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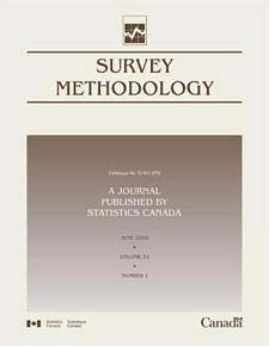

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1. Introduction

The United States (U.S.) Census Bureau Demographic Survey Sample Redesign Program, among other things, is responsible for research into improving the designs of U.S. demographic surveys, particularly focused on the design of survey sampling. Historically, the research into improving sample design has been restricted to the "mainstream" methods like basic stratification, multi-stage designs, systematic sampling, probability-proportional-to-size sampling, clustering, and simple random sampling. Over the past thirty years or more, we have increasingly faced reduced response rates and higher costs coupled with an increasing demand for more data on all types of populations. More recently, dramatic increases in computing power and availability of auxiliary data from administrative records have indicated that we may have more options than we did when we established our current methodology. Thus, we began an initiative to explore alternative sampling methods.

2. History of innovation in demographic survey sampling at the U.S. Census Bureau

The U.S. Census Bureau was created by the Permanent Census Act of 1902. Up until the late 1930s, the U.S. Census Bureau's demographic work was mostly focused on the logistics of running each decennial census and a myriad of special censuses. After the 1930 decennial census, the Census Bureau began research into sampling using the census data (Stephan 1948).

Then, in 1937, the Census Bureau took its first major step into sample survey sampling with the 1937 Enumerative Check Census of Unemployment, which used a cluster sample of counties in support of a register census of the unemployed (Dedrick 1938). About the same time, the Census Bureau brought in sampling experts (*e.g.*, W. Edwards Deming and Federick Stephan) in its decennial census expansion to assist in designing a sample survey in conjunction with the 1940 Decennial Census using a five percent systematic sample (Stephan, Deming and Hansen 1940). In 1942, the Sample Survey of Unemployment was moved from the Works Progress Administration to the Census Bureau. This survey was already a three-stage sample with county primary sampling units (PSUs), systematic sampling of blocks, and sampling listed housing units in stage three (Frankel and Stock 1942). After its transfer to the Census Bureau (and a name change to the Monthly Report on the Labor Force (MRLF)), it was extensively redesigned in 1943, dramatically improving its efficiency using larger primary sampling units (PSUs) and probability proportionate to size for selection (Duncan and Shelton 1978). Later the survey was changed to improve month-to-month and year-to-year comparisons using a more complex overlapping sample approach in which a given household remains in sample for four months, is out of the survey for eight months and then is back into the sample for four months. Its name was also changed in 1947 to the Current Population Survey (CPS). Still, the basic sampling concept remained multi-stage sample design with county or county group PSUs. It remains that way to present though there are vast differences in the within-PSU sampling methods (U.S. Bureau of Labor Statistics and U.S. Census Bureau 2006). Over the last 60 years, the U.S. Census Bureau has designed many additional demographic surveys. Some of those surveys use the same two-stage design idea used in the CPS, like the Consumer Expenditures Surveys, the Survey of Income and Program Participation, the National Crime Victimization Survey, and the National Health Interview Survey. Some others are two-stage with selection of a list source followed by sampling from the lists like the Schools and Staffing Survey, the Private School Survey, and the Survey of Inmates of Local Jails. Still other are stratified samples from a sampled frame, such as the National Survey of College Graduates that has sampled from the Decennial Census Long Form, and the American Time Use Survey that samples from the CPS. In the early 1990s, The U.S. Census Bureau initiated the development of the use of continuous measurement as a possible replacement for the Decennial Census Long Form. Those efforts have since evolved into the current American Community Survey, which, starting 2010, will provide continual mid-decade estimates down to the block group level. The Census Bureau's goal for improving our sampling methodology to the present leads us to explore alternative sample designs.

3. Alternative survey sample design seminar series

The exploration into alternative methods of sampling began with an initial seminar series that was held at the U.S.

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Census Bureau. It consisted of three seminar presentations of such methods covering the statistical bases of the methods and their limitations, especially when applied to the types of demographic surveys conducted by the U.S. Census Bureau. Each presentation also included discussant comments by Professor Jean Opsomer from Colorado State University. Three articles were then developed providing greater detail on each topic and a final discussant article covering the three subjects.

- On 26 September 2007, Professor Steven K. Thompson from Simon Fraser University gave a presentation on his research into network sampling, spatial sampling, and adaptive sampling.
- On 9 January 2008, Professor Sharon Lohr from Arizona State University gave a presentation on her research into sampling using overlapping frames.
- On 4 June 2008, Professor Yves Tillé from University of Neuchatel gave a presentation on his research into balanced sampling.

The articles resulting from this project that follow are:

"Adaptive network and spatial sampling," by Steven Thompson;

"Alternative survey sample designs: Sampling with multiple overlapping frames," by Sharon Lohr;

"Ten years of balanced sampling with the cube method: An appraisal," by Yves Tillé; and

"Innovations in survey sampling design: Discussion of three contributions presented at the U.S. Census Bureau," by Jean Opsomer.

4. Next steps

Following these three presentations, it was decided to conduct further research into these methods and their application to either existing U.S. Census Bureau Demographic surveys or to potential new surveys. There is already an urgent need for using multiple overlapping frames methods applied to the National Survey of College Graduates to deal with an old-cohort/new-cohort problem and a possible use of state hunting and fishing license registries as a second frame for the Fishing, Hunting, and Wildlife-Associated Recreation survey. We have plans to look at balanced sampling, particularly for selecting geographic primary sampling units. Lastly, the methods of adaptive sampling have the potential for us to accept surveys that we traditionally have not taken on, as well as providing a lower cost alternative for surveys that meet certain criteria.

5. Summary

This exploration into these three areas of alternative sample designs is just the beginning of our seminar series and of our intentions to explore methods to improve our demographic survey sample design methods. Future anticipated subjects include alternative listing methods, Kish's half-open interval approach to growth updates and coverage improvement, responsive survey designs, rejective sampling procedures, and model-assisted sampling.

Acknowledgements

This report is released to inform interested parties of research and to encourage discussion. The views expressed on statistical, methodological, technical, or operational issues are those of the authors and not necessarily those of the U.S. Census Bureau.

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