ESTIMATION OF PALAY PRODUCTION WITH THE 1960 AGRICULTURAL CENSUS AS THE SAMPLING FRAME*

By

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Sample surveys must be designed to provide current statistics about the country's agricultural development. One of the most important uses of agricultural census results is to serve as a framework for current agricultural statistics (1). In general, data from the agricultural censuses are obtained by enumeration or by the use of a high sampling fraction of the farm households. Thus, the results of the agricultural census can be used as the framework of the agricultural sample surveys.

This paper will illustrate some of the approaches to this problem of designing sample surveys with the agricultural agricultural census as the sampling frame. The results of the Philippine Agricultural Census of 1960 will be used in the estimation of palay production in the five selected provinces of Abra, Bulacan, Pampanga, Tarlac, and Zambales.

I. Palay Production

The Philippine 1960 Agricultural Census (2) contains data on palay production in cavans of 44 kilograms by municipality. The production data are given under five categories or strata, namely: (a) First crop, irrigated; (b) first crop, not irrigated; (c) second crop, irrigated; (d) second crop, not irrigated; and (e) kaingin and upland. In addition to palay production, the total number of farms reporting and total hectarage under palay also are tabulated by each type of strata. We will show how these two concomitant variables can be used to estimate palay production by province.

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II. Comparison of Efficiency of Estimators

Five different estimators of palay production will be used and their efficiencies will be compared (3,4,5). These estimators of total palay production of the province are as follows:

Simple random (X-only) $= \bar{T}_X = N\bar{x}$;

Stratified (optimum) $= \bar{T}_x(oa) = N\bar{x}(oa)$;

Ratio of means $= \tilde{T}_Q = \bar{q}Z$ or $= \bar{q}Y$;

Separate ratio (st) $= \tilde{T}_Q(st) = \sum_{i=1}^{L} \bar{q}_i Z_i$ or $\sum \bar{q}_i Y_i$;

Combined ratio (st) $= \tilde{T}_C(st) = q(st)Z$ or $= q(st)Y$;

and the
Unbiased separate ratio $= \tilde{T}_u$.

The variances of each of these estimators are given in Table 1. The variance of T_X is

$$N(N\text{-}n)\ S^2(X_{ij})/n$$

and this variance is not given in the table. For the ratio estimators, the number of farms reporting and the hectarage under the palay crop are used as concomitant variables. The statistics on palay production (X_{ij}), number of farms reporting (Z_{ij}) and hectarage (Y_{ij}) for the provinces of Abra, Bulacan, Pampanga, Tarlac, and Zambales are shown in Tables 2a, 2b, 2c, 2d and 2e, respectively, where

- N is the province or universe size,
- N_i is the stratum size ($i=1, 2, \ldots, 5$),
- n is the sample size for the province,
- n_i is the sample size for the stratum,
- X, Z, or Y is the total for the province,
- X_i Z_i or Y_i is the total for the i^{th} stratum,

TABLE 1

SUMMARY OF DIFFERENT ESTIMATORS OF POPULATION TOTAL, X,* THEIR VARIANCES AND ESTIMATES OF VARIANCE IN STRATIFIED SAMPLING.

Type of estimator	Form of estimators	Variance	Estimate of variance
Stratified	$\hat{T}(st) = N\bar{x}(st) = \sum_{1}^{L} N_i \bar{x}_i$	$\sum_{i=1}^{L} N_i(N_i-n_i)S_i^2(X_{ij})/n_i$	$s^2\left[\hat{T}(st)\right] = \sum_{i=1}^{L} N_i(N_i-n_i)s_i^2(X_{ij})/n_i$
Ratio of means	$\hat{T}_Q = \bar{q}Z$ or $= \bar{q}Y$	$(N-n)N\left[S^2(X_{ij})+Q^2S^2(Z_{ij}) -2QS(X_{ij},Z_{ij})\right]/n$	$(N-n)N\left[s^2(X_{ij})+q^2s^2(Z_{ij}) -2qs(X_{ij},Z_{ij})\right]/n$
Separate ratio of means	$\hat{T}_Q(st) = \sum_{i=1}^{L} \bar{q}_i Z_i$	$\sum_{i=1}^{L} N_i(N_i-n_i)\left[S_i^2(X_{ij})+Q_i^2S_i^2(Z_{ij}) -2Q_iS_i(X_{ij},Z_{ij})\right]/n_i$	$s^2\left[\hat{T}_Q(st)\right] = \sum_{i=1}^{L} N_i(N_i-n_i)\left[s_i^2(X_{ij}) +\bar{q}_i^2s_i^2(Z_{ij})-2\bar{q}_i s(X_{ij},Z_{ij})\right]/n_i$
Combined ratio of means	$\hat{T}_C(st) = \left[\bar{x}(st)/\bar{z}(st)\right] Z = qZ$	$\sum_{i=1}^{L} N_i(N_i-n_i)\left[S_i^2(X_{ij})+Q^2S_i^2(Z_{ij}) -2QS_i(X_{ij},Z_{ij})\right]/n_i$	$s^2\left[\hat{T}_C(st)\right] = \sum_{i=1}^{L} N_i(N_i-n_i)\left[s_i^2(X_{ij}) +q^2s_i^2(Z_{ij})-2qs_i(X_{ij},Z_{ij})\right]/n_i$
Separate unbiased ratio of means	$\hat{T}_u(st) = \sum_{i=1}^{L}\left\{\bar{r}_iZ_i+\left[(N_i-1)n_i/(n_i-1)\right](\bar{x}_i-\bar{r}_i\bar{z}_i)\right\}$	Use variance for separate ratio $\sigma^2\left[\hat{T}_Q(st)\right]$	Use estimator $s^2\left[\hat{T}_Q(st)\right]$

*If we want to estimate the population mean $\bar{X}$, then we divide the estimators of total by N and the corresponding variance by N^2

TABLE 2a

PARAMETERS OF PALAY PRODUCTION (X_{ij}) IN CAVANS,* NUMBER OF FARMS REPORTING (Z_{ij}), AND HECTARAGE (Y_{ij}). ABRA PROVINCE. JULY 1959 TO JUNE 1960.

Parameters of stratum	Strata					Parameters of province
	(a)	(b)	(c)	(d)	(e)	
N_i	25	22	23	17	24	$N = 111$
n (oa)	10	5	5	1	2	$n = 23$
$(N_i—n_i)$	15	17	18	16	22	
X_i	234,996	150,423	85,634	11,440	31,069	$X = 513,562$
Z_i	6,715	9,353	2,949	929	2,614	$Z = 22,560$
Y_i	8,392	8,651	2,915	758	2,447	$Y = 23,162$
$S_i^2(Z_{ij})$	110,684,260	31,237,410	31,114,311	1,093,155	6,405,335	$S^2(X_{ij}) = 48,998,431$
$S_i^2(Y_{ij})$	32,425	102,561	23,675	8,599	10,457	$S^2(Z_{ij}) = 52,176$
$S_i^2(X_{.j})$	141,663	105,443	34,928	4,849	24,911	$S^2(Y_{ij}) = 82,467$
$S(X_{ij},Z_{ij})$	1,478,676	1,548,374	705,595	82,595	151,786	$S(X_{ij},Z_{ij}) = 1,144,993$
$S_i(X_{ij}.Y_{ij})$	3,600,899	1,706,042	947,901	64,977	105,763	$S(X_{ij},Y_{ij}) = 1,745,204$
$Q(X_i/Z)$	35.00	16.08	29.04	12.31	11.89	$Q(X/Z) = 22.76$
$Q_i(X_i/Y_i)$	28.00	17.39	29.11	15.10	12.70	$Q(X/Y) = 22.17$

*A cavan of palay weighs 44 kilograms.

TABLE 2b

PARAMETERS OF PALAY PRODUCTION (X_{ij}) IN CAVANS,* NUMBER OF FARMS REPORTING (Z_{ij}), AND HECTARAGE (Y_{ij}). BULACAN PROVINCE. JULY 1959 TO JUNE 1960.

Parameters of stratum	Strata					Parameters of Province
	(a)	(b)	(c)	(d)	(e)	
N_i	19	24	20	12	16	N = 91
n_i(oa)	5	7	3	2	1	n = 18
$(N_i—n_i)$	14	17	17	10	15	
X_i	822,977	1,041,602	277,687	77,312	88,429	X = 2,308,007
Z_i	10,483	18,380	4,623	1,273	1,890	Z = 36,649
Y_i	19,894	33,926	8,343	3,853	3,715	Y = 67,731
$S^2_i(X_{ij})$	1,686,133,700	2,456,576,552	578,428,219	457,443,324	89,998,872	$S^2(X_{ij})$ = 1,459,790,959
$S^2_i(Z_{ij})$	215,103	668,084	133,783	175,471	30,672	$S^2(Z_{ij})$ = 333,742
$S^2_i(Y_{ij})$	924,192	2,850,606	503,056	248,570	170,858	$S^2(Y_{ij})$ = 1,333,980
$S_i(X_{ij},Z_{ij})$	18,267,436	39,436,315	8,647,926	7,267,317	1,552,170	$S(X_{ij},Z_{ij})$ = 21,151,549
$S_i(X_{ij},Y_{ij})$	39,146,502	82,300,869	16,996,456	10,663,103	3,853,838	$S(X_{ij}Y_{ij})$ = 42,890,382
$Q_i(X_i/Z_i)$	78.50	56.67	60.07	60.73	46.79	(QX/Z) = 62.98
$Q_i(X_i/Y_i)$	41.36	30.70	33.78	41.73	23.80	Q(X/Y) = 34.08

*A cavan of palay weighs 44 kilograms.

TABLE 2c

PARAMETERS OF PALAY PRODUCTION (X_{ij}) IN CAVANS,* NUMBER OF FARMS REPORTING (Z_{ij}), AND HECTARAGE (Y_{ij}). PAMPANGA PROVINCE. JULY 1959 TO JUNE 1960.

Parameters of stratum	Strata					Parameters of province
	(a)	(b)	(c)	(d)	(e)	
N_i	21	21	17	16	9	N = 84
n_i(oa)	10	9	4	1	1	n = 25
$(N_i—n_i)$	11	12	13	15	8	
X_i	1,220,455	809,399	483,899	31,303	45,088	X = 2,590,144
Z_i	11,804	9,410	6,568	505	1,024	Z = 29,311
Y_i	32,124	24,251	14,308	1,107	1,803	Y = 73,593
$S^2(X_{ij})$	2,091,118,610	1,980,008,430	554,418,083	20,053,831	38,281,873	$S^2(X_{ij})$ = 1,524,387,110
$S^2(Z_{ij})$	147,870	219,154	92,726	3,850	15,649	$S^2(Z_{ij})$ = 148,202
$S_i^2(Y_{ij})$	1,345,595	1,461,167	566,536	24,190	57,903	$S^2(Y_{ij})$ = 1,098,549
$S(X_{ij},Z_{ij})$	16,749,156	19,687,977	6,780,676	276,270	762,741	$S(X_{ij},Z_{ij})$ = 14,282,493
$S(X_{ij},Y_{ij})$	51,300,078	53,138,905	17,358,867	696,219	1,454,939	$S(X_{ij},Y_{ij})$ = 40,234,766
$Q(X_i/Z_i)$	103.39	86.02	73.68	61.99	44.03	Q(X/Z) = 88.37
$Q_i(X_i/Y_i)$	37.99	33.38	33.82	28.27	25.01	Q(X/Y) = 35.20

*A cavan of palay weighs 44 kilograms.

TABLE 2d

PARAMETERS OF PALAY PRODUCTION (X_{ij}) IN CAVANS,* NUMBER OF FARMS REPORTING (Z_{ij}), AND HECTARAGE (Y_{ij}) TARLAC PROVINCE. JULY 1959 TO JUNE 1960.

Parameters of stratum	Strata					Parameters of province
	(a)	(b)	(c)	(d)	(e)	
N_i	16	17	13	14	14	$N = 74$
n_i(oa)	9	4	1	1	1	$n = 15$
$(N_i - n_i)$	7	13	12	13	13	
X_i	1,367,773	1,520,281	192,424	20,593	173,940	X = 3,275,011
Z_i	10,688	23,295	2,185	304	4,011	Z = 40,483
Y_i	31,209	51,446	5,791	743	7,926	Y = 97,115
$S_i^2(X_{ij})$	27,849,077,307	4,427,164,823	409,984,984	5,311,576	417,623,094	$S^2(X_{ij})$ = 7,013,288,273
$S_i^2(Z_{ij})$	711,458	918,636	42,526	860	94,247	$S^2(Z_{ij})$ = 628,467
$S_i^2(Y_{ij})$	9,221,042	4,206,125	344,710	6,899	882,208	$S^2(Y_{ij})$ = 4,459,278
$S_i(X_{ij},Z_{ij})$	105,206,436	57,089,377	3,956,044	57,495	5,876,112	$S(X_{ij},Z_{ij})$ = 53,479,605
$S_i(X_{ij},Y_{ij})$	440,883,478	134,385,721	11,498,142	190,571	19,093,511	$S(X_{ij},Y_{ij})$ = 168,603,753
$Q_i(X_i/Z_i)$	127.97	65.26	88.06	67.74	43.36	$Q(X/Z)$ = 80.89
$Q_i(X_i/Y_i)$	43.82	29.55	33.22	27.71	21.94	$Q(X/Y)$ = 33.72

*A cavan of palay weighs 44 kilograms.

TABLE 2e

PARAMETERS OF PALAY PRODUCTION (X_{ij}) IN CAVANS,* NUMBER OF FARMS REPORTING (Z_{ij}), AND HECTARAGE (Y_{ij}). ZAMBALES PROVINCE. JULY 1959 TO JUNE 1960.

Parameters of stratum	Strata					Parameters of province
	(a)	(b)	(c)	(d)	(e)	
N_i	14	14	9	6	13	$N = 56$
$n_i(oa)$	4	4	1	1	1	$n = 11$
$(N_i—n_i)$	10	10	8	5	12	
X_i	163,491	434,836	5,087	3,796	17,704	$X =$ 624,914
Z_i	2,636	9,101	120	103	874	$Z =$ 12,082
Y_i	4,462	13,894	190	122	1,158	$Y =$ 19,826
$S^2(X_{ij})$	318,894,387	251,224,571	777,501	559,091	3,396,198	$S^2(X_{ij}) =$ 289,671,845
$S^2(Z_{ij})$	76,047	119,868	430	225	8,137	$S^2(Z_{ij}) =$ 118,497
$S_i^2(Y_{ij})$	236,588	352,143	1,020	327	16,102	$S^2(Y_{ij}) =$ 293,773
$S(X_{ij},Z_{ij})$	4,900,321	5,127,630	18,118	10,993	159,680	$S(X_{ij},Z_{ij}) =$ 5,680,636
$S_i(X_{ij},Y_{ij})$	8,640,417	8,727,399	26,678	12,510	219,422	$S(X_{ij},Y_{ij}) =$ 8,960,977
$Q(X_i/Z_i)$	62.02	46.68	42.39	36.85	20.26	$Q(X/Z) =$ 52.72
$Q_i(X_i/Y_i)$	36.64	31.30	26.77	31.11	15.29	$Q(X/Y) =$ 31.52

*A cavan of palay weighs 44 kilograms.

$S^2(X_{ij})$, $S^2(Z_{ij})$, or $S^2(Y_{ij})$
is the variance for the province,

$S^2(X_{ij})$, $S^2(Z_{ij})$, or $S^2(Y_{ij})$
is the variance for the i^{th} stratum,

$Q(X/Z)$ or $Q(X/Y)$ is the ratio for the province,

and

$Q_i(X_i/Z_i)$ or $Q_i(X_i/Y_i)$ is the ratio for the i^{th} stratum.

Note that N, the province or universe size, is assumed to be independent of Z, the total number of farms reporting.

These statistics are used to derive the variances of the estimators for a given province. These variances are compared and the relative efficiencies (R.E.) are derived. The results for a 20 percent sample of municipalities are given in Tables 3a, 3b, 3c, 3d, and 3e for the provinces of Abra, Bulacan, Pampanga, Tarlac, and Zambales, respectively.

The results indicate that the group of ratio estimators is superior to either the simple random or stratified (optimum) estimator. In turn, the separate ratio estimator $[\tilde{T}_Q(st)]$ is more efficient than the ratio means $[\tilde{T}_Q]$ or the combined ratio $[\tilde{T}_C(st)]$ estimator. With number of farms (Z_{ij}) as the concomitant variable the R.E. of $\tilde{T}_Q(st)$ to T_X ranges from 426 percent for Abra (Table 3a) to 4742 percent from Zambales (Table 3e). With hectarage (Y_{ij}) as the additional variable, the R.E. ranges from 682 percent for Abra (Table 3a) to 6669 percent for Bulacan (Table 3b). The cv $[\tilde{T}_X]$ for Pampanga was 24 percent. When we use the separate ratio estimator $[\tilde{T}_Q(st)]$, the cv was 3 percent, indicating considerable gain of statistical precision in the use of $\tilde{T}_Q(st)$ over $\tilde{T}_X$. The variance of $\tilde{T}_u(st)$ is not given as it is assumed to be equal to that of $\tilde{T}_Q(st)$. $\tilde{T}_u(st)$ may be used to remove the bias in $\tilde{T}_Q(st)$.

Table 3a

VARIANCE OF ESTIMATOR AND RELATIVE EFFICIENCY OF ESTIMATES FOR PALAY PRODUCTION. ABRA PROVINCE. JULY 1959 TO JUNE 1960

Type of estimator	Concomitant variable					
	Number of farms			Hectarage		
	Variance (000,000)	R.E.%*	cv %	Variance (000,000)	R.E.%*	cv %
Simple random = $\bar{T}_X$ (X-only)	20,809	100	28	20,809	100	28
Stratified (optimum) = $\bar{T}_X(oa)$	12,435	169	22	12,435	169	22
Ratio of means (r) = $\tilde{T}_Q$	10,153	205	20	5,160	403	14
Separate ratio (st) = $\tilde{T}_Q(st)$	4,980	426	14	3,854	682	12
Combined ratio (st) = $\tilde{\bar{T}}_C(st)$	6,775	315	16	5,952	372	15

*R.E. is relative efficiency with the variance of $\bar{T}_X$ as numerator.

Table 3b

VARIANCE OF ESTIMATOR AND RELATIVE EFFICIENCY OF ESTIMATES FOR PALAY PRODUCTION. BULACAN PROVINCE. JULY 1959 TO JUNE 1960

Type of estimator	Concomitant variable					
	Number of farms			Hectarage		
	Variance (000,000)	R.E.%*	cv %	Variance (000,000)	R.E.%*	cv %
Simple random $= \bar{T}_X$ (X-only)	538,744	100	32	538,744	100	32
Stratified (optimum) $= \bar{T}_X(oa)$	369,087	146	26	369,087	146	26
Ratio of means (r) $= \tilde{T}_Q$	44,037	1,223	9	31,639	1,702	8
Separate ratio (st) $= \tilde{T}_Q(st)$	26,939	2,000	7	8,078	6,669	4
Combined ratio (st) $= \tilde{T}_C(st)$	33,767	1,595	8	30,840	1,747	8

*R.E. is relative efficiency with the variance of $\bar{T}_X$ as numerator.

Table 3c

VARIANCE OF ESTIMATOR AND RELATIVE EFFICIENCY OF ESTIMATES FOR PALAY PRODUCTION.
PAMPANGA PROVINCE. JULY 1959 TO JUNE 1960

Type of estimator	Concomitant variable					
	Number of farms			Hectarage		
	Variance (000,000)	R.E.%*	cv %	Variance (000,000)	R.E.%*	cv %
Simple random $= \overline{T}_X$ (X-only)	402,376	100	24	402,376	100	24
Stratified (optimum) $= \overline{T}_X(oa)$	141,383	285	15	141,383	285	15
Ratio of means (r) $= \widetilde{T}_Q$	31,212	1,289	7	10,508	3,829	8
Separate ratio (st) $= \widetilde{T}_Q(st)$	14,306	2,813	5	6,512	6,179	3
Combined ratio (st) $= T_C(st)$	19,834	2,029	5	7,463	5,392	3

*R.E. is relative efficiency with the variance of $\overline{T}_X$ as numerator.

Table 3d

VARIANCE OF ESTIMATOR AND RELATIVE EFFICIENCY OF ESTIMATES FOR PALAY PRODUCTION. TARLAC PROVINCE. JULY 1959 TO JUNE 1960.

Type of estimator	Concomitant variable					
	Number of farms			Hectarage		
	Variance (000,000)	R.E.%*	cv %	Variance (000,000)	R.E.%*	cv %
Stratified (optimum) = $\overline{T}_X$(oa) (X-only)	2,041,334	100	44	2,041,334	100	44
Stratified (optimum) = $\overline{T}_X$(oa)	532,098	384	22	532,098	384	22
Ratio of means (r) = $\tilde{T}_Q$	760,322	268	27	229,080	891	15
Separate ratio (st) = $\tilde{T}_Q$(st)	217,449	939	14	111,427	1,832	10
Combined ratio (st) = $\tilde{T}_C$(st)	269	758	16	146,600	1,392	12

*R.E. is relative efficiency with the variance of $\overline{T}_X$ as numerator.

Table 3e

VARIANCE OF ESTIMATOR AND RELATIVE EFFICIENCY OF ESTIMATES FOR PALAY PRODUCTION.
ZAMBALES PROVINCE. JULY 1959 TO JUNE 1960.

Type of estimator	Concomitant variable: Number of farms			Concomitant variable: Hectarage		
	Variance (000,000)	R.E.%*	cv %	Variance (000,000)	R.E.%*	cv %
Simple random $= \bar{T}_X$ (X-only)	66,334	100	41	66,334	100	41
Stratified (optimum) $= \bar{T}_X(oa)$	20,557	323	23	20,557	323	23
Ratio of means (r) $= \tilde{\bar{T}}_Q$	4,420	1,500	11	3,891	1,704	10
Separate ratio (st) $= \tilde{\bar{T}}_Q(st)$	1,399	4,742	6	1,894	3,502	7
Combined ratio (st) $= \tilde{\bar{T}}_C(st)$	3,373	1,966	9	3,073	2,158	9

*R.E. is relative efficiency with the variance of $\bar{T}_X$ as numerator.

Hectarage appears to be a more efficient concomitant variable than number of farms reporting as indicated by the lower variance or by the higher R.E. Tables (3a to 3e). The relatively high correlations between (X_{ij}) and (Z_{ij}) and between (X_{ij}) and (Y_{ij}) are responsible for the considerable gain in the statistical precision of the ratio estimators. The correlation coefficients by strata and by province are given in Table 4. Note that in addition to the five provinces of Abra, Bulacan, Pampanga, Tarlac, and Zambales, Table 4 gives the results for 15 other provinces.

III. Discussion and Recommendation

To be of maximum use as a sampling frame, the results of the Philippine 1960 Agricultural Census, must be tabulated at least at the barrio level. With stratification by size and by category (a to e), the variability among barrios as primary sampling units (PUS's) will be relatively lower than with the municipalities as PSU's. The application of stratification with the five categories (a to e) as strata resulted in a gain of statistical precision of 46 percent for Bulacan and 284 percent for Tarlac. In addition, this type of stratification will enable us to derive precise estimates of palay production and other charateristics for each province by each category, namely: (a) First crop, irrigated; (b) first crop, not irrigated; (c) second crop, irrigated; (d) second crop, not irrigated; and (e) kaingin and upland. These estimates will be useful in the preparation and evaluation of agricultural development efforts at the provincial level.

The barrios may arranged into paper strata in each of the five categories (a to e). After application of the paper strata, the product

$$N_i S_i$$

will be approximately constant for all strata (i), where N_i is the number of farms and S_i is the standard deviation of palay production. As shown by the author (4), this condition

Table 4

CORRELATION COEFFICIENT BETWEEN PALAY PRODUCTION (X_{ij}) IN CAVANS, AND NUMBER OF FARMS REPORTING (Z_{ij}) AND HECTARAGE (Y_{ij}) BY STRATA AND BY PROVINCE.

Province	$\hat{\rho}(X_{ij}, Z_{ij})$						$\hat{\rho}(X_{ij}, Y_{ij})$					
	Strata					Whole	Strata					Whole
	(a)	(b)	(c)	(d)	(e)	province	(a)	(b)	(c)	(d)	(e)	province
Abra	0.78	0.87	0.82	0.85	0.59	0.90	0.91	0.94	0.91	0.89	0.26	0.87
Bulacan	.96	.97	.98	.99	.93	.96	.99	.98	.99	.99	.98	.97
Pampanga	.95	.95	.95	.99	.95	.95	.97	.99	.98	.99	.98	.98
Tarlac	.75	.90	.95	.85	.94	.81	.87	.98	.97	.99	.99	.95
Zambales	.99	.93	.99	.98	.96	.97	.99	.93	.95	.93	.94	.97
Aklan	.95	.90	.95	.91	.90	.90	.96	.91	.97	.98	.95	.96
Albay	.88	.93	.81	.92	.94	.74	.95	.99	.91	.99	.99	.92
Bataan	.77	.95	.79	.92	.92	.82	.92	.99	.92	.99	.98	.94
Cagayan	.87	.82	.96	.97	.91	.83	.95	.97	.99	.96	.96	.97
Camarines Norte	.95	.98	.95	.94	.99	.71	.99	.98	.98	.98	.99	.93
Catanduanes	.77	.95	.80	.97	.94	.82	.82	.95	.81	.92	.96	.87
Ilocos Norte	.92	.90	.99	.98	.58	.89	.88	.91	.97	.99	.99	.92
Misamis Occidental	.94	.73	.91	.56	.92	.85	.99	.91	.93	.96	.88	.81
Misamis Oriental	.93	.98	.94	.97	.95	.89	.99	.97	.99	.97	.99	.98
Nueva Ecija	.99	.94	.97	.98	.76	.83	.99	.99	.99	.99	.88	.84
Nueva Viscaya	.95	.97	.91	.74	.98	.93	.99	.97	.90	.95	.98	.97
Occidental Mindoro	.91	.96	.99*	.77	.84	.94	.96	.99	.99*	.99	.97	.99
Romblon	.95	.97	.93	.58	.99	.90	.95	.99	.99	.97	.99	.95
Sorsogon	.77	.95	.78	.98	.97	.80	.96	95	96	.97	.97	.93
Surigao del Sur	.99	.95	**	.43	.98	.92	.99	.98	**	.96	.99	.98

*Contains three pairs of observations.
**Contains only two pairs of observations.

will indicate that the technique of equal take is as precise as stratified optimum sampling. Also, the administrative requirements of the survey become more simple with equal take. Thus, with equal take, statistical and administrative efficiencies are improved. From the census frame, each sample barrio is drawn from a given stratum with replacment and with probability proportional to size (pps) of production. Then the estimates are adjusted with the use of ratio estimators. The concomitant variables in the ratio estimators will be the number of farms reporting (Z_{ij}) or the hectarage (Y_{ij}) which are obtained from independent sources. As shown in this paper, the correlation between production (X_{ij}) and number of farms reporting (Z_{ij}) is about 0.87 while the correlation between production (X_{ij}) and hectarage (Y_{ij}) averaged about 0.94. High levels of correlation exist in the 20 provinces where census results have been released by the Bureau of the Census and Statistics. Thus, we expect considerable gain in statistical efficiency in the use of ratio estimators in efficiency in the use of ratio estimators in each of these provinces.

As the Philippine 1960 census was a sample census,[1] then the statistical findings presented in this paper can be used to improve the results of the 1960 census. These findings also will be incorporated into the estimation procedure of the current Philippine palay survey of the Bureau of Agricultural Economics, Department of Agriculture and Natural Resources.

IV. Review of Literature

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