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A Scheme for Post-Stratification in Two Stage Sampling

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Summary

Post stratification in two-stage sampling on the basis of the sample second-stage units has been discussed. It has been empirically demonstrated that the suggested procedure not only provides estimates of the character under study according to the strata variable, but also improves the precision of the estimate pooled over the strata compared to the conventional unstratified two-stage procedure.

Key Words: Post-stratification; Two-stage sampling; Finite population

Introduction

Under the various agricultural development programmes, launched/under operation, emphasis is being put on raising the lot of the marginal and small farmers, who constitute the bulk of the farming community in a majority of under developed and developing countries. For a proper assessment and evaluation of the impact of these programmes as well as for their efficient monitoring, it is imperative to have the results available separately for each holding size class. In a majority of the surveys, in the field of social sciences and agriculture, the most commonly adopted survey design is one of stratified multi-stage random sampling, the strata generally being the geographical areas in a region for obvious reasons. In an agricultural survey, generally the villages and holdings are taken as the primary and secondary stage sampling units respectively. The stratification according to holding size is not adopted in these surveys since the frame of the holdings according to their size class is mostly not available. One possible approach to obtain estimates of characteristics of interest separately for each holding size class under these surveys is to resort to post-stratification according to the size of holding after the survey has been conducted. In this paper a scheme of post stratification in two-stage sampling on the basis of sample second-stage units in the sample primary-stage units is presented.

2. *Scheme for post-stratification in two-stage sampling*

Stratify the selected ssu's of each of the sampled fsu's into k strata on the basis of the chosen stratification character. It is possible that a selected fsu may contain more than one ssu's beloning to the same stratum. Again, a selected fsu may not contain any ssu's belonging to one or more of the K strata. Further, a selected fsu may possess at least one ssu pertaining to each of the k strata. Let the number of sample fsu's containing at least one ssu belonging to the h^{th} stratum $(h = 1, 2, \ldots, k)$ be denoted by n_h $(0 < n_h \le n)$ and $m_{i(h)}$ denote the number of ssu's from the i^{th} fsu falling in the h^{th} stratum $(0 \le m_{i(h)} \le m_i)$ and N_h and $M_{i(h)}$ denote the corresponding numbers in the population.

2.1 *Proposed estimator*

An unbiased estimator of the population total for the hth stratum viz; $Y_{s(h)}$ for the study character y is given by

$$\hat{Y}_{s(h)} = \frac{N_h}{n_h} \sum_{i}^{n_h} \frac{M_{i(h)}}{m_{i(h)}} \sum_{j}^{m_{i(h)}} y_{ij(h)} = \frac{M_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)} \tag{1}$$

where

$$\hat{Y}_{i(h)} = \frac{1}{m_{i(h)}} \sum_{j}^{m_{i(j)}} y_{ij(h)}$$

and $y_{ij(h)}$ is the value of the j^{th} ssu of the i^{th} fsu falling in the h^{th} stratum.

and an unbiased estimator of population total (Y_s) is given by

$$\hat{Y}_s = \sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} \frac{M_{i(h)}}{m_{i(h)}} \sum_{j}^{m_{i(h)}} y_{ij(h)}$$

$$= \sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)} \tag{2}$$

It is easy to see that $\hat{Y}_s$ is unbiased for Y_s

2.2 *Variance of the estimator*

For fixed $n_1, n_2, \ldots, n_k$ and $m_{i1}, m_{i2}, \ldots, m_{ik}$, the variance of the proposed estimator is given by

$$V(\hat{Y}_s) = V\left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)}\right]$$

$$= E_1 V_2 \left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)} \right] +$$

$$V_1 E_2 \left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)} \right] \quad (3)$$

where E_2 and V_2 are conditional expectation and variance respectively forgiven fsu's and for fixed n_h and $m_{i(h)}$;

E_1 and V_1 are expectation and variance for selection of fsu's for fixed n_h and $m_{i(h)}$

Now,

$$= E_1 V_2 \left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)} \right]$$

$$= E_1 \left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{ih}^2 \left(\frac{1}{m_{i(h)}} - \frac{1}{M_{i(h)}} \right) S_{i(h)}^2 \right]$$

since $\text{Cov}_2 \left[M_{i(h)} \hat{Y}_{i(h)}, \; M_{i(h')} \hat{Y}_{i(h')} \right] = 0$, and

$$S_{i(h)}^2 = \frac{1}{M_{i(h)}-1} \sum_{j=1}^{M_{i(h)}} \left(y_{ij(h)} - \hat{Y}_{i(h)} \right)^2$$

Therefore,

$$E_1 V_2 (\hat{Y}_s) = \sum_{h=1}^{k} \frac{N_h^2}{n_h} \frac{1}{N_h} \sum_{i=1}^{N_h} M_{ih}^2 \left(\frac{1}{m_{i(h)}} - \frac{1}{M_{i(h)}} \right) Si_h^2 \quad (4)$$

and

$$V_1 E_2 \left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \hat{Y}_{i(h)} \right] = V_1 \left[\sum_{h=1}^{k} \frac{N_h}{n_h} \sum_{i}^{n_h} M_{i(h)} \bar{Y}_{i(h)} \right]$$

$$= \sum_{h=1}^{k} N_h^2 \left(\frac{1}{n_h} - \frac{1}{N_h} \right) S_{b(h)}^2 + \sum_{h \neq h}^{k} \text{Cov}_1 \frac{N_h}{n_h} \sum_{i}^{n_h} Y_{i(h)}, \frac{N_h'}{n_h'} \sum_{i}^{n_h'} Y_{i(h')}$$

In order to evaluate

$$\sum_{h \neq h'}^{k} \text{Cov}_1 \left[\frac{N_h}{n_h} \sum_{i}^{n_h} Y_{i(h)} \quad \frac{N_{h'}}{n_{h'}}, \sum_{i}^{n_{h'}} Y_{i(h')} \right]$$

proceed as follows:

As mentioned above a sample fsu may contain ssu's belonging to one or more of the k strata and for that matter a fsu in the population too. Let the number of fsu's having an ssu belonging to both the hth and h'th strata in the sample be denoted by $n_{hh'}$ and that in the population by $N_{hh'}$. Likewise, let $n_{h(hh')}$ and $n_{h'(hh')}$ denote the number of fsu's having an ssu belonging only to the hth and h'th strata respectively for the strata pair (hh') and $N_{h(hh')}$ and $N_{h'(hh')}$ denote the corresponding numbers in the population. Obviously

$$N_h = N_{hh'} + N_{h(hh')}$$

and $$n_h = n_{hh'} + n_{h(hh')}$$

The above expression may, therefore, be written as

$$\sum_{h \neq h'}^{k} \text{Cov}_1 \left[\frac{N_h}{n_h} \left(\sum_{i}^{n_{hh'}} Y_{i(h)} + \sum_{i}^{n_{h(hh')}} Y_{i(h)} \right), \frac{N_{h'}}{n_{h'}} \left(\sum_{i}^{n_{hh'}} Y_{i(h')} + \sum_{i}^{n_{h'(hh')}} Y_{i(h')} \right) \right]$$

$$= \sum_{h \neq h'}^{k} \text{Cov}_1 \left[\frac{N_h}{n_h} \sum_{i}^{n_{hh'}} Y_{i(h)}, \frac{N_{h'}}{n_{h'}} \sum_{i}^{n_{hh'}} Y_{i(h')} \right]$$

$$= \sum_{h \neq h'}^{k} N_h N_{h'} \left(\frac{1}{n_{hh'}} - \frac{1}{N_{hh'}} \right) S_{h(hh')} \frac{n_{hh'}^2}{n_h n_{h'}}$$

and therefore . . . (5) may be written as

$$\sum_{h=1}^{k} N_h^2 \left(\frac{1}{n_h} - \frac{1}{N_h} \right) S_{b(h)}^2 + \sum_{h \neq h'}^{k} N_h N_{h'} \left(\frac{1}{n_{hh'}} - \frac{1}{N_{hh'}} \right) S_{b(hh')} \frac{n_{hh'}^2}{n_h n_{h'}}$$

where $$S_{b(h)}^2 = \frac{1}{N_{h-1}} \sum_{i=1}^{N_h} \left[Y_{i(h)} - \frac{1}{N_h} \sum_{i=1}^{N_h} Y_{i(h)}^2 \right] \qquad (6)$$

$$S_{b(hh')} = \frac{1}{N_{hh'} - 1} \sum_{i=1}^{N_{hh'}} \left[Y_{i(h)} - \frac{1}{N_{hh'}} \sum_{i=1}^{N_{hh'}} Y_{i(h)} \right] \left[Y_{i(h')} - \frac{1}{N_{hh'}} \sum_{i=1}^{N_{hh'}} Y_{i(h')} \right]$$

Substituting from (4) and (6) in (3) we get,

$$V(\hat{Y}_s) = \sum_{h=1}^{k} N_h^2 \left(\frac{1}{n_h} - \frac{1}{N_h}\right) S_{b(h)}^2 + \sum_{h \neq h'}^{k} N_{h'} N_h \left(\frac{1}{n_{hh'}} - \frac{1}{N_{hh'}}\right) S_{b(hh')} \frac{n_{hh'}^2}{n_h n_{h'}} + \sum_{h=1}^{k} \frac{N_h^2}{n_h} \frac{1}{N_h} \sum_{i=1}^{N_h} M_{i(h)}^2 \left[\frac{1}{m_{i(h)}} - \frac{1}{M_{i(h)}}\right] S_{i(h)}^2 \quad (7)$$

Now in order to find the average value of $V(\hat{Y}_s)$ in repeated samples of size n, proceed as follows :

$$V(\hat{Y}) = E\left[V\{Y_s/(n_1, n_2, \ldots, n_k) ; (m_{i(1)}, m_{i(2)}, \ldots, m_{i(k)})\}\right] + V\left[E\{Y_s/(n_1, n_2, \ldots, n_k) ; (m_{i(1)}, m_{i(2)}, \ldots, m_{i(k)})\}\right]$$

Since, $E\{\hat{Y}_s/(n_1, n_2, \ldots, n_k) ; m_{i(1)}, m_{i(2)}, \ldots, m_{i(k)}\}$ is a constant independent of $n_h, m_{i(h)}$,

$$V(\hat{Y}_s) = \sum_{h=1}^{k} N_h^2 \left[E\frac{1}{n_h} - \frac{1}{N_h}\right] S_{b(h)}^2 + \sum_{h \neq h'}^{k} N_h N_{h'} \left[E\frac{n_{hh'}}{n_h n_{h'}} - \frac{1}{N_{hh'}} E\left(\frac{n_{hh'}^2}{n_h n_{h'}}\right)\right] S_{b(hh')} + \sum_{h=1}^{k} N_h^2 \; E\frac{1}{n_h} \frac{1}{N_h} \sum_{i=1}^{N_h} M_{i(h)}^2 \left(E\frac{1}{m_{i(h)}} - \frac{1}{M_{i(h)}}\right) S_{i(h)}^2 \quad (8)$$

The expectations required in the above equation may be obtained, to the first order of approximation utilizing the usual technique in ratio method of estimation as follows :

$$E\left(\frac{1}{n_h}\right) = \frac{1}{nw_h}\left(1 + \frac{(1-w_h)}{nw_h}\right) \quad (9)$$

$$E\left(\frac{n_{hh'}}{n_h n_{h'}}\right) = \frac{w_{hh'}}{nw_h w_{h'}}\left(1 + \frac{1-w_{h'}}{nw_{h'}} + \frac{1-w_h}{nw_h} + \frac{1}{n}\right) \quad (10)$$

$$E\left(\frac{n_{hh'}^2}{n_h n_{h'}}\right) = \frac{w_{hh'}^2}{w_h w_{h'}}\left(1 + \frac{1-w_{h'}}{nw_{h'}} + \frac{1-w_h}{nw_h} + \frac{1-w_{hh'}}{nw_{hh'}} + \frac{3}{n}\right) \quad (11)$$

$$E\left(\frac{1}{m_{i(h)}}\right) = \frac{1}{m_i \varphi_{hi}}\left(1 + \frac{1-\varphi_{hi}}{m_i \varphi_{hi}}\right) \tag{12}$$

where $w_h = \frac{N_h}{N}$, $w_{h'} = \frac{N_{h'}}{N}$, $w_{hh'} = \frac{N_{hh'}}{N}$ and $\varphi_{hi} = \frac{M_{i(h)}}{M_i}$. Substituting in (8) from (9), (10), (11) abd (12), we get,

$$V(\hat{Y}_s) = N^2 \sum_{h=1}^{k} \left(\frac{1}{n} - \frac{1}{N}\right) w_h S^2_{b(h)} + \frac{N^2}{n^2} \sum_{h=1}^{k} (1-w_h) S^2_{b(h)} +$$

$$N^2 \sum_{h \neq h'}^{k} \left[w_{hh'} \left(1 + \frac{1-w_h}{nw_h} + \frac{1-w_{h'}}{nw_h} + \frac{1}{n}\right)\left(\frac{1}{n} - \frac{1}{N}\right) - \left(\frac{1+w_{hh'}}{N_h}\right)\right]$$

$$S_{b(hh')} + N^2 \sum_{h=1}^{k} \frac{1}{nN}\left(1 + \frac{1-w_h}{nw_h}\right) \sum_{i=1}^{N_h} M_i^2 \left\{\varphi_{hi}\left(\frac{1}{m_i} - \frac{1}{M_i}\right) + \frac{1-\varphi_{hi}}{m_i^2}\right\} S^2_{i(h)} \tag{13}$$

The variance expression given in (13) is seen to be made up of four components. The first term is the variance of a stratified sample taken with proportional allocation at the first stage, the second represents the adjustment at the first stage due to post-stratification of the sampled first stage units on the basis of the sampled second–stage units and the last two terms represent the contribution to the variance on account of stratification of the second–stage units and the adjustment at the second stage due to post-stratification of the second stage units.

2.2 *Particular cases*

(i) If $N_1 = N$, $n_1 = n$; $N_2 = N_3 = \ldots, = N_k = 0$ and $n_2 = n_3 = \ldots = n_k = 0$ and $M_{i(1)} = M_i$, $m_{i(1)} = m_i$; $M_{i(2)} = M_{i(3)} = \ldots, Mi_{(k)} = 0$ and $m_{i(2)} = m_{i(3)} = \ldots\ldots = m_{i(k)} = 0$ and therefore $\varphi_{hi} = 1$ and $w_h = 1$ the variance expression at (13) reduces to

$$N^2\left(\frac{1}{n} - \frac{1}{N}\right) S_b^2 + \frac{N}{n} \sum_{i=1}^{N} M_i^2 \left(\frac{1}{m_i} - \frac{1}{M_i}\right) S_i^2$$

which is the known result appropriate for two-stage sampling without post–stratification.

(ii) If $m_i = M_i$, the variance expression at (13) reduces to

$$N^2 \sum_{h=1}^{k} \left(\frac{1}{n} - \frac{1}{N}\right) w_h S^2_{b(h)} + \frac{N^2}{n^2} \sum_{h=1}^{k} (1-w_h) S^2_{b(h)} + N^2 \sum_{h \neq h'}^{k}$$

$$\left(w_{hh'}\left(1+\frac{1-w_h}{nw_h}+\frac{1-w_{h'}}{nw_{h'}}+\frac{1}{n}\right)\left(\frac{1}{n}-\frac{1}{N}\right)-\frac{1+w_{hh'}}{nN}\right)S_{b(hh')}$$

which corresponds to the variance expression for a uni-stage cluster design with post-stratification on the basis of the elements of the selected clusters (Mehrotra et al 1984)

3. *Empirical illustration*

Consider simulated data on area under high yielding varieties (HYV) of wheat crop in a holding as the character to be studied. The population consisted of 100 first- stage units, being the number of village growing HYV wheat in a district. The second stage-units were cultivator's holdings growing HYV wheat. The number of such holdings ranged between 19 and 41 per first-stage units *i.e.* a village growing HYV wheat. The holdings were categorized into three size classes on the basis of the operational area of a holding. The size classes were small (less than 2 hectares), medium (2-4 hectares), and large (above 4 hectares). It is desired to estimate the area under HYV wheat for each of the three hoding size classes as well as for the district as a whole, on the basis of a sample of 10 first stage units drawn with equal probability without replacement and a sample of 10 second stage units per sample first-stage unit again with equal probability without replacement, *i.e.* a sample of 100 elements.

The value of n_1, n_2 and n_3 in the sample and the value of N_1, N_2, N_3, N_{12}, N_{13} and N_{23} in the population are as follows :

N	N_1	N_2	N_3	N_{12}	N_{13}	N_{23}
100	89	89	85	80	78	80
n	n_1	n_2	n_3			
10	8	6	9			

Estimates of stratum-wise and overall totals of and their variances are as follows.

Under post stratification scheme	Stratum (holding size class)	$\hat{Y}$	$V(\hat{Y})$
	Small	13287	2026951
	Medium	28866	20062941
	Large	86950	102653320
	Overall	129103	124743212
Without post stratification	Overall	127747	200669953

It is observed that the suggested scheme of post-stratification has not only provided estimates of the total according to the strata variable but has also improved the precision of the estimate of the overall total. The efficiency of the suggested procedure compared to that of the usual procedure is 161 per cent.

REFERENCES

[1] Sukhatme, P.V. and Sukhatme, B.V., 1970. Sampling theory of surveys with applications (2nd Ed.), Iowa State University Press, Ames; Iowa U.S.A.

[2] Cochron, W.G., 1977. Sampling Techniques, (3rd Ed.), John Willy and Sons, New York.

[3] Mehrotra, P.C., Srivastava A.K. & Tyagi, K.K., 1984. On post-stratification for cluster sampling; *J. Ind. Soc. Agri. Stat.*, **36**; 98–104

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NEWS AND NOTES

Prof. Prem Narain, Principal Scientist, Indian Agricultural Research Institute, New Delhi received the "Distinguished Service Award" of the Mathematical Association of India. It was presented to him by Dr. S.Z. Qasim, Member, Planning Commission, Government of India on 13 April, 1993 at a function held at Delhi University, Delhi.

Dr. B.D. Tikkiwal, Ex-Senior Professor & Founder Head, Department of Statistics, University of Rajasthan, Jaipur attended the Conference on Small Area Statistics and Survey Designs at Warsaw, Poland in Sept.-Oct., 1992 and presented his paper "Modelling Through Survey Data for Small Domains".

Based on the assessment done by the Agricultural Scientists Recruitment Board of ICAR, Dr. Shivtar Singh has become w.e.f. 1st January, 1986 the Principal Scientist at Indian Agricultural Statistics Reseach Institute, New Delhi-110 012.

ANNOUNCEMENT

The membership fees of the Indian Society of Agricultural Statistics have been revised from 1993 in view of the increase in publication cost, postal charges and establishment charges. The members of the Society will bear with us for this increase and continue to extend their cooperation. The revised rates are as follows :

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Subscription to Journal		Rs. 200.00 (Inland)
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ANNOUNCEMENT

The 47th Annual Conference of the Indian Society of Agricultural Statistics will be held during 1993 at **S.V. Agricultural College** (Campus of Andhra Pradesh University), **Tirupati.** Prof. Prem Narain, Sessional President will deliver the Technical Address. The dates of the conference and other details will be announced as and when finalised.

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