

Application of Sampling Variance Smoothing Methods for Small Area Proportion Estimation

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Sampling variance smoothing is an important topic in small area estimation. In this article, we propose sampling variance smoothing methods for small area proportion estimation. In particular, we consider the generalized variance function and design effect methods for sampling variance smoothing. We evaluate and compare the smoothed sampling variances and small area estimates based on the smoothed variance estimates through analysis of survey data from Statistics Canada. The results from real data analysis and simulation study indicate that the proposed sampling variance smoothing methods perform very well for small area estimation.

Key words: Coefficient of variation; design effect; generalized variance function; log-linear model; relative error.

1. Introduction

Small area estimation has become very popular and important in both public and private agencies due to the growing demand for reliable small domain estimates. Small area estimation is based on models that borrow strength across areas and combine different sources of information in order to obtain reliable estimates. In this article, we focus on area level models that are based on direct survey estimates aggregated from the unit level data and area level auxiliary variables. Various area level models have been proposed in the literature to improve the precision of the direct survey estimates; a good summary of these methods is discussed in Rao and Molina (2015). The Fay-Herriot model (Fay and Herriot 1979) is a basic area level model that is widely used in practice. The Fay-Herriot model has two components, namely, a sampling model for the direct survey estimates and a linking model for the small area parameters of interest. The sampling model assumes that there exists a direct survey estimator y_i , which is usually design unbiased, for the small area parameter θ_i such that

$$y_i = \theta_i + e_i, \quad i = 1, \dots, m, \quad (1)$$

where e_i is the sampling error associated with the direct estimator y_i and m is the number of small areas. It is customary in practice to assume that the e_i 's are independently distributed normal random variables with mean $E(e_i) = 0$ and sampling variance $Var(e_i) = \sigma_i^2$. The linking model assumes that the small area parameter of interest θ_i is related to area level auxiliary variables $\mathbf{x}_i = (x_{i1}, \dots, x_{ip})'$ through a linear regression model

$$\theta_i = \mathbf{x}_i' \boldsymbol{\delta} + v_i, \quad i = 1, \dots, m, \quad (2)$$

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