Statistics Canada Statistique Canada

A test of sample matching using a pseudo-web sample

Telling Canada's story in numbers

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INPS Conference, March 16, 2017

Canada

Outline

- Introduction
- Sample matching
- Pseudo-web sample
- Simulation results
- Carrot project: an experiment

Introduction

- With increasing levels of **nonresponse** in household surveys, there is renewed interest in alternatives to the traditional way of conducting surveys.

- Can we use non-probability samples in a probabilistic way? How about the self selection bias?

- Bethlehem (2014)

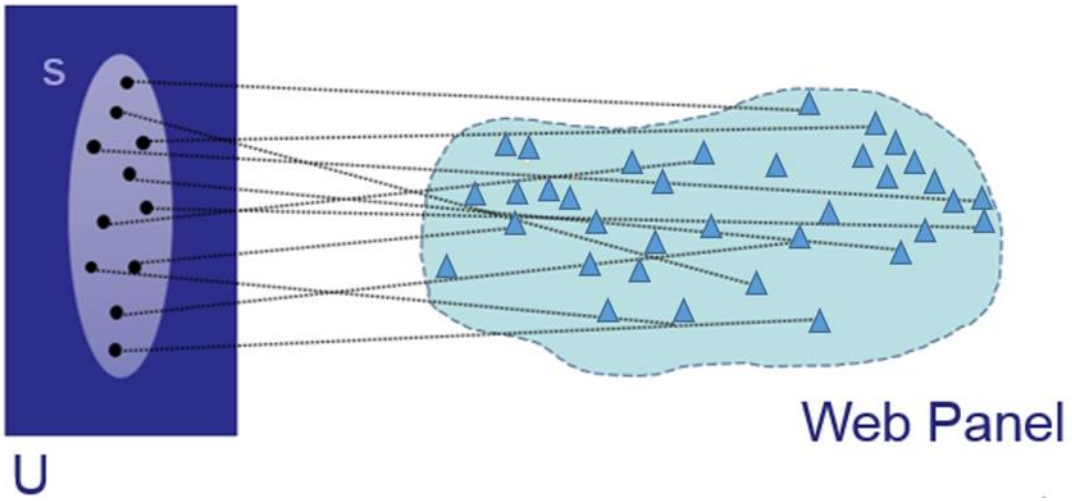
  "*Due to (high) nonresponse, probability sampling surveys more and more resemble self-selection surveys*."

- Rivers (2007)

  "There is no logical difference between the type of modeling assumptions needed for nonresponse adjustments and those needed for self-selected samples."

Sample Matching (SM)

- Rivers (2007) proposed the application of Sample Matching.



- The variable of interest is not measured directly from s.

SM- population of interest

- Let U be a population of size N.
- A probability sample s of size n is drawn using a sample design $p(s)$.
- Let π_i be the probability of selection of unit $i \in U$.
- Variable of interest is y.
- Let $\boldsymbol{x}_i$ be the auxiliary variables in the entire population U or for the sample s.

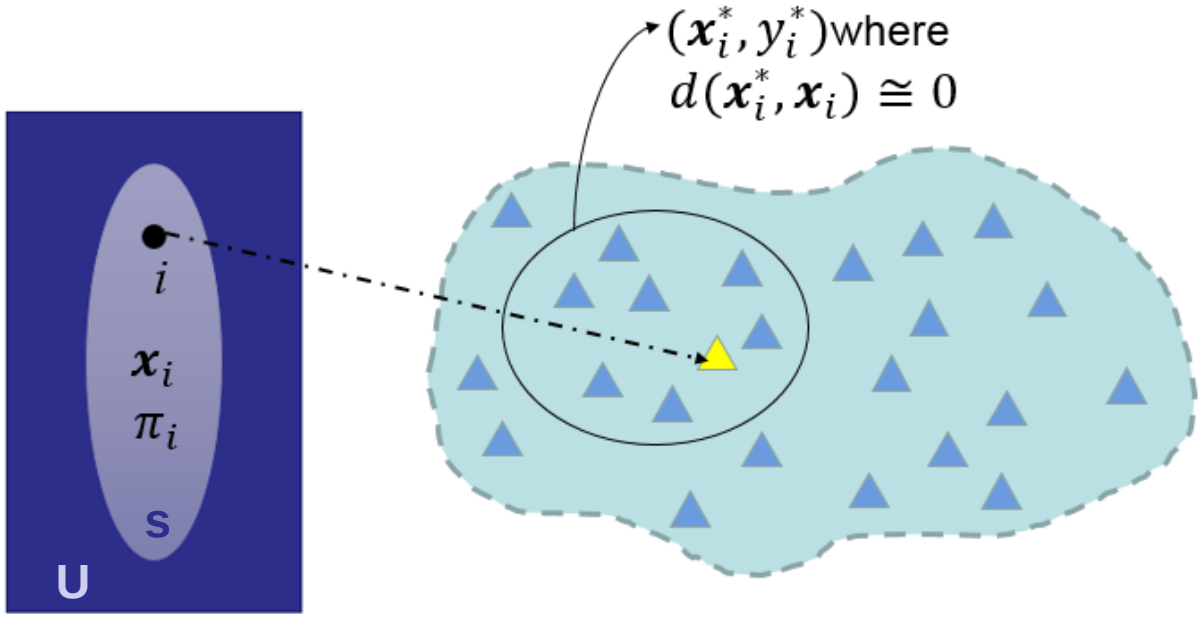
SM- panel

- Let n^* be the size of panel.
- Let $\boldsymbol{x}_1^*, \ldots, \boldsymbol{x}_{n^*}^*$ be the auxiliary variables in the panel.
- Let $y_1^*, \ldots, y_{n^*}^*$ be the values of the measurements in the panel.
- Let z_i be an indicator of responding to the web-panel survey.
- We assume that $z_i = 1, \mathrm{i} = 1, \ldots, n^*$.

SM- mechanism

- Let $d(a,b)$ be a measure of distance between a and b.
- For each unit i in sample s, we find a set of pairs $(y_i^*, \boldsymbol{x}_i^*)$ on the panel where $d(\boldsymbol{x}_i, \boldsymbol{x}_i^*)$ is small.
- We select one unit at random from the set and substitute y_i with y_i^*.

SM- mechanism



- Estimator of total: $\hat{T} = \sum_{i \in s} \frac{y_i^*}{\pi_i}$

SM- assumptions

There are three main assumptions in Rivers' paper:

1. "iid" data generating process $(y_i, \boldsymbol{x}_i, z_i)$
2. The panel covers all relevant portions of the population U.
3. **Ignorable selection**

$$F_{Y|X}(y|\boldsymbol{x}) = F_{Y^*|X^*}(y|\boldsymbol{x}) \; \forall \boldsymbol{x}, y$$

The conditional distribution of Y on **X** in the population is identical to that in the panel.

Pseudo-web sample

- Two different household surveys are used to simulate the SM methodology:
  - 2011 National Household Survey (NHS)
  - 2011 Canadian Labour Force Survey (LFS)
- NHS respondents are considered as the population of the study. A probability sample s is selected from the NHS.
- LFS respondents are treated as a pseudo-web sample.

National Household Survey (NHS)

- Statistics Canada conducted the NHS in May 2011 as a replacement for the long census questionnaire.

- The survey was designed to collect social and economic data about the Canadian population.
- NHS respondents~ 6.7 million persons ("**population size**")

Labour Force Survey (LFS)

- The LFS is a household survey carried out monthly by Statistics Canada.
- The goal of the survey is to provide information on major labour market trends such as unemployment rates.
- May 2011 LFS respondents ~127,000 persons ("**Panel size**")

Why NHS and LFS?

- Demographic information from both surveys can be used as auxiliary information.
- NHS is large enough to be considered as our population.
- Both surveys were conducted in May 2011.
- Both surveys collect information on the labour force status and we can evaluate the method using NHS data.

Variables

- **Variables of interest**

  1- **employed**

  2- unemployed

  3- not in Labour force

  6- not applicable
  (less than 15 years old)

- **Matching variables** (x_i, x_i^*)

  geographical variables, sex, age, education

Simulation

- Random sample from NHS
- Sample size : 5000, 10000, 25000
- R=1000 simulated samples
- Matching variables:
  - Age/sex/province
  - Age/sex/education
- Variable of interest: respondent was employed during the reference week

$$y = \begin{cases} 1 & \text{if respondent was employed} \\ 0 & \text{otherwise} \end{cases}$$

Simulation

- Two performance measures are considered:
- Absolute bias (AB)

$$AB = \left|\left(\frac{1}{R}\sum_{r=1}^{R}\hat{\theta}^{(r)}\right) - \theta\right|$$

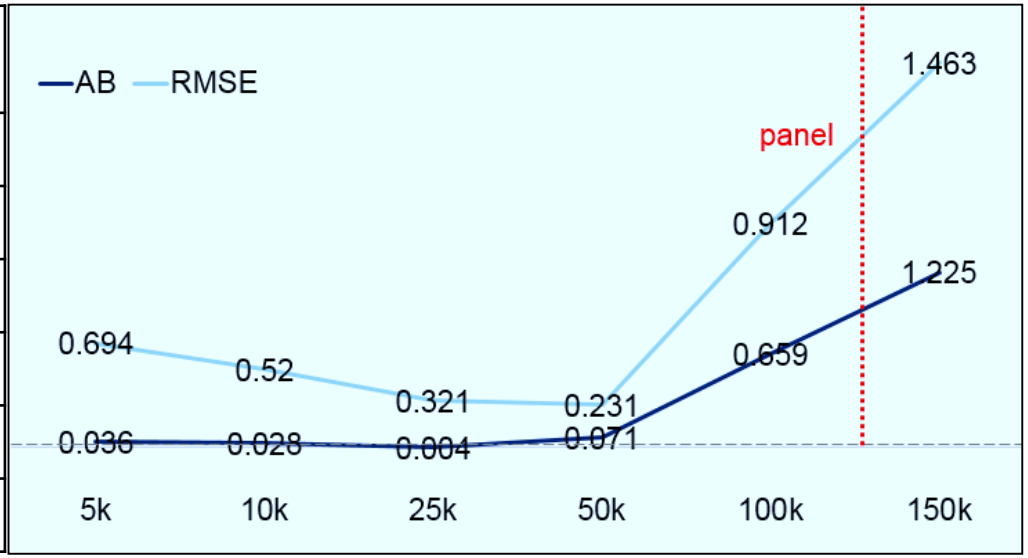
- Root mean square error (RMSE)

$$RMSE = \sqrt{\frac{1}{R}\sum_{r=1}^{R}(\hat{\theta}^{(r)} - \theta)^2}$$

Simulation 1

- Matching variable: province*age*sex
- R=1000 simulated samples
- SRS

n	*AB*	*RMSE*
5000	0.036	0.694
10000	0.028	0.520
25000	0.004	0.321
50000	0.071	0.230
100000	0.659	0.912
150000	1.225	1.463



Simulation 2

- Matching variable: age*sex*level of education
- R=1000 simulated samples
- SRS

n	*AB*	*RMSE*
5000	1.002	1.197
10000	0.951	1.313
25000	0.676	0.730

Simulation 3

- Matching variable: province*age*sex
- R=1000 simulated samples
- Stratified sampling with power allocation(q=0.5)

$$n_h = n\frac{M_h^q}{\sum_{h=1}^{L} M_h^q}$$

- M_h is total number of persons with employment income

n	*AB*	*RMSE*
5000	0.335	0.640
10000	0.303	0.530
25000	0.021	0.327

Lessons learned

- Sample size
- Matching variables
- Sampling mechanism

Rivers (2007)

- *"Sample matching is nearly unbiased if the panel is five times the size of the target sample."*
- *"The plausibility of this assumption depends largely on the extent and relevance of the matching variables."*
- *"Matching from a sufficiently large and diverse panel yields results similar to a SRS."*

Limitations of the method

- Survey data don't have the same characteristics as the panel data
  - self-selected
  - coverage
- Variable of interest (LFS) is a complex derived variable.
  - Imputation impact

Carrot Project: an experiment

- Carrot Rewards app*
  - incentive-based digital platform
  - originally, a wellness app for making healthy choices

- Register using basic demographic information
- Register rewards card (gas card, movie card, AEROPLAN miles)
- Receive mini surveys
- Complete tasks and collect reward points

*non-governmental application developed by Social Change Rewards (www.carrotinsights.com)

Carrot Project: an experiment

- Three mini surveys were tested using content from the Canadian Community Health Survey (CCHS).

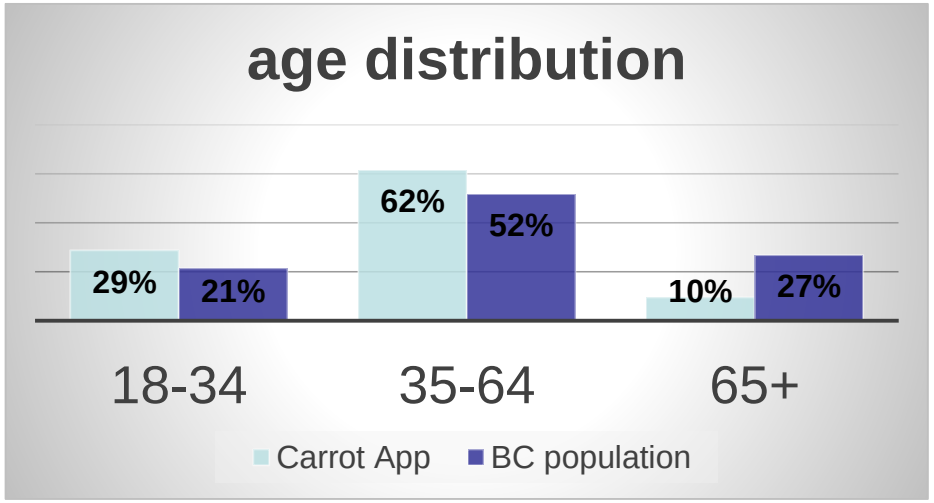
- Survey #1: Demographics + Alcohol consumption
- Survey #2: Exposure to second hand smoke
- Survey #3: Neighbourhood environment
- Surveys #2 and #3 were only sent to respondents of the first survey.

Carrot Project: an experiment

- Survey #1 was sent to around 41K users

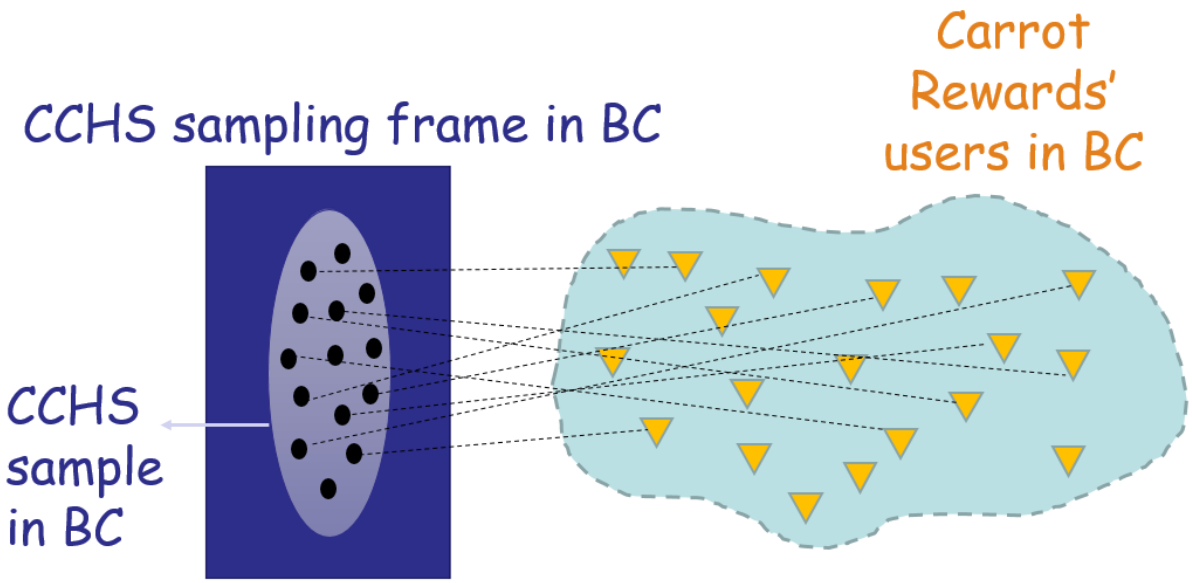
  Response rate: 28%
- Survey #2 and #3 was sent to around 11.5K users

  Response rate: 65%

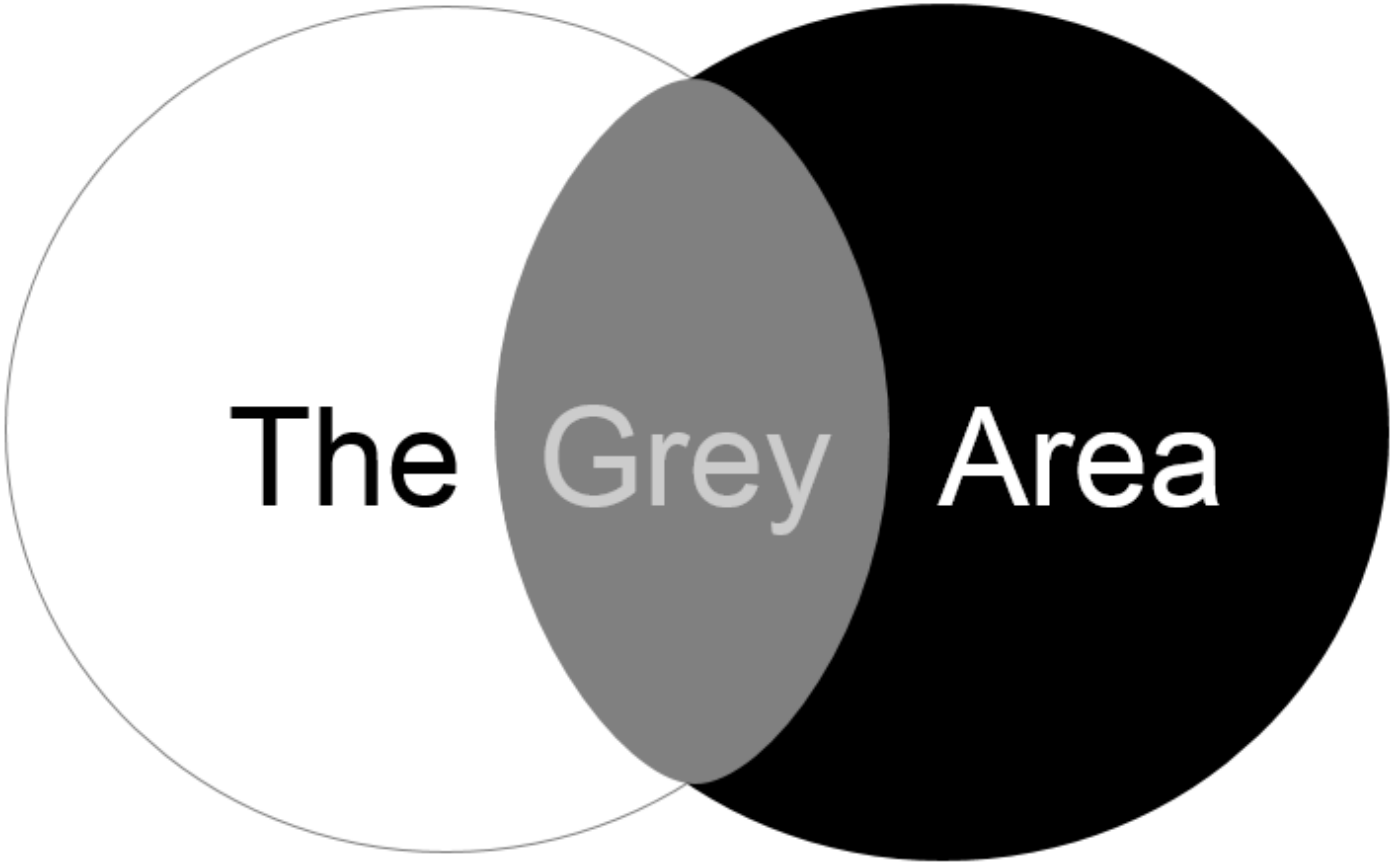


Carrot Project: an experiment

- **Goal**: compare CCHS estimates to Carrot sample matched estimates on the same variables.



Where are we heading?



Thank you

Merci

For more information please contact:

Pour plus d'information, veuillez contacter:

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