An Efficient Ratio Type Predictive Estimator of Finite Population Mean using Known Median of the Study Variable

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Abstract*-The present manuscript pertains to an efficient ratio type predictive estimator for estimating finite population mean using the information on median of the study variable. Mathematical expressions for the bias and mean squared error (MSE) of the proposed predictive estimator have been obtained upto the first order of approximation. A theoretical efficiency comparison of the proposed estimator has been made with the Singh et al.(2014) and Yadav and Mishra (2015) estimators under predictive modelling approach. Theoretical findings are validated through the numerical study, and it has been found that proposed estimator performs better than the existing estimators.*

Key words: *Ratio Estimator, Predictive Approach, Bias, Mean Squared Error*

I. INTRODUCTION

In many practical situations it has been observed that population mean of the study variable is unknown, however, the population median of the study variable may be known. For example it is very hard to get the exact value if we attempt to know the weight or basic salary of a person; however, we may get the desired information in terms of interval or the pay band. Here, we can easily get the median of the study variable which can be utilized for improved estimation of population mean of study variable. It is a well-known fact in sampling theory that the use of auxiliary information accentuates the efficiency of the estimator. But this information is collected by incurring additional cost. Therefore, use of median of study variable may be a better option to improve the efficiency without increasing the cost of survey. In the present manuscript, we have proposed an improved estimator of population mean of the study variable using median of the study variable.

To understand the problem in a better way, one can refer some interesting examples of mean estimation of study variable using median of study variable given by Subramani (2016).

The model-based approach or the predictive method of estimation in sampling theory is based on super population models. This approach assumed that the population under consideration was a realization of super-population random variables containing a super population model. Under this super population model the prior information about the population is formalized and used to predict the non-sampled values of the population that is the finite population quantities, mean and other parameters of the study variable.

Many authors have used ratio, product and regression type estimators of population parameters for predictive estimation. In this article we have proposed a predictive estimator of population mean for simple random sampling design using median of the study variable.Some notable efforts in this direction are reported by many authors. Agrawal and Roy (1999) proposed the efficient estimators of population variance using ratio and regression type predictive estimators, Upadhyaya and Singh (1999) used transformed auxiliary variable and proposed the estimator of population mean, Singh (2003), suggested the improved product type estimator of population mean for negative correlated auxiliary variable, Singh and Tailor (2003), utilized the correlation coefficient of auxiliary and main variable and proposed the improved estimator of population mean, Singh et al. (2004, 2014) proposed improved estimators using power transformation and the predictive exponential estimators of population mean, respectively,Kadilar and Cingi (2004, 2006) utilized the different parameters of auxiliary variable and proposed improved ratio type estimators of population mean, Yan and Tian (2010), suggested the estimators of population mean using coefficient of skewness of auxiliary variable, Yadav (2011), proposed an efficient ratio estimator of population variance using auxiliary variable, Subramani and Kumarapandiyan (2012) suggested the efficient estimator of population mean using coefficient of variation and the median of auxiliary variable, Solanki et al. (2012) proposed an alternative estimator of population mean using variable for improved estimation of population mean, Onyeka (2012), proposed improved estimator of population mean in post stratified random sampling scheme, Jeelani et al. (2013), suggested modified ratio estimators of population mean using linear combination of coefficient of skewness and the quartile deviation of auxiliary variable, Saini (2013), proposed a predictive class of estimators on two stage random sampling, Yadav and Kadilar (2013) proposed the improved class of ratio and product estimators of population mean, Yadav et al. (2014) suggested the improved ratio estimators for population mean based on median using linear combination of population mean and median of an auxiliary variable and Yadav and Mishra (2015) proposed an improved estimator for estimating population mean under predictive modelling approach using linear combination of estimators proposed by Singh et al.(2014).

Let Y_i $(i = 1,2,\dots,N)$ be the real value taken by the variable under study from the finite population of U of size N. Here, the population parameter to be estimated is the population mean on the basis of observed values of y in an ordered sample of the finite population U of size N. Let S denote the collection of all possible samples from the finite population U. Let $w(s)$ denote the effective sample size, for any given $s \in S$ and $\bar{s}$ denote the collection of all those units of U which are not in S.

Now we denote:

$$\bar{y}_s = \frac{1}{w(s)}\sum_{i \in s} y_i$$

$$\bar{y}_{\bar{s}} = \frac{1}{N - w(s)}\sum_{i \in \bar{s}} y_i$$

We have,

$$\bar{Y} = \frac{w(s)}{N}\bar{y}_s + \frac{N - w(s)}{N}\bar{y}_{\bar{s}}$$

Basu (1971), asserted that in the representation of $\bar{Y}$ above the sample mean $\bar{y}_s$ being based on the observed y values on units in the samples is known, therefore the statistician should attempt a prediction of the mean $\bar{y}_{\bar{s}}$ of the unobserved units of the population on the basis of observed units in s.

For $s \in S$ under simple random sampling without replacement (SRSWOR) with sample size $w(s) = n$ and $\bar{y}_s = \bar{y}$, the population mean $\bar{Y}$ is given by

$$\bar{Y} = \frac{n}{N}\bar{y}_s + \frac{(N - n)}{N}\bar{y}_{\bar{s}} \quad (1)$$

In view of equation (1) above, an appropriate estimator of population mean $\bar{Y}$ is obtained as

$$\tilde{y} = \frac{n}{N}\bar{y} + \frac{(N-n)}{N}T$$

where T is taken as the predictor of $\bar{y}_{\bar{s}}$.

Let x_i $(i = 1,2,\dots,N)$ denote the i[th] observation of the auxiliary variable x and $X_i (i = 1,2,\dots,N)$ be the values of x on the i^{th} unit of the population U. Auxiliary variable x is correlated with the variable under study y.

Let

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} X_i$$

and

$$\bar{x} = \frac{1}{N}\sum_{i \in s} x_i$$

$$\tilde{y} = \frac{n}{N}\bar{y} + \frac{(N-n)}{N}T \quad (2)$$

II. REVIEW OF SOME EXISTING ESTIMATORS

(i). Singh et al.(2014) have proposed the following ratio and product type exponential estimator of population estimator of population mean $\bar{Y}$ using Bahl and Tuteja (1991), ratio and product types exponential estimator of population mean as the predictive estimator of $Y_{\bar{s}}$ respectively as

$$t = t_{Re} = \left[\frac{n}{N}\bar{y} + \left(\frac{N-n}{N}\right)\bar{y}\exp\left(\frac{\bar{X}_{\bar{s}} - \bar{x}}{\bar{X}_{\bar{s}} + \bar{x}}\right)\right]$$

$$= \frac{n}{N}\bar{y} + \left(\frac{N-n}{N}\right)\bar{y}\exp\left(\frac{N(\bar{X} - \bar{x})}{N(\bar{X} - \bar{x}) - 2n\bar{x}}\right)$$

$$t = t_{pe} = \left[\frac{n}{N}\bar{y} + \left(\frac{N-n}{N}\right)\bar{y}\exp\left(\frac{\bar{x} - \bar{X}_{\bar{s}}}{\bar{x} + \bar{X}_{\bar{s}}}\right)\right]$$

$$= \frac{n}{N}\bar{y} + \left(\frac{N-n}{N}\right)\bar{y}\exp\left(\frac{N(\bar{x} - \bar{X})}{N\bar{X} + (N-2n)\bar{x}}\right)$$

$$\text{Bias}(t_{Re}) = \frac{\theta}{8}\bar{Y}C_x^2[3 - 4(C + f)]$$

$$\text{Bias}(t_{pe}) = \frac{\theta}{8}\bar{Y}C_x^2\left[4C - \frac{1}{(1-f)}\right]$$

$$\text{MSE}(t_{Re}) = \theta\bar{Y}^2\left[C_y^2 + \frac{C_x^2}{4}(1 - 4c)\right] (3)$$

$$\text{MSE}(t_{pe}) = \theta\bar{Y}^2\left[C_y^2 + \frac{C_x^2}{4}(1 + 4c)\right] (4)$$

(ii) Yadav and Mishra (2015) hasproposed an improved estimator for estimating population mean under predictive modelling approach using linear combination of estimators proposed by Singh et al.(2014).

$$\tau = \alpha t_{Re} + (1 - \alpha)t_{pe}$$

wheret_{Re} and t_{pe} are estimators proposed by Singh at al. (2014) and α is the characterizing scalar to be determined such that mean squared error of τ is minimum.

$$\text{MSE}(\tau) = \bar{Y}^2\left[\theta C_y^2 + \alpha_1^2\frac{1}{4}\theta C_x^2 - \alpha_1\theta CC_x^2\right]$$

$$\alpha = \frac{2\theta CC_x^2}{\theta C_x^2} = 2C, \text{or}, \alpha = \frac{1}{2}(1 + 2C)$$

$$\text{MSE}_{min}(\tau) = \theta\bar{Y}^2[C_y^2 - CC_x^2] (5)$$

III. PROPOSED ESTIMATOR FOR ESTIMATION OF POPULATION MEAN

Subramani (2016) used the population median of the study variable and proposed the following ratio estimator of population mean of the study variable,

$$t = \bar{y}\left(\frac{M}{m}\right) \quad (6)$$

where M and m are the population and sample medians of study variable, respectively.

Motivated by Subramani (2016), we have used (6) as a predictor for (2),thus our proposed estimator under predictive approach will be

$$\tilde{y}_p = \frac{n}{N}\bar{y} + \frac{(N-n)}{N}\bar{y}\left(\frac{M_{\bar{s}}}{m}\right)$$

$$\tilde{y}_p = f\bar{y} + (1-f)\bar{y}\left(\frac{M_{\bar{s}}}{m}\right)$$

$$\tilde{y}_p = f\bar{y} + (1-f)\bar{y}\left(\frac{\frac{NM - nm}{N-n}}{m}\right) (7)$$

(where $M_{\bar{s}} = \frac{NM - nm}{N-n}$) as predictor for T in equation (1).

The following approximations have been made to study the properties of the proposed estimator as,

$\bar{y} = \bar{Y}(1 + e_0)$ and $m = M(1 + e_1)$ such that

$E(e_0) = 0$, $E(e_1) = \frac{\bar{M} - M}{M} = \frac{Bias(m)}{M}$ and

$E(e_0^2) = \lambda C_y^2$, $E(e_1^2) = \lambda C_m^2$,

$E(e_0 e_1) = \lambda C_{ym}$,

where, $\bar{M} = \frac{1}{n}\sum_{i=1}^{n} m_i$

$\lambda = \frac{1-f}{n}$

Equation (7) can also be written as,

$$\tilde{y}_p = f\bar{y} + (1-f)t_1 \quad (8)$$

where ,$t_1 = \bar{y}\left(\frac{\frac{NM - nm}{N-n}}{m}\right)$

$$= \bar{y}\left[\frac{NM - nm}{m(N-n)}\right]$$

$$= \bar{Y}(1 + e_0)\left[\frac{NM - nM(1 + e_1)}{M(1 + e_1)(N-n)}\right]$$

$$= \bar{Y}(1 + e_0)\left[\frac{NM - nM - nMe_1}{(MN - nM)(1 + e_1)}\right]$$

$$= \bar{Y}(1 + e_0)\left[\frac{(N-n) - ne_1}{(N-n)(1 + e_1)}\right]$$

$$= \bar{Y}(1+e_0)\left[\frac{1-\frac{n}{N-n}e_1}{(1+e_1)}\right]$$

$$= \bar{Y}(1+e_0)\ [(1\text{-}f_1\ e_1)(1+f_1)^{-1}]$$

where $f_1 = \frac{n}{N-n}$

$$= \bar{Y}(1+e_0)[1-f_1e_1-e_1+f_1e_1^2+e_1^2]$$

$$= \bar{Y}(1+e_0)[1+(f_1+1)(e_1^2-e_1)]$$

$$= \bar{Y}[\,1+e_0+(f_1+1)(e_1^2-e_1) + (f_1+1)(e_1^2e_0-e_0e_1)]$$

$$= \bar{Y}[\,1+e_0+f_2(e_1^2-e_1)-f_2(e_0e_1)]$$

where$f_2 = (f_1+1) = \frac{1}{1-f}$

$$t_1 \quad = \bar{Y}[\,1+e_0-f_2e_1+f_2e_1^2-f_2(e_0e_1)](9)$$

Substituting value of t_1 from (9) in (8),

$$\tilde{y}_p = f\,\bar{y}+(1-f)\bar{Y}[1+e_0-f_2(e_1-e_1^2+e_0e_1)]$$

$$= [f\,\bar{Y}(1+e_0)+(1-f)\bar{Y}(1+e_0) - (1-f)\bar{Y}f_2(e_1-e_1^2+e_0e_1)]$$

$$= [f\,\bar{Y}+f\,\bar{Y}\,e_0+\bar{Y}-f\,\bar{Y}+\bar{Y}\,e_0-f\,\bar{Y}\,e_0 - \bar{Y}(e_1-e_1^2+e_0e_1)]$$

$$= \bar{Y}+\bar{Y}[e_0-e_1+e_1^2-e_0e_1]$$

$$\tilde{y}_p - \bar{Y} = \bar{Y}[e_0-e_1+e_1^2-e_0e_1]\ (10)$$

Taking expectation on both sides in (10), we have

$$E(\,\tilde{y}_p-\bar{Y}) = \bar{Y}[E(e_0)-E(e_1)+E(e_1^2) - E(e_0e_1)]$$

On substituting the values of$E(e_0)$, $E(e_1), E(e_1^2)$ and $E(e_0e_1)$, we get the Bias$(\tilde{y}_p)$ as,

$$\text{Bias}(\tilde{y}_p) = \lambda\bar{Y}\left[C_m^2-C_{ym}-\frac{\text{Bias}(m)}{M}\right]$$

Squaring (10) and taking expectation both sides, we get MSE$(\tilde{y}_p)$ upto the first order approximation,

$$\text{MSE}\,(\tilde{y}_p) = \bar{Y}^2E[e_0-e_1]^2$$

$$= \bar{Y}^2E[e_0^2+e_1^2-2e_0e_1]$$

$$= \bar{Y}^2[E(e_0^2)+E(e_1^2)-2E(e_0e_1)]$$

Substituting values of $E(e_0^2), E(e_1^2)$and $E(e_0e_1)$, we have

$$\text{MSE}\,(\tilde{y}_p) = \lambda\bar{Y}^2[C_y^2+C_m^2-2C_{ym}]\ (11)$$

IV. THEORETICAL EFFICIENCY COMPARISON

Under this section, theoretical efficiency comparison of the proposed estimator has been made with Singh et al.(2014) estimator &Yadav and Mishra (2015) estimator of population mean under predictive modelling approach. The conditions under which the proposed estimator performs better than the existing estimators have also been given.

From equation (11) and equation (3), we have

$$\text{MSE}\,(\tilde{y}_p)-\text{MSE}(t_{Re})<0, if\ \lambda[C_y^2+C_m^2-2C_{ym}]<\theta[C_y^2+\tfrac{C_x^2}{4}(1-4C)](12)$$

Under the above condition proposed estimator is better than the Singh et al (2014) ratio type estimator.

From equation (11) and equation (4), we have

$$\text{MSE}\,(\tilde{y}_p)-\text{MSE}(t_{Pe})<0, if\ \lambda[C_y^2+C_m^2-2C_{ym}]<\theta[C_y^2+\tfrac{C_x^2}{4}(1+4C)]\ \ (13)$$

Under the above condition our proposed estimator performs better than the Singh et al. (2014) product type estimator.

From equation (11) and equation (5), we have

$$\text{MSE}\,(\tilde{y}_p)-\text{MSE}_{min}\,(\tau)<0, if\ \lambda[C_y^2+C_m^2-2C_{ym}]<\theta[C_y^2-CC_x^2]\ \ (14)$$

Under the above condition our proposed estimator performs better than the Yadav and Mishra (2015) estimator.

V. NUMERICAL ILLUSTRATION

To judge the theoretical findings, we have considered the natural populations given in Subramani (2016). He has used three natural populations. Population 1 and 2 have been taken from Singh and Chaudhary (1986, page no. 177) and population 3 has been taken from

Mukhopadhyay (2005, page no. 96). In populations 1 and 2, the study variable is the estimate of the area of cultivation under wheat in the year 1974, whereas the auxiliary variables are the cultivated areas under wheat in 1971 and 1973, respectively. In population 3, the study variable is the quantity of raw materials in lakhs of bales and the number of labourers as the auxiliary variable, in thousand for 20 jute mills. Table 2 and3 represent the parameter values along with constants, proposed estimator, variance andmean squared errorof existing and proposed estimator & Table 4 represent the per cent relative efficiency of the proposed estimator over the competing estimators.

TABLE-I

PARAMETER VALUES AND CONSTANTS FOR THREE NATURAL POPULATIONS

Parameter	Population-1	Population-2	Population-3
N	34	34	20
n	5	5	5
${}^{N}C_{n}$	278256	278256	15504
$\bar{Y}$	856.4118	856.4118	41.5
$\bar{M}$	736.9811	736.9811	40.0552
M	767.5	767.5	40.5
$\bar{X}$	208.8824	199.4412	441.95
R_7	1.1158	1.1158	1.0247
C_y^2	0.125014	0.125014	0.008338
C_x^2	0.088563	0.096771	0.007845
C_m^2	0.100833	0.100833	0.006606
C_{ym}	0.07314	0.07314	0.005394
C_{yx}	0.047257	0.048981	0.005275
ρ_{yx}	0.4491	0.4453	0.6522

TABLE-II

MEAN SQUARED ERRORS OF EXISTING AND PROPOSED ESTIMATORS

Estimator	Popln-1	Popln-2	Popln-3
t_{Re}	85,864.74	86,239.53	11.50
t_{Pe}	1,26,865.60	1,10,103.18	35.67
τ	66,876.33	65,415.03	31.18
$\tilde{y}_p$	25,645.25	9,919.07	9.27

TABLE-III

PERCENT RELATIVE EFFICIENCY OF THE PROPOSED ESTIMATOR

Estimator	Popln-1	Popln-2	Popln-3
t_{Re}	334.82	869.43	124.06
t_{Pe}	494.69	1110.02	384.79
τ	260.77	659.49	336.35

VI. RESULTS AND CONCLUSIONS

From Table-II, it is evident that the proposed estimator has the minimum mean squared error among the other competing estimators of population mean of study character. Thus, proposed estimator is better than the Singh at al.(2014) ratio and product type estimators and Yadav and Misra (2015) estimator. Therefore, it is recommended that the proposed estimator may be used by the survey practitioners for improved estimation of population mean under predictive modelling approach using the information on median of the study variable.

REFERENCES

[1] Cochran,W.G.(1977): Sampling Techniques. John Wiley and Sons, New York.

[2] Murthy,M.N. (1977): Sampling Theory & Methods. Statistical Publishing society, Calcutta.

[3] Misra, S., Singh, R. K and Shukla, A.K. (2013): Partial Predictive Estimation of Finite Population Variance Using Product Type Estimator,International Journal of Statistics and Analysis (IJSA) Number 2, pp. 211-219.

[4] Hald, A. (1952). Statistical theory with engineering applications. John Wiley and Sons, Inc, New York.

[5] Sukhatme, P.V, Sukhatme, B.V. ,Sukhatme, S .and Ashok, C (1984). *Sampling Theory of Surveys with Applications*, 3rd Ed., Iowa State University Press, Ams, Iowa(USA) and Indian Society of Agricultural Statistics, New Delhi

[6] Agrawal, M. C., Roy, D. C.(1999): Efficient estimators of population variance with regression-type and ratio-type predictor-inputs.*Metron*, 57(3), pp. 4–13.

[7] Jeelani, M. I., Maqbool, S., Mir, S. A.(2013): Modified Ratio Estimators of Population Mean Using Linear Combination of Coefficient of Skewness and Quartile Deviation. *International Journal of Modern Mathematical Sciences*, 6, 3, pp. 174–183.

[8] Kadilar, C., Cingi, H,(2006): An improvement in estimating the population mean by using the correlation coefficient. *Hacettepe Journal of Mathematics and Statistics*, 35 (1), pp. 103–109.

[9] Singh, G. N.(2003): On the improvement of product method of estimation in sample surveys. *JISAS*, 56, pp. 267–275.

[10] Srivastava, S. K (1983): Predictive estimation of finite population meanusing product estimator. *Metrika*, 1983, 30, pp. 93–99.

[11] Singh, H. P., Tailor, R.(2003). Use of known correlation coefficient in estimating the finite population means. *Statistics in Transition*, 6 (4), pp. 555–560.

[12] Singh, H. P., Tailor, R., Tailor, R., Kakran, M. S. (2004). An improved estimator of population mean using power transformation.*Journal of the Indian Society of Agricultural Statistics*, 58 (2), pp. 223–230.

[13] Singh, H. P., Solanki, R. S., Singh, A. K.(2014): Predictive Estimation of Finite Population Mean Using

Exponential Estimators.*Statistika: Statistics and Economy Journal*, 94 (1), pp. 41–53.

[14] Subramani, J., Kumarapandiyan, G.(2012): Estimation of Population Mean Using Coefficient of Variation and Median of an Auxiliary Variable. *International Journal of Probability and Statistics*, 1 (4), pp. 111–118.

[15] Subramani, J (2016): A New Median Based Ratio Estimator For Estimation Of The Finite Population Mean. *Statistics in Transition*, New Series, 17(4),pp-1-14

[16] Upadhyaya, L. N., Singh, H. P.(1999): Use of transformed auxiliary variable in estimating the finite population mean.*Biometrical Journal*, 41 (5), pp. 627–636.

[17] Yadav, S. K.(2011): Efficient estimators for population variance using auxiliary information. *Global Journal of Mathematical Sciences: Theory and Practical*, , 3, pp. 369–376.

[18] Yadav, S. K., Kadilar, C.(2013): Improved class of ratio and product estimators. *Applied Mathematics and Computation*, 219, pp. 10726–10731.

[19] Yadav, S. K., Mishra, S. S., Shukla, A.(2014): Improved ratio estimators for population mean based on median using linear combination of population mean and median of an auxiliary variable. *American Journal of Operations Research*, Scientific and Academic Publishing, 4, 2, pp. 21–27.

[20] Yadav, S. K., Mishra, S. S,(2015): Developing Improved Predictive Estimator for Finite Population Mean Using Auxiliary Information, *Statistika*, 95(1).

[21] Yan, Z., Tian, B.(2010) Ratio method to the mean estimation using coefficient of skewness of auxiliary variable. *ICICA*, Part II, CCIS, 106, pp. 103–110.

[22] Kadilar, G.O. (2016). A New Exponential Type Estimator for the Population Mean in Simple Random Sampling, *Journal of Modern Applied Statistical Methods*, 15, 2, 207-214.

[23] Reddy, V.N. (1974): On a transformed ratio method of estimation. *Sankhya*, C, 36(1), 59-70.

[24] Srivastava, S.K. (1967): An estimator using auxiliary information in sample surveys. *Cal. Statist. Assoc. Bull*., 16, 62-63.

[25] Subramani, J. (2013). Generalized modified ratio estimator of finite population mean, *Journal of Modern Applied Statistical Methods*, 12 (2), 121–155.

[26] Subramani, J., Kumarapandiyan, G. (2012). Estimation of population mean using coefficient of variation and median of an auxiliary variable, *International Journal of Probability and Statistics*, 1 (4), 111–118.

[27] Subramani, J., Kumarapandiyan, G. (2013). A new modified ratio estimator of population mean when median of the auxiliary variable is known, *Pakistan Journal of Statistics and Operation Research*, Vol. 9 (2), 137–145.

[28] Subramani, J. (2016).A new median based ratio estimator for estimation of the finite population mean, *Statistics in Transition New Series*, 17, 4, 1-14.

[29] Tailor, R., Sharma, B. (2009). A modified ratio-cum-product estimator of finite population mean using known coefficient of variation and coefficient of kurtosis, *Statistics in Transition-New Series*, 10 (1), 15–24

[30] Watson, D.J. (1937). The estimation of leaf area in field crops, *The Journal of Agricultural Science*, 27, 3, 474-483.

[31] Yadav, S.K; Mishra, S.S. and Shukla, A.K. (2014). Improved Ratio Estimators for Population Mean Based on Median Using Linear Combination of Population Mean and Median of an Auxiliary Variable. *American Journal of Operational Research*, 4, 2, 21-27.

[32] Yadav, S.K; Mishra, S.S. and Shukla, A.K. (2015). Estimation Approach to Ratio of Two Inventory Population Means in Stratified Random Sampling, *American Journal of Operational Research*, 5, 4, 96-101.

[33] Yadav, S. K; Gupta, Sat; Mishra, S. S. and Shukla, A. K. (2016). Modified Ratio and Product Estimators for Estimating Population Mean in Two-Phase Sampling, *American Journal of Operational Research*, 6, 3, 61-68.

[34] Yadav, S.K., Kadilar C.(2013): Improved Exponential Type ratio estimator of population variance. Rev. Colom. Estad.,36, 145-152.

[35] Yadav, D.K., Kumar R., Misra S., Yadav S.K.(2017): Estimating Population Mean using Known Median of the Study Variable, International Journal of Engineering Sciences and Research Technology(IJESRT) 6(7),15-21.

[36] Yadav,D.K.,Kumar R., Misra S., Yadav, S.K (2017): An Improved Estimator of Population Mean using Information on Median of the Study Variable,*International Journal of Mathematics Trends and Technology (IJMTT)***,** 46(2), 118-124.

[37] Yadav, D.K**.,**Dipika, Misra S (2017).: An Efficient Estimator for Estimating Finite Population Mean Using Known Median of the Study Variable*International Journal of Engineering Sciences and Research Technology(IJESRT)*,6(6), 503-509