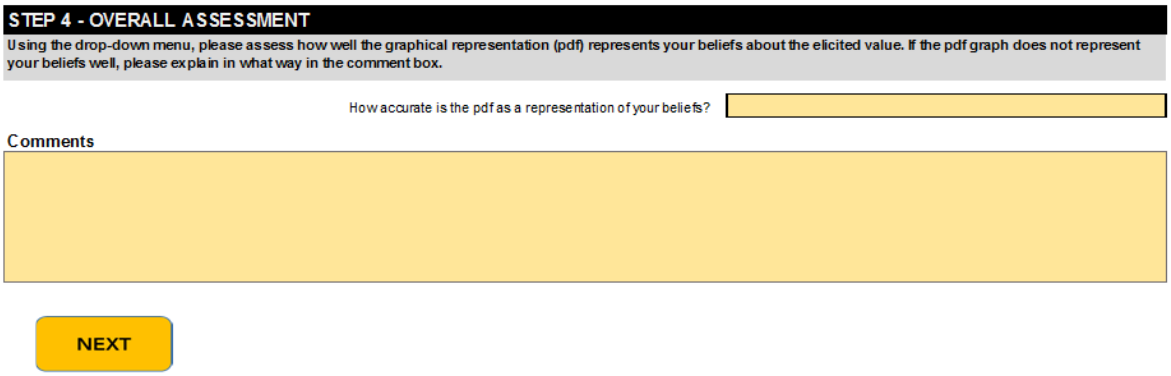


Figure 3 : Excerpt (3) from the 2018 Survey of Experts on Future Demographic Trends



References

Allan, J., S. L. Choy, S. and K, Mengersen. 2010. Elicitator: An Expert Elicitation Tool for Regression in Ecology, *Environmental Modelling & Software* 25(1): 129-145

Bijak J. and A. Wiśniowski. 2010. Bayesian forecasting of immigration to selected European countries by using expert knowledge. Journal of the Royal Statistical Society. Series A, 173(4): 775-796.

Billari, F.C., R. Graziani and E. Melilli. 2012. Stochastic population forecasts based on conditional expert opinions. Journal of the Royal Statistical Society A 175(2): 491–511.

Dias, L. C., A. Morton and J. Quigley. 2018. Elicitation: State of the Art and Science. In: L. C. Dias et al. (eds), Eliccitation, International Series in Operations Research & Management Science, 261, https://doi.or./10.1007/978-3-319-65052-4_1.

Garthwaite P. H., J. B. Kadane and A. O'Hagan. 2005. Statistical methods for eliciting probability distributions. Journal of the American Statistical Association.

Goldstein D. G. and D. Rothschild. 2014. "Lay understanding of probability distributions". *Judgment and Decision Making* 9(1):1–14.

Gosling, J.P. 2014. "Methods for eliciting expert opinion to inform health technology assessment, Vignette on SEJ methods for MRC" Accessed at www.mrc.ac.uk/documents/pdf/methods-for-eliciting-expert-opinion-gosling-2014/

Hora, S. 2007. Eliciting Probabilities from Experts. Pages 129-153 in W. Edwards, R. Miles Jr., & D. Von Winterfeldt (Eds.), *Advances in Decision Analysis: From Foundations to Applications*. Cambridge: Cambridge University Press.

Keelin, T. W. 2016. "The Metalog Distributions" *Decision Analysis* 13(4): 243-277.

Kynn, M. 2008. “The 'Heuristics and Biases' Bias in Expert Elicitation” *Journal of the Royal Statistical Society. Series A* (*Statistics in Society*) 171(1): 239-264.

Lutz, W. 2009: Towards A Systematic, Argument-Based Approach to Defining Assumptions for Population Projections. IIASA.

Meehl, P. E. 1954. Clinical versus statistical prediction: A theoretical analysis and a review of the evidence. Minneapolis: University of Minnesota Press. Reprinted with new Preface, 1996, by Jason Aronson, Northvale, NJ. Reprinted 2013 by Echo Point Books.

Morgan, M. G. and M. Henrion. 1990. *Uncertainty: A Guide to Dealing with Quantitative Risk and Policy Analysis.* Cambridge University Press.

O'Hagan, A. et al. 2006. *Uncertain judgements: eliciting experts' probabilities*. John Wiley & Sons.

Speirs-Bridge, A. et al. 2010. Reducing Overconfidence in the Interval Judgments of Experts, *Risk Analysis* 30(3):512-523.

Sperber, D. et al. 2013. « An Expert on Every Street Corner? Methods for Eliciting Distributions in Geographically Dispersed Opinion Pools”. *Value in Health* 16(2): 434-437.

Tetlock, P. E. and D. Gardner. 2015. Superforecasting: The art and science of prediction. Random House. p. 352.

Tversky A. and D. Kahneman. 1974. Judgment under uncertainty: Heuristics and biases, *Science* 185(4157): 124-1131.

UNECE. 2018. Recommendations on communicating population projection. Accessed at https://www.unece.org/statistics/networks-of-experts/task-force-on-population-projections.html

Wilson, T., E. Charles-Edwards and M. Bell. 2011. Australia's Future Net Overseas Migration: A Survey of Expert Opinion. Queensland Centre for Population Research.

Contact information

Name: Patrice Dion
Affiliation: Statistics Canada
Email: patrice.dion@canada.ca