The Philippine Statistician

SEPT. - DEC., 1969 ● VOL. XVIII ● NOS. 3-4

THE PHILIPPINE STATISTICIAN

(Entered as second class mail matter at the Manila Post Office on August 25, 1953)

Annual Subscription: Philippines — ₱6.00; Foreign — $4.00

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Footnotes are to be enumerated successively on a separate sheet and should be minimized, or, if at all possible, completely avoided.

References should be given at the end of the article on a separate sheet. The following forms should be followed.

[2]. M. A. NAIMARK, *Normed Complete Rings.* Groningen: P. S. Noordhoof, 1964.

[3]. JAMES R. CLAY AND JOSEPH J. MALONE JR. "The near rings with identities on certain finite groups," *Mathematica Scandinavica,* Volume 19, Number 1 (1966) pp. 146-167.

Office of Publication
RIZAL HALL—Padre Faura, Manila
P.O. Box 3223

The Philippine Statistician
Vol. XVIII, Nos. 3 and 4, 1969

STOCK AND FLOW DATA AS ANALYTIC TOOLS FOR MANPOWER-EDUCATION PLANNING *

by

BERNARDINO A. PEREZ **

The last few years have witnessed a great increase of interest concerning the need to ensure that education develops in harmony with the needs of economic development and to the changes in society at large. Problems on the available amount and characteristics of human resources and on their proper utilization, such as unemployment and skill shortages, arise in large measure from deficiencies of the educational system and distortions in the labor market structure. Comprehensive, integrated planning of the economy, manpower, and education is therefore imperative and has become a major concern of governments. A prerequisite of rationality in these policies and plans is reliable, relevant statistical data and analysis. But the efforts especially of educational and manpower planners, if these are to have a real impact on the nation's development, will depend on major improvements in the statistics of education and manpower.

It is inefficient and uneconomical to collect statistics without a reasonably clear idea of the purposes for which they are used. About five years ago, Harbison and Myers said:

> "The major problems of human resources analysis are conceptual. They involve the purposes of manpower estimates, the scope of assessments, and the relevancy of qualitative as well as quantitative data... The development of clear concepts and systematic

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* Paper contributed to the 17th Annual Conference of the Philippine Statistical Association, Inc., held on July 18, 1969.

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> methodology will ultimately determine the kind of empirical data which is most relevant, and thus perhaps forestall the collection of facts and figures for which there would be little use. In any case, the present dearth of statistical data provides no excuse for failure to develop sharper concepts and more systematic methods of analysis."[1]

Many systematic studies, articles and publications have since appeared dealing on the planning approaches, concepts and methods involved in human resources development. A good deal of labor force and education statistics is generally available in many countries, but at present such data are still rarely in adequate form which is useful for the new kind of comprehensive, integrated planning for education and manpower. Often the data on economic activity, occupational structure, educational attainment are found in census returns and are at least potentially available in punch cards. These, however, have not been tabulated for the minimum number of required cross-classifications. Infrequently, these usually neglected tabulations have been obtained only through special contractual arrangement with the census office. To meet the requirements, ad-hoc projects are undertaken for the systematic gathering of data from school records and related sources. When major adjustments in the presentation were necessary, these often resulted in alterations affecting the comparability of the scope and coverage of such statistical series.

For these reasons, generally the manpower projections of the labor force by economic characteristics, as attempted up till now, have had to be undertaken on a rather shaky statistical basis which diminishes their usefulness as an educational-manpower policy and planning instrument.

In the above context, this paper is concerned with suggesting a suitable statistical basis for the quantitative first step in planning for the optimum formation and utilization of manpower. It considers an overall conceptual frame work of the

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[1] Frederick Harbison and Charles A. Myers, *Education Manpower, and Economic Growth-Strategies of Human Resources Development.* McGraw-Hill, Inc., N.Y., 1964, pp. 202.

planning problem, which in relation to its elements, the needed statistics are to be defined, collected, and standardized. This would in a way ensure that the development of this kind of statistics is made relevant to decisions taken on policy questions. Elucidating the structure of, as well as flows between the labor market and the educational system in a unified basis conveniently brings up suggested needs in the future for different kinds of analysis and projections.

A Schematic Framework

Manpower planning at the beginning tended unfortunately towards a fragmentary approach with attention focused to determining manpower shortages and to programming measures for the training of qualified manpower required for economic development. On the other hand, educational planning traditionally was concerned with estimating the demand (number) for places by pupils and students that had to be provided with teachers, funds, and buildings, etc. The basic orientation was on the supply of young people entering the system rather than the products which it provides to meet needs in the labor market. One notable aspect of recent developments is a shift towards a more comprehensive, integrated approach to human resources development and utilization. In order to ensure the simultaneous examination of the inter-relationships between economic growth, manpower, and education, Harbinson has suggested a systems analyis approach.[2] The education-manpower system is viewed as somewhat analorous to an electric power grid system: we could think of schools, employing firms, etc. as generating centers, the linkages between the centers as transmission lines, and labor surpluses and skill shortages as power failures or faulty design which results in the system's inability to carry the "loads" expected of it.

A systems analysis approach permits an easier identification and examination of the critical interrelationships of problem areas. Along with this idea of using a unified frame of

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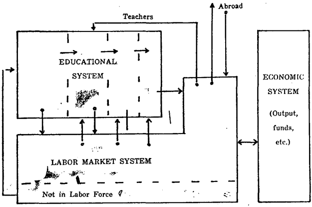
[2] F. Harbinson, *Educational Planning and Human Resource Development*, UNESCO: ILEP, 1967 Paris, p. 25.

analysis, it would also be possible to view the sectors of economic activity, educational system, and the labor market together with the overall demographic situation as comprising a three-scheme shown in diagram 1.

Diagram 1.

SCHEMATIC VIEW OF FLOWS BETWEEN EDUCATION, MANPOWER, AND THE ECONOMY



This schematic framework is a very simplified representation of the stocks of humans within each of the systems and of the flows of humans within and between them. Another kind of flow takes place within and between the three domains, i.e., the flow of goods and services of intermediate and final products, but this is the subject of National Economic Accounting which we are not concerned with here. A convenient way of looking at the statistical data implication of the system is thus provided in terms of stocks and flows which will now be described as follows:

Within the educational system are the students and teachers distributed among the various levels, grade, and types of courses and institutions. In the labor market are manpower distributions (not shown as disaggregated) by labor force activity, i.e., the employed, the unemployed, each with their attributes,— occupational, industrial, type of worker, and other demographic and social characteristics. Also included are those not available in the labor market force such as housewives, retirees, handicapped, the young and the aged. And within the economy are the interindustry distribution of workers.

The three systems are linked by flows of new entrants into the educational system consisting of young pupils entering the first grade, drop-outs, temporary drop-outs resuming their schooling, and graduates. Humans also flow from the manpower sector to the educational sector as teachers and other manpower requirements for school administration. The major flow is to the economic sector to provide the required direct and indirect labor for production. The so-called "brain drain" and other emigrations could also be depicted as an outward flow from the manpower sector.

The intra-education flow of human represent the progress of students from one grade and level of education to another. Within the manpower sector is another flow representing changes of individuals from one occupation or industry to another. It is clear that an extremely large number of possible flows could be identified through appropriate schemes of data gathering.

Looked at in this way, the schematic representation becomes not so much a device only for describing the structure of the system but a framework for analysis and projection of educational/manpower inputs and outputs. The appropriate information needed in planning could then be defined and collected to serve as basis for bringing harmony between economic needs for trained manpower of different types and the capacity of training and educational facilities.

Needed Data on Stocks

Manpower and educational planners agree on the fundamental importance of data and analyses of population distribution classified by a number of demographic characteristics such as age, sex, location and type of residence, etc. Methods of forecasting the demand for classrooms and teachers have depended upon estimates and projections of trends in the demographic, geographic, and socio-economic structure of the population.

Traditionally, most educational statistics are "stock" data. They show the number of pupils and teachers at a particular point in time. These stocks are given for each level and grade. Estimates of pupil-teacher ratios in different levels and branches of education can indicate the location of teacher shortages. Besides the demographic characteristics, data on father's occupation, family income, etc., have been found useful for multivariate analysis resulting in measures in the form of partial and multiple correlations between social status variables and educational variables such as school achievement.[3] These data are normally collected from records and reports annually sent to central offices by school administrators.

The basic statistics available, however, have been deficient in several aspects. For one thing, estimates on future student numbers have in the past been usually made on an ad-hoc basis. These stock data, however, are becoming increasingly inadequate for the analysis of educational developments over time because of rigidities in the aggregation imposed by the initial collecting form.

In order to project the total labor force for relevant areas of the country, data on population by age, sex, marital status, rural-urban location, are required since the labor force partici-

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[3] See D. Lerner and H.D. Lasswell, ed., *The Policy Sciences*, Stanford, 1951, and U.S. Office of Education, *Equality of Educational Opportunity*, Washington, D.C., 1966.

pation rates vary between these different groups. For manpower planning it is not enough to know the total labor force subdivided only into demographic and geographic categories. To assess the supply of manpower, it is necessary to determine the present and future supply according to educational qualification and skills, besides type of activity, industry and occupation. The latter distribution on the number of persons employed by branch of industry, occupation and educational attainment, provide a basis also for projecting manpower requirements or demand.

In establishing educational output targets, detailed census data on the stock by educational attainment in the labor force are used. The kind of education which is to be associated with each occupation has to be determined. Multiplying estimates of these by the number required in each occupation gives the figures of the total required educational stock or the number of workers having each type of education in the labor force.

These needed stock data are often met satisfactorily by current population sample surveys and censuses. However, cross-or three-way classification of occupational structure by sectors of economic activity and by levels of educational attainment are minimum tabulation requirements which very often are neglected in official publication programs.

Needed Data on Flows

While much useful information can be perceived from stock data, the educational and manpower planners are not, however, satisfied with the static picture. Although such data can of course be used to obtain net flows, the policies based on them would likely soon become outmoded because of the very dynamic nature of the educational and labor market conditions inherent in the systems for which such policies apply.

Global projections of total enrolments are often unsatisfactory because to be useful, such estimates must take into account the different distributions among various types of schools, courses, and geographic areas, and also of the movements of pupils and students between the different elements of the educational system at each age. These movements do not consist of homogeneous groups. Gross flows are necessary to know and these can be appreciated if we return to the schematic diagram and view the children as basic raw materials as they proceed from grade to grade within a course or between courses, say, academic to vocational. They are transformed by the action of teachers and educational facilities into educated or trained people. We can therefore view such pupils, teachers, and facilities as "inputs" into the educational system and the graduates, the partly educated school leaves, as well as the qualified labor produced by the system as "outputs".

These flows therefore can be represented in a simple input-output matrix as shown by the following table:

Flow Tabulation:
A Simple Education-Manpower Matrix

From: (t_o) To: (t_1)	1	2	3	4	Total in (t_o)
1. Education	x_{11}	x_{12}	x_{13}	x_{14}	x_{1j}
2. Labor market	x_{21}	x_{22}	x_{23}	x_{24}	x_{2j}
3. Abroad	x_{31}	x_{32}	x_{33}	x_{34}	x_{3j}
4. Non-active	x_{41}	x_{42}	x_{43}	x_{44}	x_{4j}
Total in (t_1)	x_{i1}	x_{i2}	x_{i3}	x_{i4}	x_{ij}

It is of course possible for planning purposes to expand the table. Firstly, the educational system (for simplicity of discussion only students are included) could be subdivided into different levels and types such as elementary, general secondary, vocational secondary, university, and so on. The row totals of the matrix show the number of pupils in each level in a particular year, say t_o. The column totals show the number of pupils in each level in the following year, say, t_1. To complete the picture of flows of people from education, rows and columns can be shown under such heading as: Labor Market, Abroad, and Non-active, to show where school leavers come from or go to. The category, Non-active, could include all forms of manpower attrition such as retirement, death, etc.

It could be seen that the gross flow to the labor market during the period from (t_0) to (t_1) is x_{12} and the gross wastage is x_{2j}. The entrants consist predominantly of school leavers entering the labor market x_{12} and adults such as women who for various reasons did not belong earlier at time (t_o) in the labor force (x_{32} and x_{42}). The loss consists mainly of old people leaving the labor force because of retirement or death. Some flows such as those from inactive status and traveling or returning from abroad (x_{43} and x_{34}), the permanent inactive (x_{44}) are not of significant interest. (X_{33}) to some extent and (x_{13}) may well represent the brain drain.

Expansion of the matrix by further breakdown of subheadings of x_{11} and x_{22} is desirable to enable us to follow the flows within the educational system, and the inter-industry mobility of the labor force.

Ordinary stock statistics (i.e., the row and column totals) would not record these movements at all, yet such transfer can be of great interest. Apart from the importance of distinguishing the various components of net changes in student numbers during a year, these cross flows reveal the importance of an integrated flow framework. Without such a framework, pupils who leave general curriculum schools to enter vocational schools are often recorded as drop-outs, and thence wastage, despite the fact that they have merely shifted to another branch of the system.

For the manpower approach in educational planning, a linking of the educational system and the labor market sector divided into sub-sectors of the labor market by occupational branches has to be established in order to ascertain occupational branches to which the youth go after leaving the educational system. A survey of the output of vocational schools and other training schemes could gather information concerning the actual educational and skill requirements for different occupations.

In order that the matrices may be used for forecasting, the absolute figures of the suggested expanded version of flow Table can be converted into a set of coefficients showing for example the proportion of students in one classification cell who are in any other cell in a subsequent time period. The basic "transition coefficients" are obtained by dividing each cell by the corresponding row total. Thus each cell under a sub-heading of (x_{11}) is divided by (x_{11}) itself.

These transition proportions show the proportion in which the individuals in process are distributed between various categories after a period from time (t_0) to (t_1). The past data on flows between the different parts of the educational system can now be used in preparing projections of a part of, or the whole of the educational system.

In summary, needed data on gross flows should be collected, ideally, for all strategic points on the number of persons who transfer from one sector to another. The manpower and educational planning strategy adopted should provide a guide for the general criterion as to which points are considered important. Generally, the following would be included:

Transfer to, from, and within the educational system,
Entry and withdrawal from the labor force,
Inter-industry shifts,
Inter-occupational shifts,
International migration of qualified personnel.

Implications on Data Collection

The growing complexity of the statistical information required for educational and manpower planning presents formidable problems of data collection. The development of an individualized data collection (ID) system offers, however, good prospects to establish the needed link of data about an individual between various years. The essence of an ID collection system is the assignment of a unique identification code number to each pupil, teacher or worker upon registration in school or any place of work. The same code number would be consistently written down each time the individual wrote his name and personal circumstances. Analysts would collect all the records and place them on central records of students or teachers or of certain significant category of qualified manpower, as the case may be. The use of electronic computers with their vast capacities for stored information, retrieval and computation, will, in principle, enable the rapid printing of tables on the basicstock and flow characteristics of most manpower assessment questions.

The availability of remote teletype consoles linked with a central data bank should make it possible to test in a routine manner a wide range of forecasting, simulation and planning models. In fact, the use of "gaming" simulation techniques to give the feel of the inter-relations and feed-back mechanism involved in decision taking has been tried in sessions of educational planners.

The main problem of making educational or manpower projections and forecasts is not so much of data collection when ID systems at least come into more general use; it is rather the making of reasonable assumptions about the factors affecting the movements of manpower from one activity to another and the way different policy measures effect these movements. There are a wide variety of types of such policy measures to consider, including a type such as (a) to create employment, (b) to improve labor mobility, and (c) those to affect the length of schooling as student grants, allowances, and re-training opportunities.

The statistician of the manpower-educational planning team thus becomes less concerned with merely designing survey operations and the processing of returns. His service are increasingly required in making forward estimates through judicious selection of sophisticated techniques for analyzing manpower data.

The Philippine Statistician
Vol. XVIII, Nos. 3 and 4, 1969

SOME STATISTICAL PROPERTIES OF VARIANCES ESTIMATORS IN SYSTEMATIC SAMPLING*

By

CASIANO B. MENDOZA

1. *Summary*

Unbiasedness, positive definiteness, and minimum variance property are three basic properties of variance estimators. The amount of computational work to accomplish, a fourth property, could also be considered. These properties served as bases of comparison for five popularly known variance estimators in systematic sampling. To compare their performances, three sets of numerical examples were utilized. Relative precisions were measured using Geary's formula for evaluating Pitman's closeness criterion.

2. *Introduction*

The systematic sampling variance under favorable conditions are more precise and efficient than Simple Random Sampling Variance and often times Stratified Random Sampling Variance which could be found in the works of L. H. Madow, W. G. Cochran, Yates, etc. These are established facts and there are no questions about them. However, the accuracy and adoptability of the existing variance estimators made available under varying conditions are the problems that beset any sampler who uses the systematic choice of samples. In this connection, Cochran (1953) once remarked:

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* Part of Thesis submitted to the Statistical Center, University of the Philippines in partial fulfillment of the requirements for the degree of M.A. in Statistics.

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> . . . there is no dearth of formula for the estimated variance, but all appear to have a limited range.

The remark could mean that despite the existence of many estimators for the variance none so far was found to be valid under all conditions. Or, it could possibly mean that variance estimation is considered as one of the more formidable difficulties that could be encountered in systematic sampling. It is so far relegated to the background despite theoretical sophistication of the sample survey design. Probably, this could be the reason why systematic sampling is not used to choose the primary sampling units for multi-stage survey designs.

The Cochran estimators are simple random model variance estimator, successive difference model variance estimator, model with linear trend variance estimator, and correlogram model variance estimator. Their areas of applicability are implied by their respective names. The Vos-Zinger Estimator is the last estimator under study. It is considered to be general in application. Its non-positive definiteness is the primary objection against the estimator.

3. *Test for Unbiasedness*

The variance of the mean in systematic sampling is

$$V(\bar{y}_{sy}) = \frac{1}{k} \sum_{i=1}^{k} (\bar{y}_{y}. - \bar{Y})^2 \qquad (1)$$

where,

$N = nk$

$i = 1, 2, \ldots, k$

$y_i. = \frac{1}{n} \sum_{i=1}^{n} {}_{ij}$, the i^{th} systematic sample mean.

$j = 1, 2, \ldots, n$

$\bar{Y} = \frac{1}{N} \sum_{i=1}^{N} y_i$, the true mean.

The variance of the population total, Z, is:

$$Z = V(N\bar{y}_{sy}) = N^2\, V(\bar{y}_{sy})$$

$$= k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2 \qquad (2)$$

Note: The following notations are considered equivalent:

$y_i = y_{ij}$

$y_{i+k} = y_{i,\ j+1}$

$y_{i+2k} = y_{i,\ j+2}$

3.1. *Simple random model variance estimator*:

$$s^2_1 = N^2 \frac{(N\text{-}n)}{Nn} \frac{(y_i - y_{sy})^2}{(n\text{-}1)}$$

$$= N^2 \frac{(N\text{-}n)}{Nn} \frac{[y_{ij} - n(y_{sy})^2]}{(n\text{-}1)}$$

Simplifying,

$$s^2_1 = \frac{N(k\text{-}1)}{(n\text{-}1)} \left[\sum_{j=1}^{n} y^2_{ij} - \frac{\left(\sum_{j=1}^{n} y_{ij}\right)^2}{n} \right] \qquad (3)$$

$$E\, s^2_1 = \frac{N(k\text{-}1)}{(n\text{-}1)}\ E \left[\sum_{j=1}^{n} y^2_{ij} - \frac{\left(\sum_{j=1}^{n} y_{ij}\right)^2}{n} \right]$$

But, $E \sum_{j=1}^{n} y^2_{ij} = \frac{1}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij}$ i.e., averaging over all k possible samples yields the expectation of

$$\sum_{j=1}^{n} y^2_{ij}.$$

Also,

$\frac{1}{n} E \left(\sum_{j=1}^{n} y_{ij} \right)^2 = \frac{1}{n} \cdot \frac{1}{k} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2$, using the same reasoning. Therefore,

$$E\ s^2{}_1 = \frac{N(k-1)}{(n-1)} \frac{k}{1} \left[\sum_{i=1}^{k} \sum_{j=1}^{n} y^2{}_{ij} - \frac{1}{nk} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 \right]$$

$$= \frac{k-1}{n-1} \left[n \sum_{i=1}^{k} \sum_{j=1}^{n} y^2{}_{ij} - \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 \right]$$

Comparing the above equation with Z, the true variance, it shows that $s^2{}_1$ is a biased estimator.

Bias = [E ($\hat{\theta}$) — θ], according to the definition. To find an expression for the bias of $s^2{}_1$ just substitute the corresponding values for each of the two terms.

$$\text{Bias of } s^2{}_1 = [\ E\ (\ \hat{\theta}\ ) - \theta\ ]$$

$$= \frac{k-1}{n-1}\, n \sum_{i=1}^{k} \sum_{j=1}^{n} y^2{}_{ij} - \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 -$$

$$\left[k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2 \right]$$

$$= \frac{N-n}{n-1} \sum_{i-1}^{k} \sum_{i-j}^{n} y^2{}_{ij} - \frac{N-1}{n-1} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 +$$

$$\left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2.$$

$$\text{Bias of } s^2{}_1 \text{ for } \left(n = \frac{N}{n}\right) = \left(\frac{N/2}{N/2-1} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2{}_{ij} - \right.$$

$$\frac{N-1}{N/2-1} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 + \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2$$

$\doteq \sum_{i=1}^{k} \sum_{j=1}^{n} y^2{}_{ij} - \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 + \left(\sum_{i=1}^{k} \sum_{i=1}^{n} y_{ij} \right)^2$. This bias is large which is even bigger than the sum of squares of the individual observations. When $n = N$, the bias of $s_1{}^2$ becomes:

$$\text{Bias of } s_1{}^2 \text{ for } (n = N) = O - \sum_{i=1}^{1} \left(\sum_{j=1}^{N} y_{ij} \right)^2 + \left(\sum_{i=1}^{1} \sum_{j=1}^{N} {}_{ij} = O.\right.$$

3.2. *Successive difference model variance estimator*

$$s_2^2 = N^2 \frac{N-n}{Nn} \frac{\sum^{n} (y_i - y_{i+k})^2}{2\,(n-1)}$$

$$= N^2 \frac{N-n}{Nn} \frac{\sum^{n} (y_{ij} - y_{i,\,j+1})^2}{2\,(n-1)} \qquad (4)$$

Squaring and simplifying,

$$s^2_2 = \frac{N(k-1)}{2(n-1)}\left[\sum_{j=1}^{n} y^2_{ij} - 2 \sum_{j=1}^{n} y_{ij}\, y_{i,\,j+1} + \sum_{j=1}^{n} y^2_{i,\,j+1}\right]$$

If the expectation of s^2_2 is taken it would involve the expectation of the three terms inside the bracket. The expectation of the first term was already shown. The expectation of the second and third terms are:

$$2\,E\left(\sum_{j=1}^{n} y_{ij}\, y_{i,\,j+1}\right) = \frac{2}{k} \sum_{i=1}^{n} \sum_{j=1}^{k} y_{ij}\, y_{i,\,j+1}$$

$E\left(\sum_{j=1}^{n} y^2_{i,\,j+1}\right) = \frac{(n-1)}{N-k} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{2i,\,j+1}\right)$, because there are (N-k) possible squares in the whole population. (N-k) can be written as (nk-k). Simplifying,

$$E\left(\sum_{j=1}^{n} y^2_{i,\,j+1}\right) = \frac{1}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{i,\,j+1}$$

Therefore,

$$E\,S^2_2 = \frac{N(k-1)}{2\,(n-1)}\left[\frac{1}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij} - \frac{2}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} y_{i,\,j+1} + \frac{1}{k} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_i{}^2{}_{,\,j+1}\right)\right]$$

$= \frac{n(k-1)}{2\,(n-1)} \sum_{i=1}^{k} \sum_{j=1}^{n} (y^2_{ij} - 2\, y_{ij} y_{i,\,j+1} + y^2_{i,\,j+1})$. Comparing this equation with Z shows that s^2_2 is a biased estimator.

$$\text{Bias of } s^2_2 = [E(s^2_2) - Z]$$

$$= \frac{n(k-1)}{2(n-1)} \sum_{i=1}^{k} \sum_{j=1}^{n} (y^2_{ij} - 2\, y_{ij} y_{i,\, j+1} + y^2_{i,\, j+1})$$

$$- \left[k \sum_{i=1}^{k} (\sum_{j=1}^{n} y_{ij})^2 -) \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij})^2 \right]$$

$$\text{Bias of } s^2_2 \text{ for } (n = \frac{N}{2}) \doteq \tfrac{1}{2} \sum_{i=1}^{k} \sum_{j=1}^{n} (y^2_{ij} - 2 y_{ij} y_{i,\, j+1} + y^2_{i,\, j+1}) -$$

$$\left[k \sum_{i=1}^{k} (\sum_{j=1}^{n} y_{ij})^2 - (\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij})^2 \right]$$

When $n = \frac{N}{2}$ the term inside the bracket becomes negligible however, the three terms inside the parenthesis sum up to a big quantity which is comparable to the bias of s^2_1 under the same circumstances. Similarly, when $n = N$, bias of $s^2_2 = 0$.

3.3 *Model with linear trend variance estimator*

$$s^2_3 = N^2 \frac{N-n}{Nn} \frac{\sum_{j=1}^{n} (y_i - 2y_{i+k} + y_{i+2k})^2}{6(n-2)} \tag{5}$$

$$= N^2 \frac{N-n}{Nn} \frac{\sum_{j=1}^{n} (y_{ij} - 2y_{i\ j+1} + y_{i,,\ j+2})^2}{6(n-2)}$$

Squaring and simplifying,

$$s^2_3 = \frac{N(k-1)}{6(n-2)} (\sum_{j=1}^{n} y^2_{ij} + 4 \sum_{j=1}^{n} y^2_{i,\ j+1} + \sum_{j=1}^{n} y^2_{i,\ j+2} -$$

$$4 \sum_{j=1}^{n} y_{ij}\, y_{i,\ j+1} + 2 \sum_{j=1}^{n} y_{ij}\, y_{i,\ j+2} - 4 \sum_{j=1}^{n} y_{i,\ j+1}\, y_{i,\ j+2}).$$

The expectations of the first, second, and fourth terms inside the parenthesis are already known. What is left to be done is to find the expectations of the third, fifth, and sixth terms.

$$E\left(\sum_{j=1}^{n} y^2_{i,\ j+2}\right) = \frac{n-2}{N-2k} \sum_{i=1}^{n} \left(\sum_{j=1}^{n} y^2_{i,\ j+2}\right) = \frac{1}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} y_{i,\ j+2}$$

$$2\,E\left(\sum_{j=1}^{n} y_{ij} y_{i,\ j+2}\right) = \frac{2}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} y_{i,\ j+2}$$

$$4\,E\left(\sum_{j=1}^{n} y_{i,\ j+1}\, y_{i,\ j+2}\right) = \frac{4}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{i,\ j+1}\, y_{i,\ j+2}$$

$$\therefore\ E\, s^2_3 = \frac{N(k-1)}{6(n-2)} \left(\frac{1}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij} + \frac{4}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{i,\ j+1} + \right.$$

$$\frac{1}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{i,\ j+2} - \frac{4}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} y_{i,\ j+1} + \frac{2}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} y_{i,\ j+1} -$$

$$\left. \frac{4}{k} \sum_{i=1}^{k} \sum_{j=1}^{n} y_{i,\ j+1}\, y_{i,\ j+2} \right).$$

This shows that s^2_3 is biased.

$$\text{Bias of } s^2_3 = \frac{n(k-1)}{6(n-2)} \sum_{i=1}^{k} \sum_{j=1}^{n} \left(y^2_{ij} + 4\, y^2_{i,\ j+1} + y^2_{i,\ j+2} \right.$$

$$\left. - 4\, y_{ij}\, y_{i,\ j+1} + 2\, y_{ij}\, y_{i,\ j+2} - 4\, y_{i,\ j+1}\, y_{i,\ j+2} \right)$$

$$- \left[k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2 \right].$$

The bias of s^2_3 for $n = \frac{n}{2}$ is large. It is comparable to the biases of s^2_i and s^2_2. However, if $n = N$, the bias becomes zero.

3.4. *Correlogram model variance estimator*

$$s^2_4 = N^2 \frac{N-n}{Nn} \sum_{u=1}^{g} \frac{d^2_{iu}}{7.5g} \qquad (6)$$

where,

$$d_{i1} = (1/2\, y_1 + y_3 + y_5 + y_7 + 1/2\, y_9) - (y_2 + y_4 + y_6 + y_8)$$

$$d_{i2} = (1/2\ y_9 + y_{11} + y_{13} + y_{15} + 1/2\ y_{17}) - (y_{10} + y_{21} + y_{14} + y_{16})$$

... etc. ...

$$i = 1, 2, \ldots, k$$

$$u = 1, 2, \ldots, \frac{n}{9}\ .$$

$$E\ s_2^4 = \frac{Nn(k\text{-}1)}{n} \cdot E \sum_{u=1}^{g} \frac{d^2_{iu}}{7.5_g}$$

$$= \frac{N\ (k\text{-}1)}{7.5_g}\ E \sum_{u=1}^{g} d^2_{iu}$$

$$= \frac{N\ (k\text{-}1)}{7.5_g} \cdot \frac{1}{k} \sum \sum d^2_{iu}$$

$$\neq k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{j1} \right)^2.$$

Evidently, s^2_4 has a bias that behaves like the biases of the three estimators before it.

3.5. *Vos-Zinger estimator*

$$\hat{Z} = \frac{(N\text{-}n\text{-}b)}{N} \frac{1}{n+b} \left(\frac{\propto}{(N\text{-}n\text{-}1)\ n\ (n+b)} \Big[- (N\text{-}n\text{-}b)\ b\ (n+\beta)\ s_1y^2 - (N\text{-}n\text{-}b)\ n\ (b\text{-}\beta)\ s_2y^2 - b\ (b\text{-}1)\ (n+b)\ (s_1y)^2 - (k\text{-}2)\ (b\text{-}1)\ n\ (n+b)\ s_1y\ s_2y + (N\text{-}n\text{-}1)\ n\ (n+b)\ (s_2\ y)^2 \Big] + k\ (k\text{-}1)\ (s_1y)^2 - \frac{nk(k\text{-}1)}{b}\ s_1y\ s_2y \right) \qquad (7)$$

where:

N = nk — population size

n — systematic sample size

k — number of possible systematic samples

N-n — resulting population size after the systematic sample is drawn

b — random sample rize

$$S_1y = \sum_{i=1}^{n} y_{ij} \text{ — systematic sample total}$$

$$S_2y = \sum_{r=1}^{b} y_r \text{ — random sample total}$$

$$S_1y^2 = \sum_{j=1}^{n} y^2_{ij};\ (S_1y)^2 = (\sum_{j=1}^{n} y_{ij})^2$$

$$S_2y^2 = \sum_{r=1}^{b} y^2_r;\ (S_2y)^2 = (\sum_{r=1}^{b} y_r)^2$$

$$S_1y\ S_2y = \sum_{j=1}^{n} y_{ij} \sum_{r=1}^{b} y_r$$

$\propto$ and β — arbitrary parameters whose numerical values can be solved from equation:

$$\propto = \frac{N\ (N\text{-}n)\ (N\text{-}n\text{-}1)\ (n+b)}{Nb\ (n\text{-}b) + nb\ (kb\text{-}2)\ (n+b) + \beta\ (N\text{-}n\text{-}b)\ 2b} \tag{8}$$

$\frac{N\text{-}n\text{-}b}{N} \cdot \frac{1}{n+b}$ — the finite population correction

$$E\,Z = E\{ \propto \Big[- \underbrace{\frac{(N\text{-}n\text{-}b)\ b\ (n+\beta)\ S_1y^2}{(N\text{-}n\text{-}1)\ n\ (n+b)}}_{1} - \underbrace{\frac{(N\text{-}n\text{-}b)\ n\ (b\text{-}\beta)\ S_2y^2}{(N\text{-}n\text{-}1)\ n\ (n+b)}}_{2}$$

$$- \underbrace{\frac{b\ (b\text{-}1)\ (n+b\ (S_1y)^2}{n\ (N\text{-}n\text{-}1)\ (n+b)}}_{3} - \underbrace{\frac{(k\text{-}2)\ (b\text{-}1)\ n\ (n+b)\ S_1y\ S_2y}{(N\text{-}n\text{-}1)\ n\ (n+b)}}_{4}$$

$$+ \underbrace{\frac{(N\text{-}n\text{-}1)\ n\ (n+b)\ (S_2y)^2}{(N\text{-}n\text{-}1)\ nn\ (n+b)}}_{5} \Big] + \underbrace{k\ (k\text{-}1)\ S_1y)^2 - \frac{N(k\text{-}1)}{b}\ S_1yS_2y}_{6} \}$$

Let the terms on the right side of the equation be numbered as shown above to facilitate the taking of their individual expectations. The finite population correction is disregarded.

The expectation of terms 1 and 2 taken together is,

$$E\ (1+2) = E\left[-\frac{(N\text{-}n\text{-}b)\ b\ (n+\beta)\ S_1y^2}{(N\text{-}n\text{-}1)\ n\ (n+b)} - \frac{(N\text{-}n\text{-}b)\ n\ (b\text{-}\beta)\ S_2y^2}{(N\text{-}n\text{-}1)\ n\ (n+b)} \right]$$

$$= \frac{(N\text{-}n\text{-}b)\ b\ (n+\beta)}{(N\text{-}n\text{-}1)\ n\ (n+b)} \cdot \frac{n}{N} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij}$$

$$- \frac{(N\text{-}n\text{-}b)\ n\ (b-\beta)}{(N\text{-}n\text{-}1)\ n\ (n+b)} \cdot \frac{b}{N} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij}$$

Simplifying,

$$E\ (1+2) = \frac{b\ (N\text{-}n\text{-}b)}{N\ (N\text{-}n\text{-}1)} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij}$$

$$E\ (3+4) = E\left[-\frac{b\ (b\text{-}1)\ (n+b)\ (S_1y)^2}{(N\text{-}n\text{-}1)\ n\ (n+b)} - \frac{(b\text{-}2)(b\text{-}1)\ n\ (n+b)\ S_1y\ S_2y}{(\ N\text{-}n\text{-}1)\ n\ (n+b)} \right]$$

$$= -\frac{b(b\text{-}1)}{n(N\text{-}n\text{-}1)} \frac{\sum_{i=1}^{k} (\sum_{j=1}^{n} y_{ij})^2}{k}$$

$$- \frac{(k\text{-}2)(b\text{-}1)b}{(N\text{-}n\text{-}1)k(N\text{-}n)} \left[(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij})^2 - \sum_{i=1}^{k} (\sum_{j=1}^{n} y_{ij})^2 \right]$$

$$= -\frac{b(b\text{-}1)(N\text{-}2n)}{(N\text{-}n\text{-}1)(N(N\text{-}n)} (\Sigma\ \ \Sigma\ y_{ij})^2$$

$$- \frac{nb(b\text{-}1)}{N(N\text{-}n)(N\text{-}n\text{-}1)} \sum_{i=1}^{k} (\sum_{j=1}^{n} y_{ij})^2$$

$$E\ (5) = E\ (S_2y)^2 = \frac{N(N\text{-}n\text{-}1)}{(N\text{-}n\text{-}b)b} \sum_{i=1}^{k} \sum_{j=1}^{n} y^2_{ij}$$

$$+ \frac{b(b\text{-}1)(N\text{-}2n)}{N(n\text{-}n)(N\text{-}n\text{-}1)} (\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij})^2$$

$$+ \frac{nb(b\text{-}1)}{N(N\text{-}1)(N\text{-}n\text{-}1)} \sum_{i=1}^{k} (\sum_{j=1}^{n} y_{ij})^2$$

$$E\ (6) = E \left[k(k\text{-}1)\ (S_1y)^2 - \frac{N(b\text{-}1)}{b}\ S_1y\ S_2y \right]$$

$$= b\ (k\text{-}1)\ .\ \frac{1}{k} \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2$$

$$- \frac{N(k\text{-}1)}{b}\ .\ \frac{b}{k(N\text{-}n)} \left[\left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2 - \sum_{i=1}^{k} \left(\sum_{j=1}^{u} y_{ij} \right)^2 \right]$$

$$= (k\text{-}1) \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 + \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2$$

$$- \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2$$

$$\therefore\ E\ (6) = k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2$$

$$E\ \hat{Z} = \propto \left[E(1+2) + E(3+4) + E(5) \right] + E(6)$$

$$= \propto\ [\,O\,] + k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right) - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2$$

Finally,

$$\hat{E}\ (Z) = k \sum_{i=1}^{k} \left(\sum_{j=1}^{n} y_{ij} \right)^2 - \left(\sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij} \right)^2 = Z, \text{ unbiased.}$$

4. *Minimization of Vos-Zinger Estimator*

The Vos-Zinger estimator is expected to give negative estimates of the variance half of the time due to the nature of the formula. Besides, the estimator gives a fairly big estimate if systematic sample size n and random sample size b is not properly chosen.

Zinger (1963) used the weighted mean

$$\bar{y} = \frac{n\bar{y}_1 + b\bar{y}_2}{n+b} \qquad (9)$$

to derive his estimator for the systematic sampling variance. Vos (1967) used the same weighted mean to derive what is now called the Vos-Zinger estimator. The latter contains Zinger's estimator as a special case. $\bar{y}_1$ stands for the systematic sample meand and $\bar{y}_2$ stands for the random sample mean. Case I occurs when the systematic samples are not replaced before the random samples are drawn. Case II happens when the systematic samples are replaced before the random samples are chosen.

4.1. *Case I*

The variance of the weighted mean can be derived.

$$
\begin{aligned}
V(\bar{y}) &= V \frac{(n\bar{y}_1 + b\bar{y}_2)}{n+b} \\
&= \frac{1}{(n+b)^2} \left[V(n\bar{y}_1) + V(\bar{y}_2) \right] \\
&= \frac{n^2}{(n+b)^2} V(\bar{y}_1) + \frac{b^2}{(n+b)^2} V(\bar{y}_2)^*.
\end{aligned}
$$

where,

$V(\bar{y}_1)$	is the systematic sampling variance
$V(\bar{y}_2)^*$	is the conditional variance. It is the simple random sampling variance of the remaining (N-n) elements after n systematic samples were drawn.

Let $(n+b) = m =$ constant; and let ϕ represent the function

$$
\phi = \frac{n^2}{m^2} V(\bar{y}_1) + \frac{b^2}{m^2} \frac{N-n-b}{N-n} \frac{S^{2*}}{b} + \lambda\ (m-n-b).
$$

The partial derivative of ϕ with respect to n subject to the restriction that $m = n+b$ is:

$$\frac{\partial\phi}{\partial n} = \frac{2n\ V(\bar{y}_1)}{m^2} + \frac{bS^{2*}}{m^2} \cdot \frac{(N\text{-}n)(k\text{-}1) - (N\text{-}n\text{-}b)(k\text{-}1)}{(N\text{-}n)^2} - \lambda = 0$$

or,

$$\text{i.}\quad \lambda = \frac{2n\ V(\bar{y}_1)}{m^2} + \frac{b^2S^{2*}}{m^2} \cdot \frac{1}{n^2(k\text{-}1)}$$

In like manner, the partial derivation of ϕ with respect to be subject to the same restriction is:

$$\frac{\partial\phi}{\partial b} = 0 + \frac{S^{2*}}{m^2(N\text{-}n)}(N\text{-}n\text{-}2b) - \lambda = 0$$

or,

$$\text{ii.}\quad \lambda = \frac{S^{2*}\ (N\text{-}n\text{-}2b)}{m^2(N\text{-}n)}$$

Equating lambdas,

$$\frac{S^{2*}\ (N\text{-}n\text{-}2b)}{m^2(N\text{-}n)} = \frac{2n\ V(\bar{y}_1)}{m^2} + \frac{b^2S^{2*}}{m^2n^2(k\text{-}1)}$$

or,

$$\frac{S^{2*}\ b^2}{n^2(k\text{-}1)} + \frac{2S^{2*}b}{N\text{-}n} + 2n\ V(\bar{y}_1) - S^{2*} = 0$$

But $b = m\text{-}n$, $b^2 = (m\text{-}n)^2 = m^2 - 2mn + n^2$; substituting and simplifying,

$$-\frac{2\ V(\bar{y}_1)}{S^{2*}}\ n^3 + \frac{2N\ V(\bar{y}_1)}{S^{2*}} \cdot n^2 - Nn + m = 0 \qquad (10)$$

This is a third degree polynomial in n. Any of the roots of this polynomial could be the minimum designated by the symbol n_i. Estimates of $(V(\bar{y}_1)$ and S^{2*} could be used in the absence of the actual values. S^{2*} on the average approaches the value of S^2. Thus, it could be assumed that $S^2 \doteq S^{2*}$.

4.2. *Case II*

Going back to the variance of $\bar{y}$,

$$V(\bar{y}) = \frac{n^2}{(n+b)^2} V(\bar{y}_1) + \frac{b^2}{(n+b)^2} V(\bar{y}_2).$$

where,

$$V(\bar{y}_1) = \frac{1}{k} \sum_{i=1}^{k} (\bar{y}_{1.} - \bar{y})^2$$

$$V(\bar{y}_2) = \frac{N\text{-}b}{Nb} \sum_{i=1}^{N} \frac{(y_i - \bar{y})^2}{N\text{-}1} = \frac{N\text{-}b}{Nb} \cdot \frac{S^2}{b}$$

alternatively,

$$V(\bar{y}_1) = \frac{n_2}{(n+b)^2} V(\bar{y}_1) + \frac{b^2}{(n+b)^2} \cdot \frac{N\text{-}b}{N} \cdot \frac{S^2}{b}.$$

Impose the condition $(n+b) = m =$ constant. Let ϕ denote the function

$$\phi = \frac{n^2}{m^2} (V(\bar{y}_1) + \frac{b(N\text{-}b)}{m^2\, N} S^2 + \lambda\ (m\text{-}n\text{-}b)$$

Minimizing the variance with respect to n and later with respect to b subject to the constraint $m = (n+b)$,

$$\frac{\partial \phi}{\partial n} = \frac{2n}{m^2} V(y_1) - \lambda = O$$

or,

$$\text{i. } \lambda = \frac{2n\ V(\bar{y}_1)}{m^2}$$

$$\frac{\partial \phi}{\partial b} = \frac{1}{m^2 N} \left[(N\text{-}b) + b(\text{-}1) \right] S^2 - \lambda = O$$

or,

$$\text{ii. } \lambda = \frac{(N\text{-}2b)S^2}{N\ m^2}.$$

Equating lambdas,

$$2\ Nn\ V(\bar{y}_1) = (N\text{-}2b)S^2;\ \text{but, } n = m\text{-}b,$$

$$2\ N(m\text{-}b)\ V(\bar{y}_1) = (N\text{-}2b)S^2.$$

Simplifying,

$$b = \frac{N}{2}\left[\frac{m - \dfrac{S^2}{V(\bar{y}_1)}}{N - \dfrac{S^2}{V(\bar{y}_1)}}\right] \tag{11}$$

5. *Numerical Example*

Three sets of numerical data were used. The first set of data is a population believed to be in random order, the second set is a population with linear trend, and the last is one on natural population. The first set of data is a complete enumeration of household sizes of barrio Bambang, Bulacan which was collected in the early part of 1967 in conjunction with a research conducted by the U.P. Statistical Center on the subject "non-sampling errors". The second set of data is a list of heights of Philippine Navy enlisted personnel arranged in descending order to produce a linear trend. The last set of data was borrowed from problem (8.1) of Cochran's Sampling Techniques (1953) which consists of the number of pine seedlings per foot of bed measuring 200 feet long. The population values and derived values for each of the three types of population are summarized in Table I.

A limited population of variance estimates for each of the five estimators per type of population was generated to be able to test for the "importance" of the biases. The total number variance estimates computed is 250. The results are found in Table II, Table III, and Table IV. The factor $N^2 \frac{N-n}{Nn}$ was not included in the estimates to simplify the computations.

The formula recommended by Geary (1944) for evaluating the probability of $| x-\theta | < | y-\theta |$ is the equation

$$P = 1 \quad \tan^{-1} [\, 2 \, \sigma_x \, \sigma_y \, \surd \, 1-p^2 \, / \, \overline{(\sigma^2_x} - \sigma^2_y) \,], \tag{12}$$

assuming that the joint distribution of the estimate is normal. Departure from normality like skewed distributions do not affect greatly the probability associated with the criterion of closeness as illustrated by Gutierrez (1958). x and y are two sets of estimates of θ, the population parameter. σ^2_x and σ^2_y are their respective variances. ρ is the correlation coefficient. This probability is a measure of relative precision. The results are found in Table V.

6. *Conclusion*

Analyses made on the five estimators show that the Cochran estimators are biased. Their respective biases increase as sample size n becomes large. However, when n is small they may even perform better than the unbiased estimator depending upon their individual specialties.

The Vos-Zinger estimator is unbiased. The minimization procedure proved effective inminimizing the estimates; however, negative estimates were only partially limited. The amount of computations involved may discourage other people from using the estimator. Despite these imperfections, the Vos-Zinger could possibly fit the description of a "good" estimator being sought in systematic sampling.

TABLE I

POPULATION VALUES AND DERIVED VALUES FOR EACH OF THE THREE TYPES OF POPULATION

Item No.	Parameters & Other Values	Population I	Population II	Population III
1	N	918	400	200
2	n	46	20	20
3	k	20	20	10
4	$S^2 \doteq S^{2*}$	5.7775	3.1303	119
5	$\frac{N\,n}{(N\text{-}n)} V(\bar{y}_{sy})$	6.194	0.2200	100.7886
6	$V\ (\bar{y})$	0.119	2.817	5.355
7	$V(\bar{y}_{sy})$	0.1243	0.01035	4.7876
8	Z	104,819	1,656	191,525
9	$N^2\,V(\bar{y})$	100,432	450,720	213,476
10	$m = n_i + b$	46	20	20
11	n_i min.	24	10*	13
12	b	22	10*	7
13	a	290	150*	120
14	β	269	156*	107

* *Not minimum.*

TABLE II

VARIANCES ESTIMATES FOR POPULATION IN RANDOM ORDER (POPULATION I)

Sample No.	s^2_1	s^2_2	s^2_3	s^2_4	$\hat{Z}_1$
1	8.90	10.85	28.64	4.42	2.23
2	5.33	6.20	14.89	5.22	2.54
3	8.02	7.83	23.21	7.75	2.73
4	8.63	8.30	18.50	4.52	2.28
5	5.85	4.25	9.39	1.72	5.34
6	8.90	8.78	18.54	7.37	2.51
7	9.43	9.85	21.85	9.79	3.07
8	5.59	6.52	12.46	3.91	2.26
9	6.84	7.87	19.54	9.01	2.90
10	5.84	6.62	16.41	3.81	3.19
11	6.67	5.37	13.40	1.30	3.09
12	4.57	4.32	9.15	3.91	3.06
13	6.57	7.02	18.20	3.30	2.65
14	5.49	5.78	14.29	0.46	3.04
15	4.58	6.41	16.56	3.09	3.05
16	8.34	7.28	18.21	3.33	2.63
17	7.55	8.69	22.15	10.78	2.75
18	8.07	7.24	16.44	5.44	3.15
19	6.66	6.25	14.42	6.46	3.38
20	5.78	5.87	13.87	1.57	3.13
Mean s^2	6.88*	7.0650*	17.006**	4.8565[1]	2.9490**
Var s^2	2.1505	2.7125	21.0143	7.9076	0.4090
s.d. s^2	1.4664	1.6470	4.5841	2.8120	0.6395

[1] significant, $(.05 \leq P \leq .025)$

* significant, $(.01 \leq P \leq .005)$

** highly significant

$$\mu = \frac{Nn}{} V(y_{sy}) = 6.0194$$

TABLE III

VARIANCE ESTIMATES FOR POPULATION WITH LINEAR TREND (POPULATION II)

Sample No.	s^2_1	s^2_2	s^2_3	s^2_4	$\hat{Z}_1$
1	4.3300	0.3947	0.1666	0.2333	0.6843
2	4.3300	0.3947	0.1666	0.2333	0.4976
3	3.7800	0.1111	0.1203	0.2000	2.4128
4	3.9600	0.1111	0.1111	0.1000	− 0.3358
5	3.5000	0.0777	0.0925	0.0998	4.2641
6	3.5000	0.0777	0.0925	0.0998	− 0.0965
7	3.5000	0.0777	0.0925	0.0998	− 0.2053
8	3.2500	0.0777	0.0648	0.1333	− 0.1802
9	3.0900	0.3444	0.3148	1,2000	− 1.4854
10	2.7200	0.1111	0.1203	0.2667	− 0.1258
11	2.7500	0.3947	0.1666	0.4889	− 0.1301
12	3.0900	0.3444	0.3148	1.2000	− 0.1612
13	2.7400	0.3947	0.1666	0.4889	− 0.1700
14	2.7400	0.3947	0.1666	0.4889	− 0.1844
15	2.7201	0.1111	0.1203	0.2667	− 0.1688
16	3.0140	0.1777	0.1666	0.4889	− 0.1704
17	3.1500	0.1222	0.1111	0.2222	0.8293
18	2.9800	0.2555	0.2129	0.7111	− 0.1152
19	2.9400	0.2555	0.1574	0.7556	− 0.5072
20	2.9500	0.1272	0.1574	0.2667	− 1.1950
Mean s_2	3.2517**	0.2178	0.1541**	0.3706*	0.1728
Var s^2	0.2506	0.1672	0.004127	0.1041	1.4546
s.d. s^2	0.5006	0.1293	0.06424	0.3226	1.2060

* significant, $(.05 \leqq P \leqq .025)$

** highly significant

$$\mu = \frac{Nn}{N\text{-}n} V(\bar{y}_{sy}) = 0.2200$$

TABLE IV

VARIANCE ESTIMATES FOR NATURAL POPULATION (POPULATION III)

Sample No.	s^2_1	s^2_2	s^2_3	s^2_4	$\hat{Z}_1$
1	90.24	44.67	36.35	11.03	12.90
2	69.92	39.65	40.14	10.53	3.62
3	128.72	83.23	45.55	10.46	15.64
4	61.16	18.04	30.23	6.69	— 7.86
5	174.47	18.32	23.00	98.50	12.73
6	149.33	27.91	33.32	91.79	— 6.90
7	113.57	25.75	18.99	13.60	1.28
8	202.78	34.60	44.83	19.79	— 2.79
9	184.51	39.80	47.28	175.39	43.23
10	113.68	24.44	34.44	47.61	23.10
Mean s^2	128.838[a]	35.641**	35.413**	48.539*	9.495**
Var s^2	2,107.33	327.36	81.15	2,855.90	220.59

[a] significant, ($.05 \leqq P \leqq .025$)

* significant, ($.01 \leqq P \leqq .005$)

** highly significant

$$\mu = \frac{Nn}{N-n} V(y_{sy}) = 100.7886.$$

TABLE V

THE PROBABILITY OF $\left| \hat{\sigma}^{2_2}_{s_i} - \sigma 2 \right| < \left| \hat{\sigma}^{2_2}_{s_j} - \sigma 2 \right|$ APPLYING GEARY'S FORMULA IN EVALUATING PITMAN'S CRITERION OF CLOSENESS TO THE THREE TYPES OF POPULATION ($i \neq j$). (THIS PROBABILITY IS A MEASURE OF RELATIVE PRECISION.)[a]

Sample No.	Probability	Population I	Population II	Population III
1	P 2.1[b]	0.4611	0.8166	0.6388
2	P 3.1	0.1944	0.5777	0.6222
3	P 3.2	0.0944	0.7444	0.8388
4	P 4.1	0.3055	0.8555	0.4388
5	P 4.2	0.3000	0.2111	0.2055
6	P 4.3	0.8277	0.0055	0.1055
7	P 5.1	0.7666	0.2166	0.6888
8	P 5.2	0.7111	0.0611	0.9333
9	P 5.3	0.5722	0.0277	0.3330
10	P 5.4	0.6388	0.1555	0.6388

[a] When $P_{ij} < 0.5$, estimator j is more precise than estimator i; when the inequality sign is reversed the opposite is true.

However, when $P_{ij} = 0.5$ then estimator j is as precise as estimator i.

$$ {}^{b}P_{2.1} = \left| \hat{\sigma}^{2_2}_{s_2} - \sigma^{2} \right| < \left| \hat{\sigma}^{2_2}_{s_1} - \sigma^{2} \right| $$

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The Philippine Statistician
Vol. XVIII, Nos. 3 and 4, 1969

A STATISTICAL ANALYSIS OF RICE FARMERS' DECISIONS *

By

JOSE S. GUTIERREZ**

Rice farmers are assumed to make decisions in their given uncertain environment. Each individual rice farmer operates his farm in accordance with these decisions based on a certain level of farming techniques. The different factors of production and the price fluctuations of farm products and supplies are considered in deciding the plan of operation to follow to achieve the maximum return from his efforts and investments. In other words, the rice farm is considered an economic unit organized for the search of maximum economic return.

The planning of rice production is not simply an economic problem but also involves different non-economic factors. The objective of this study is to ascertain through observation and statistical analysis of individual rice farms the factors which affect rice farmers in their production planning and decisions with the expectation that some knowledge may be gained to be useful for the rice farmers to improve their farm business and management. The results however of this statistical analysis may only yield a general directional position and relative magnitude of the influence of the responsible factors. Further studies are needed in terms of depth and coverage on the more important economic variables. Besides, this study has been confined to only two rice producing provinces.

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* Conducted under a grant given by the Social Science Research Council University of the Philippines.

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FARM AND FARM CHARACTERISTICS

The farms and farm characteristics in this section are taken from the 1960 Census of Agriculture.

High Degree of Utilization of Farm Lands

In both provinces covered in this study the degree of utilization of arable lands is high. About 83% of the farm lands in Bulacan is planted to temporary crops and for Nueva Ecija about 80% of the farm lands reported is devoted to the cultivation of temporary crops. Percentage wise and the area lying idle in Bulacan (4,450 has. or 5.96%) is larger than that of Nueva Ecija (4,340 has. or 1.99%). The area planted to permanent crops in Bulacan (2.402 has) is also larger than the corresponding area for that of Nueva Ecija (2.063). However, the area covered with permanent pasture in Nueva Ecija (35,255 has.) is very much larger than that of Bulacan (1,012 has).

High Proportion of Tenant-operated Farms

About 69% of the farms in Bulacan is operated by tenants and for Nueva Ecija about 76% is tenant-operated. Owner-operated farms in Bulacan is about 18% of all farms and for Nueva Ecija, about 8%. Share tenancy is the dominant type of tenancy tenure in both provinces. About 57% of farms in Bulacan is operated under a share-tenancy agreement and for Nueva Ecija, about 72%

Dominantly Palay-type Farms

At least 90% of farms in both provinces is classified as palay-type farm. About 91% of the farms in Bulacan is of this and about 94% for Nueva Ecija. In both provinces poultry-farms come second in importance (Bulacan, 4.71% and Nueva Ecija, 2.04%). The importance of palay and palay by-products in poultry feeding may have contributed to this relatively large number of poultry farms in these two provinces.

Small-sized Farms

Majority of the farms in both provinces are of size 1 to less than 5 hectares. The modal size in Bulacan is between 1 and 2 hectares and in Nueva Ecija between 2 and 3 hectares.

About 85% of farms in Bulacan belongs to 1 to 5 hectares as compared to about 84% in Nueva Ecija. There are however more large farms in Nueva Ecija (11.94%) than in Bulacan 6.08%). The farms of less than 1 hectare in Bulacan are about 9% and for Nueva Ecija about 4% of the total farms reported in these provinces.

Middle-aged Farm Operators

In both provinces majority of the farmers are between 25 and 54 years old. Percentagewise, Bulacan (about 24%) has more farmers of 55 and over in age as compared with that of Nueva Ecija (about 15%). The modal age group in both provinces is 35-44 years. More than ¼ of farmers in Bulacan (25.-59%) and in Nueva Ecija (28.55%) belong to this age group 35% of farms in Nueva Ecija consists of 2 — 3 parcels and the rest consists of 3 and more parcels. About 22% of farms in Bulacan consists of 2 — 3 parcels; about 75%; of 4 — 5 parcels and the more than 5 parcels. Percentagewise, there is relatively higher degree of fragmentation of farms in Bulacan than in Nuva Ecija.

Gravity Flow, Common Method of Irrigation

Gravity flow is the common method of irrigation used in Bulacan only 24, 173.0 hectares are irrigated and of this irrigated area, 20,321.0 hectares are irrigate by gravity flow. In Nueva Ecija, of the total farm area of 217,730.3 hectares, only 88,863.8 hectares are irrigated and of this irrigated 70,763.2 hectares are irrigated by gravity flow.

Besides the low proportion of farm area with irrigation, the number of farms with irrigation reporting only portions of the farms are irrigated is large. More than one third (1/3) of farms with irrigation in Bulacan is not completely irrigated and in Nueva Ecija about one fourth (¼) of farms with irrigation is not completely irrigated. Of the 31,854 farms in Bulacan 21,268 farms are without irrigation and of the 58,566 farms in Nueva Ecija, 33,042 farms are without irrigation.

Dominantly First Crop Lowland Rice Production

Rice production in both provinces are dominantly first crop lowland rice production. This is due to the heavy dependence on rain water of many rice farms in the two provinces. Almost all farm reporting rice production in the two provinces have first crop lowland rice. There are more farms, however, in Bulacan (5,881 farms) reporting second crop lowland rice production as compared to that of Nueva Ecija (2,869 farms). This is due to the fact that there are more farms reporting palay second crop lowland with irrigation in Bulacan (4,263 farms) than in Nueva Ecija (2,478 farms)

On the other hand, there are more farms reporting palay first crop with irrigation in Nueva Ecija (25,197 farms) than in Bulacan (10,483 farms).

RESULTS OF THE STUDY

Characteristics of the Samples

Distributions of Sample Farms by Size. The distribution of the farms covered in this project is as follows:

Size of Farm (hectares)	Distribution	
	Frequency	Percentage
< 1	4	1.90
1— 2	106	50.48
2— 5	85	40.48
5—10	12	5.71
10 and over	3	1.43
Total	210	100.00

About 91% of the farms studied belongs to the size groups 1—2 and 2—5 hectares.

Characteristics of farm operators. The distribution of the sample farm operators by age is as follows:

Age Group (years)	Distribution	
	Frequency	Percentage
< 30	19	9.05
31—35	14	6.67
36—40	26	12.38
41—45	46	21.90
46—50	50	23.81
50 and over	55	26.19
Total	210	100.00

Older farm operators dominate the sample. Farm operators of age group 41—45, 46—50 and 50 and over constitute more than 70% of the farm operators interviewed. The writer, however, observed that age seems not to be a factor in decision-making.

The distribution by educational attainment of the farm operators surveyed is given in the following table:

Highest Grade Completed	Distribution	
	Frequency	Percentage
≦ Grade I	19	9.05
Grade I-IV	89	42.38
Grade V-VII	81	38.57
Grade VII-H. S.	18	8.57
H.S.-College	2	0.95
Others	1	0.48
Total	210	100.00

More than 80% of the farmers interviewed has completed not more than grade seven. About 42% reported completion of 1—4 years of schooling and about 39% has completed five to less than seven years of schooling.

The distribution by index of agricultural knowledge based on arbitrary set criteria of the farmers studied is as follows:

Index of Agricultural Knowledge	Distribution	
	Frequency	Percentage
Low (0—6 pts.)	37	17.62
Medium (7—12 pts.)	121	57.62
High (13—18 pts.)	52	24.76
Total	210	100.00

In general the index of agricultural knowledge of the rice farmers surveyed is low. However, an understanding of how the aforementioned was established is needed for better appreciation for the inclusion of this variable in this study.

The index of agricultural knowledge was arbitrarily computed on the basis of the following:

1. Contact with extension workers and participation in study groups and meetings with following items and corresponding points considered:

Frequency of Contact/Participation	Quality Points
Very frequent, once a month	4
Frequent, twice a month	3
Seldom, once a month	2
Rare, once in two or more months	1
Never, no contact at all	0

2. Reading and listening to farm news and participation in farm demonstrations. The items considered and points assigned are as follows:

Frequency of Activity	Quality Points
Regular, every issue, broadcast, etc.	2
Casual, once in a month or so	1
Never, none at all	0

The total points were added and three index categories were formed, namely:

Low agricultural index	0— 6 points
Medium agricultural index	7—12 points
High agricultural index	13—18 index

In another study the writer observed that operators classified as of low index of agricultural knowledge tended to have a higher level of education and do a lot of reading and listening to farm news than those classified as of high index of agricultural knowledge.

The rice farmers included in the project are dominantly share tenants. The distribution by tenure of farm operators is as follows:

Tenure of Farm Operator	Distribution	
	Frequency	Percentage
Owner	14	6.66
Part Owner	1	0.48
Share Tenant	155	73.81
Lease Tenant	39	18.58
Farm Manager	1	0.48
Total	210	100.00

The size of families of the farmers interviewed tended to group in the larger family size group as can be seen in the following table:

Size of Family	Distribution	
	Frequency	Percentage
< 2	8	3.81
2—3	13	6.19
3—4	31	14.76
4—5	31	14.76
5—6	29	13.81
6 and over	98	46.67
Total	210	100.00

Price Information on Farm Products and Equipment

All the farmers interviewed expressed interests on price information on farm products and equipment. They also have expressed their primary interest on the price of palay. Their main source of price information is their fellow farmers. The distribution of sample farmers by source of price information is as follows:

Source of Price Information	Distribution	
	Frequency	Percentage
Co-farmers	92	43.81
Mill Owners	63	30.00
Government Fieldmen	54	25.71
Newspapers & other press media	1	0.48
Total	210	100.00

In general the co-farmer is the most important source of information. Those who reported completing grade five to seven tended to get more of their price information from government fieldmen.

Decisions on Farm Operation and Production Plans

Most important person(s) influencing crop and livestock production plan. The exchange of information among farmers is evident on the role of the other farmers in influencing crop and livestock production plan of a farm operator. The number of farmers who have reported their co-farmers as the most important persons who have influenced their crop and livestock production plan can be seen in the following table:

Person(s) Influencing Crop and Livestock Production Plan	Distribution	
	Frequency	Percentage
Co-farmers	144	68.57
Mill Owners	1	0.48
Government Fieldmen	65	30.95
Total	210	100.00

Government fieldmen is a poor second to the co-farmers as persons influencing the farm production plan of the rice farmer.

There is a tendency for those other farm operators, those with lower educational attainment, those with smaller farm size and those with bigger family size to avail of the services of government fieldmen.

Most important factor considered in the choice of crops and livestock. The most important factor considered in the choice of crops and livestock as reported by the farmers interviewed is the price of the crops and livestock. Labor and capital as factors in the consideration of choice of crops are poor second and third respectively as can be seen in the following table:

Most Important Factors Considered in the Choice of Crops and Livestock	Distribution	
	Frequency	Percentage
Price of crops and livestock	160	76.19
Labor required	26	12.28
Capital required	22	10.48
Area of farm	2	0.95
Total	210	100.00

Those farmers classified as medium index of agricultural knowledge and share tenants tended to put more importance to labor and capital in the consideration of factors in the choice of crops.

Most important basis in the selection of rice varieties. As can be seen the following table

Most Important Basis in the Selection of Rice Varieties	Distribution	
	Frequency	Percentage
Adaptability	147	70.00
High yield	61	29.04
Price	1	0.48
Eating quality	1	0.48
Total	210	100.00

is adaptability to local conditions. High yield is a poor second most important basis for the selection of rice varieties. The other factors mentioned as most important basis are price and eating quality. There is however a tendency for farmer operator of older age, low educational attainment, high index of agricultural knowledge, smaller area of farm, as share tenants, and larger family size to give more emphasis on high productivity as the most important basis for the selection of rice varieties.

Most important source of guiding information in the selection of rice varieties. The influence exerted by other farmers on a farmer on the latter's farm operation is again demonstrated in the selection of rice varieties to be planted. As shown in the following table:

Most Sources of Guiding Information in the Selection of Rice Varieties	Distribution	
	Frequency	Percentage
Co-farmers	88	41.90
Newspapers	78	37.15
Government Fieldmen	40	19.05
Total	210	100.00

the most important source of guiding information in the selection of rice varieties is the co-farmers. Newspapers and similar media of communication follow co-farmer as the most important of guiding information in the selection of rice varieties. Another most important of guiding information in the selection of rice varieties is government fieldmen.

As the age of the operator becomes advanced, as school years completion becomes low, as area of farm becomes small, as share tenants and as family size become large the tendency is to rely more on the co-farmers for guidance in the selection of rice varieties.

Consideration of the effects of the selection of rice varieties on other farm products. The effects on other farm products have been generally considered by farmers interviewed in their selection of rice varieties. One hundred ninety-nine (199) out of 210 farmers interviewed have reported that they considered the effect on other farm products in their selection of rice varieties.

Most important factor affecting other farm products. Labor required and price are the two most importane factors considered affecting other farm products.

Satisfactory current rice productivity. All the farmers interviewed expressed satisfaction on their current rice productivity. They also have indicated satisfaction with the amount of time and resources they have devoted to their farm operations. However, they are also willing to change the amount of time and resources they devote to their current farm operations to increase their rice productivity.

Change of present rice varieties to high yielding ones. The same number of farmers have expressed the desire to change their present rice varieties with other without change in the amount of time and resources devoted to their farm operations. One hundred ninety-three (193) out of 210 have expressed this desire and only 17 seemed to be not interested at all. This desire for high productivity coupled with local adaptability of the rice variety may yet solve the present rice dilemma.

Willingness to be indebted to improve rice productivity. The writer observed in another study that debt position of the rice farmers exerts a strong influence on their decisions as regards their farm operations. This influence is rather strong on the changing of the current rice varieties with new ones in spite of an expected high yield. This also explains the importance given to adaptability to local conditions in the selection of rice varieties. The same observation seemed to be true in this study under report. Although majority (151) have expressed willingness to get cash loans in order to improve their rice productivity, 59 have expressed otherwise. Many of those farmers who have expressed unwillingness to get cash loans to improve their rice production are 50 years and over of medium index of agricultural knowledge with a farm size of 1 to 5 hectares share tenants, and of large family size.

Availability of water — the most important factor considered in the timing of land preparation, transplanting and cultivation. One hundred and eighty-three (183) farmers interviewed considered availability of water as the most important factor in their timing of land preparation for rice culture, seed bed preparation and sowing, transplanting and cultivation. The remaining twenty-seven (27) considered general climatic conditions as the most important factors in their timing of the above farm operations.

Most important factors considered in the timing of other farm operations. The most important factors considered in the timing of other farm operations can be summarized as follows:

Farm Operations	Most Important Factors in the Timing
Application of fertilizer	Routinary, before and after transplanting
Application of other agricultural chemicals	At the outbreak or presence of disease
Harvesting	Routinary, maturity period
Threshing	Availability of thresher
Milling	Need of family
Selling	Price
Storing	Not a general practice

Essentially no decisive factors have been considered in the timing of farm operations such as application of fertilizers and other agricultural chemicals. The performance of the aforementioned phases of farm operations is basically routinary i.e., cultural requirements.

The family need is the basis of the timing of the milling of the palay produced on farm; selling is based on the current price, and storing is practically not practical at all.

Need of technical assistance. The need for technical assistance has been expressed by 176 farmers interviewed. The remaining 34 expressed the lack of need for technical assistance. Of these 34, 15 are of age 50 and over; 17 have reported a completed grade of 1-4; all are of medium index of agricultural knowledge, 32 have reported operating farms of size 1 to 5 hectares; 30 are share tenants and 13 have a family size of at least 6 members.

Particular technical advice needed in farm operation. The need for technical advice as reported by the farmers interviewed is primarily on increasing production. The next important technical advice needed, which is also related to the first, is on the control of rice diseases.

Farmers of age 50 years and over; with highest grade completed of 1 to 4 years; of medium index of agricultural knowledge; with farm area of 1 to 5 hectares; as share tenants and with family of 6 or more members tended not to need any particular technical advice.

Membership in marketing organization. A high degree of membership in marketing organization (FACOMA) have been observed among the farmers interviewed. Of the 210 interviewed 206 have been or are still members of marketing organizations.

Those who were not members tended to be of younger age (31 to 35 years); of medium index of agricultural knowledge; as share tenants, and with larger family size.

The same farmers are also willing to join another or a new marketing organization.

Technical advice needed in the marketing of products. All the farmers interviewed expressed the need for technical advice in the marketing of their farm products. The particular aspect of technical advice needed in the marketing of their products is on price information of palay.

Services expected from farmer organizations. The two most important services rice farmers expect from farmer organizations are the provision of supply of high-yielding rice varieties and supply of farm tools and equipment. More of the farmers interviewed (186) expressed the service they expect most from farmer organization is the provision of high-yielding varieties.

Rice varieties. The common rice varieties planted in the area surveyed are Intan, Binato, Tyeremas, BE-3, Wagwag, Raminad, Peta, Ramaga, Burma, Milagrosa, Lanugo and Dara. Rice farmers in general do not confine themselves to single rice variety as can be seen in the following table:

Rice Varieties	Distribution	
	Frequency	Percentage
Intan and Binato	29	13.81
Tyeremas and Intan	3	1.43
Intan	85	40.38
Intan and BE-3	2	0.95
Tyeremas, Intan and Wagwag	1	0.48
Binato	16	7.62

Rice Varieties	Distribution	
	Frequency	Percentage
Raminad	16	7.62
Tyeremas	18	8.57
Peta	2	0.95
Wagwag	10	4.76
Ramaga	2	0.95
Burma	2	0.95
BE-3	17	8.10
Milagrosa	1	0.48
Intan & Wagwag	1	0.48
BE-3, Wagwag & Tyeremas	1	0.48
Tyeremas & Lanugo	1	0.48
Dara	2	0.95
BE-3 & Tyeremeas	1	0.48
Total	210	100.00

The rice variety Intan appeared to be the most popular variety planted in the two provinces covered in the survey. More rice farmers in Nueva Ecija and Bulacan plant rice singly or in combination with other varieties. The other popular varieties are Binato, Ramiad, Tyeremas, Wagwag and BE-3. The most popular variety-mobination is Intan and Binato.

RICE PRODUCTIVITY AND FARMER'S DÉCISIONS

In another paper the writer observed that about 52% of the farmers interviwed, reported making decision on the over-all production plan. These farmers have, however, slightly smaller yields than those who have relinquished the decision making to the landlord. In this paper additional observations were made on the relations of productivity and farmer's decisions and related activities.

Rice Productivity and Price Interest

The distribution of the farmers interviewed and their productivity is as follows:

Average Production (Cavans Palay)	Distribution	
	Number	Per Cent
30	43	20.48
30 — 40	52	20.48
40 — 50	47	22.38
50 +	68	32,38
Total	210	100.00

Almost 1/3 of the farmers interviewed reported an average production of at least 50 cavans per hectare. To what extent price have influenced the rice productivity of the farmers will be discussed in another section.

Rice Productivity and the Most Important Persons Who Have Influenced the Farmers' Production Plan.

Percentage wise there is a tendency for those farmers who considered the government fieldmen as the most important persons who have influenced their production plan to have a better rice productivity than those farmers who have reported other persons: as shown in the following table:

Average Production	Most Important Persons Influencing Farmers Production Plan					
	Co-Farmer :		Government Fieldmen :		Mill Owner	
	No.	%	No.	%	No.	%
30	32	22.22	11	16.92	0	0
30 — 40	35	24.31	16	24.62	0	0
40 — 50	41	28.47	6	9.23	0	0
50 +	36	25.00	32	49.23	1	0
Total	144	100.00	65	100.00	1	0

Almost 50% of the former reported yield 50 cavans or better as compared to 25% of the latter. However, the influence of government fieldmen on the overall production plan of the rice farmers is still not satisfactory considering they have influenced a little more than 1/3 of the farmers interviewed.

Rice Productivity and the Most Important Factor Considered in the Choice of Crops and Livestock Combination.

The distribution of the farmers by productivity and the most important factor considered in the choice of crop and livestock combination is as follows:

Average Production	Most Important Factor Considered in the Choice of Crops and Livestock Combination							
	Price		Labor		Capital		Farm Area	
	No.	%	No.	%	No,	%	No.	%
30	37	23.12	4	15.39	2	9.09	0	0
30 — 40	38	23.75	10	38.46	4	18.18	0	0
40 — 50	22	13.75	12	46.15	11	50.00	0	0
50 +	63	39.38	—	—	5	22.73	0	0
Total	144	100.00	65	100.00			1	0

The farmers who considered price as the most important factor considered in the choice of crops and livestock combinations have a modal productivity range of 50 and over cavans per hectare. Those who considered labor, and those who considered capital as most factor in determining the crop and livestock combination have 40—50 cavans per hectare as the modal productivity range.

Rice Productivity and the Most Important Basis in the Selection of Rice Varieties.

Among the agronomic characteristics rice farmers usually consider in the selection of rice varieties are yield-capacity, adaptability, eating-quality and disease-resistance. The importance placed by the rice farmer on his choice of rice varieties to these agronomic characteristics depends on their ability to withstand the consequences of uncertainty and variations in economic outcomes. The result of this project on the factor considered most important in the selection of rice varieties may be seen in the following table:

Average Production	Most Important Basis in the Selection of Rice Varieties							
	High Field		Adaptability		Cash Needed		Eating Quality	
	No.	%	**No.**	%	No.	%	No.	%
< 30	2	3.28	**41**	27.89	—	—	—	—
30 — 40	10	16.40	**42**	28.57	—	—	—	—
40 — 50	7	11.47	**40**	27.21	—	—	—	—
50 +	42	68.85	**24**	16.33	1	100.00	1	100.00
Total	61	100.00	**147**	100.00	1	100.00	1	100.00

Adaptability to local conditions is most common basis of the selection of rice varieties.

The use of economic factors in the choice of rice varieties were also askéd. The result may also be seen in the above table.

Those farmers who have considered high yield as the most important basis in the selection of rice varieties have a modal productivity range of 50 cavans and over as compared to the 30—40 cavans for those whose gave more importance on adaptability in their selection of rice varieties.

Rice Productivity and the Most Important Person or Group of Persons (or Sources of Information) that Guide in the Selection of Rice Varieties.

In the selection of rice varieties, particularly new ones, farmers depend on government fieldmen, other farmers and the various communication media. The rating placed by farmers interviewed on these sources of guiding information in the selection of rice varieties is given in the following table:

Average Production Cavans/ha.	Most Important Source of Guiding Information in the Selection of Rice Varieties							
	Government Fieldman		**Other Farmers**		Newspaper		General Information	
	No.	%	**No.**	%	No.	%	No.	%
30	3	7.50	**10**	11.37	28	35.90	2	50.00
30 — 40	6	15.00	**19**	21.59	26	33.33	1	25.00
40 — 50	5	12.50	**19**	21.59	22	18.21		
50 +	26	65.00	**40**	45.45	2	2.56	—	—
	40	100.00	**88**	100.00	78	100.00	4	100.00

It may be apparent from the preceding table that government fieldmen and other farmers seemed to have better influenced on rice productivity of farmers concerned than those relying on the general communication media. In a person-to-person contact, a question and answer meeting between the farmers and the sources of information could have taken place. Information other than those published, read or shown in various means of communication media could have been illicited.

SUMMARY AND CONCLUSIONS

Rice farmers make decisions as to which production plan to use in a given and uncertain environment. They differ in their aversion to uncertainty and in their ability to withstand the consequences of uncertainty and variation in economic outcomes. They consult government fieldmen, other farmers, read newspapers, listen to radio and avail of other sources of information for guidance in the selection of crop and livestock combination particularly of rice with other crops.

A statistical analysis of rice farmers' decision in Bulacan and Nueva Ecija that they are more rationale in their production decisions than before. However, because (perhaps) of their debt positions in their selection of rice várieties, they tend to put more importance on the adaptability of the variety. This to some extent may be the reason of a seemingly stable national rice productivity.

There seems that there are discernible changes in the rice farmers' process of decision making indicating their adjustment to suit the changes in the rice economic structure rather than as adaptations of farmers' decision to the changing rice economic institutions.

This study only serves a notice to other researchers that there is still much more to learn on the process rice farmers follow in their decisions regarding their rice farm operation with the hopes of improving their economic positions.

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ACKNOWLEDGMENT

The writer would like to make the following acknowledgment:

1. To the Social Science Research Council, University of the Philippines for the financial support given to the writer;

2. To Dr. Cristina P. Parel, Director, Statistical Center, University of the Philippines for her help in the revision of the proposed schedule;

3. To Mr. Ildefonso M. Cruz, Regional Director, and Mr. Oscar Tobias, Provincial Statistician for Nueva Ecija for the help they extended in facilitating the collection of the data used in this paper; and

4. To Dr. R. Santos-Cuyugan, Chairman and Mrs. Lolita K. Asuncion, Executive Secretary, of the Social Science Research Council, for the administrative help they extended to the writer.

The Philippine Statistician
Vol. XVIII, Nos. 3 and 4, 1969

"THE DISTRIBUTION OF FILIPINO FAMILY SAVING AND EXPENDITURE"[1]

BY MILAGROS J. EUSTAQUIO[2]

One of the most important factors in any study of the economy of the Philippines is saving. The meager amount of saving in the Philippines has been attributed as one of the greatest factors in the slow pace of economic development.

Hooley (4) formerly of the U.P. Institute of Economic Development and Research (IEDR) wrote:

Few variables have been singled out so often as a major obstacle to Philippine economic development as the inadequate rate of saving.

Hand-in-hand with saving comes another important variable — expenditure.

A good number of economists and statisticians have written extensively on Filipino family income and its distribution within the population. However, no one has yet made a study on the distribution of saving and expenditure — two variables as equally important as income.

This paper then seeks to find out the distribution of family saving and expenditure.

Hampered by lack of available data, we have made use of a sample of 100 families surveyed by the Phil. Virginia Tobacco Administration (PVTA).

Here, data on income and expenditure per family are available. From these figures, one can make a frequency table

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[1] Part of thesis submitted in partial fulfillment of the requirements for the degree M.A. in statistics.

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giving the number of families per expenditure level; as follows:

Expenditure Level	*Number of Households*
₱ 250 — ₱ 499	4
₱ 500 — ₱ 999	17
₱1000 — ₱1499	26
₱1500 — ₱1999	17
₱2000 — ₱2499	17
₱2500 — ₱2999	11
₱3000 — ₱3499	4
₱3500 — ₱3999	2
₱4000 — ₱4499	1
₱4500 — ₱4999	1
₱5000 and over	0
TOTAL	100

By subtracting expenditure form income for each family, one can get frequency of families per saving level, as follows:

Saving Level	*No. of Households*
—₱1,000 to —₱ 501	3
—₱ 500 to —₱ 1	12
₱ 0 to ₱ 499	27
₱ 500 to ₱ 999	20
₱1,000 to ₱1,499	16
₱1,500 to ₱2,499	15
₱2,500 to ₱2,999	4
₱3,000 to ₱3,499	1
₱3,500 to ₱3,999	1
₱4,000 to ₱8,000	1
TOTAL	100

We have considered three models to fit: the Pearsonian Type I Curve, the Pareto and the Lognormal distributions.

We shall give a brief description of each of these distributions.

The Pearsonian Type I Distribution

The frequency of the Pearsonian Type I Distribution is given as:

$$y = y_o \left(1 + \frac{A_1}{X}\right)^{m_1} \left(1 - \frac{X}{A_2}\right)^{m_2} \qquad (1)$$

where the curve is expressed with the origin at the mean, and were

$$(2)$$

$$ye = \frac{N}{A_1 + A_2} \frac{(m_1 + m_2 + 2)^{m_1+m_2} \Gamma(m_1 + 1) \Gamma(m_2 + 1)}{(m_1 + 1)^{m_1} (m_2 + 1)^{m_2} \Gamma(m_1 + m_2 + 2)}$$

$$m_1 = \tfrac{1}{2} \{(r-2) - r(r+2)\sqrt{\beta_1/[\beta_1 (r+2)^2 + 16(r+1)]}\} \quad (3)$$

$$m_2 = \tfrac{1}{2} \{(r-2) + r(r+2)\sqrt{\beta_1/[\beta_1(r + 2)^2+16(r+1)]}\} \quad (4)$$

$$r = \frac{6 (\beta_2 - \beta_1 - 1)}{6 + 3\beta_1 - 2\beta_2}, \text{and} \frac{m_1 + 1}{A_1} = \frac{m_2 + 1}{A_2} \quad (5) \text{ and } (6)$$

$$N = \text{total frequency} \qquad (7)$$

$$A_1 + A_2 = \tfrac{1}{2} \sqrt{\mu_2} \sqrt{\beta_1 (r+2)^2 + 16(r+1)} \qquad (8)$$

$$\hat{\beta}_1 = \frac{\hat{\mu}_3^2}{\hat{\mu}_2^2} \qquad (9)$$

$$\hat{\beta}_2 = \frac{\hat{\mu}_4^2}{\hat{\mu}_2^2} \qquad (10)$$

In order to determine whether the Pearsonian Type I Curve is the proper curve to use, we make use of Elderton's κ criterion.

Elderton's κ criterion is defined as follows:

$$\kappa = \frac{\hat{\beta}_1 (\hat{\beta}_2 + 3)^2}{4(2 \hat{\beta}_2 - 3 \hat{\beta}_1 - 6) (4 \hat{\beta}_2 - 3 \hat{\beta}_1)} \qquad (11)$$

According to Elderton (3), if κ is negative we have the Pearsonian Type I curve. If κ is positive and less than unity, the proper type of curve to use is the Pearsonian Type IV curve. Lastly, if κ is positive and greater than unity, we have the third type of curve, the Pearsonian Type VI curve.

Later in our study, we shall find out the κ's for saving and expenditure are negative.

The Pareto Distribution

In, 1897, Vilfredo Pareto, an Italian economist, noted certain patterns in the distribution of income in capitalistic economies.

He found out that in most cases the distribution followed the curve:

$$Y^{I} = \frac{A}{(Z - a)} \qquad (12)$$

where

a = lowest income
A, α = parameters

Moving the Y axis to the lowest income in the economy, i.e., making X = (Z − a), transforms the curve to:

$$Y = AX^{-\alpha} \qquad (13)$$

Calculating the derivative,

$$dy = A \ \alpha \ X_{-\alpha-1} \ dx \qquad (14)$$

Thus the relative increment is:

$$\frac{dY}{Y} = - \frac{\alpha}{X} \, dx \qquad (15)$$

From Lange (7) we have an example. If we have our

$X = 10{,}000$ and or $dX = 1{,}000$, we get a relative decrease of

$$\frac{Y}{dY} = -\frac{a}{10}$$

If we continue to increase by 1,000, we get a further decrease of

$$\frac{dY}{Y} = -\frac{a}{11}$$

Note the $\frac{a}{11} < \frac{a}{10}$. Likewise, if we continue the process, we shall see that the relative decrease in the number of persons becomes less and less.

This now is Pareto's law of income distribution: "The relative decrease in the number of persons with given incomes becomes smaller and smaller and dinimished in proportion to the income:

$\frac{dY}{Y} = -\frac{a}{X}\, dX$."

The Pareto (13) can be rewritten as:

$$Y = aX^{b} \qquad (16)$$

Using logarithms, we can rewrite (16) as:

$$\log Y = \log a + b \log X \qquad (17)$$

We could therefore fit a linear regression line and solve for the parameters log a and b to estimate log Y and subsequently, Y.

The Lognormal Distribution

The frequency of the lognormal distribution is given as:

$$f(X) = \frac{1}{X\,\sigma\sqrt{(2\pi)}} \exp\left\{-\frac{1}{2\,\sigma}(\log X - \mu)^2\right\} \qquad (18)$$

$$0 \leqq X \leqq \infty$$

Using the method of probits, let us denote Q(X) to be the proportion of families with savings or expenditures of X or more.

Then, if the distribution is lognormal, we must have:

$$Q(X) = \phi\left(\frac{\log X - \theta}{\lambda}\right) \qquad (19)$$

where ϕ is the normal probability integral:

$$\phi\,(t) = \frac{1}{\sqrt{2\pi}} \int_{t}^{\infty} e^{-\frac{1}{2}u^2}\, du \qquad (20)$$

where θ and λ are, respectively, the mean and standard deviation of the distribution of the logarithm of X.

Therefore, if the probit of Q, namely η, is defined by

$$Q(X) = \phi\,(\eta) \qquad (21)$$

then,

$$\eta = \left(\frac{\log X - \theta}{\lambda}\right) \qquad (22)$$

$$= -\frac{\theta}{\lambda} + \frac{\log X}{\lambda} \qquad (23)$$

$$= A + B \log X \qquad (24)$$

where

$$A = \frac{-\theta}{\lambda} \qquad (25)$$

$$B = \frac{1}{\lambda} \qquad (26)$$

Therefore, if η is plotted against log X, we shall have a straight line.

Thus, to use the method of probits, to fit the saving and expenditure data to a lognormal distribution, we first look for the parameters A and B. After knowing A and B, we can get the value of θ and λ.

We can now solve for the expected Q(X), from the formula (19).

To test for goodness of fit, we compare the observed Q(X) with the expected Q(X) using the X^2 test for goodness of fit.

THE STUDY

The Distribution of Expenditure

a. *Fitting the Pearsonian Type I Distribution*

The frequency curve for the Pearsonian Type I Distribution is given as (1), where the curve has its origin at the mean.

In order to get the moments μ_2, μ_3, and μ_4, we make use of the method suggested by Hardy which was described by Elderton (3).

The following table of sums are therefore first constructed:

Expenditures Level	*Frequency*	(1) *1st Sum*	(2) *2nd Sum*	(3) *3rd Sum*	(4) *4th Sum*
1 — 499	4	100	398	1151	2844
500— 999	17	96	298	753	1693
1,000—1,499	26	79	202	455	940
1,500—1,999	17	53	123	253	485
2,000—2,499	17	36	70	130	232
2,500—2,999	11	19	34	60	102
3,000—3,499	4	8	15	26	42
3,500—3,999	2	4	7	11	16
4,000—4,499	1	2	3	4	5
4,500—4,999	1	1	1	1	1
TOTAL	100	398	1151	2844	6360

Where cols. (1), (2), (3), and (4) are "greater than" cumulative frequencies.

From the table,

$$S_2 = \frac{398}{100} = 3.98$$

$$S_3 = \frac{1,151}{100} = 11.51$$

$$S_4 = \frac{2,844}{100} = 28.44$$

$$S_5 = \frac{6,360}{100} = 63.60$$

$$d = S_2 = 3.98$$

$$\nu_2 = 2\ S_3 - d\ (1 + d)$$

$$= 3.1996$$

$$\nu_3 = 6\ S_4 - 3\ \nu_2\ (1 + d) - d\ (1 + d)\ (2 + d)$$

$$= 4.311984$$

$$\nu_4 = 24\ S_5 - 2\ \nu_3 \{2\ (1 + d) + 1\} - \nu_3 \{6\ (1 + d)\ (2 + d) - 1\} - d\ (1 + d)(2 + d)(3 + d)$$

$$= 36.057279$$

$$\hat{\mu}_2 = \nu_2 - \tfrac{1}{12} = 3.1163$$

$$\hat{\mu}_3 = \nu_3 = 4.311984$$

$$\hat{\mu}_4 = \nu_4 - \tfrac{1}{2}\ \nu_2 + \tfrac{7}{240} = 34.486645$$

Since $\hat{\mu}_3$ is positive, we know that the curve is skewed to the right.

$$\hat{\beta}_1 = .614379$$

$$\hat{\beta}_2 = 3.55177$$

κ, the criterion for determining which type of Pearsonian Curve will best fit the data is given as (11):

$$\kappa = -\ 1.171693$$

Thus, since κ is negative, the proper type of curve to use is the Pearsonian Type I Curve.

Now,

$$r = 15.687168$$

$$m_1 = 1.770892$$

$$m_2 = 11.916276$$

$$A_1 + A_2 = 18.913677$$

$$\frac{m_1 + 1}{A_1} = \frac{m_2 + 1}{A_2}$$

$$\text{or} \quad A_1 = \frac{A_2\ (m_1 + 1)}{(m_2 + 1)}$$

Therefore,

$$\frac{A_2\ (m_1 + 1)}{(m_2 + 1)} + A_2 = 18.913677$$

$$A_2 = \frac{(18.913677)\ (12{,}916276)}{15.687169} = 15.572872$$

$$A_1 = 3.340805$$

We can now solve for y_e, where y_e was defined as (2).

$$\begin{array}{lcl}
\text{Using logs, } \log N & = & 2.000000 \\
\quad \text{colog } (A_1 + A_2) & = & 8.723217 - 10 \\
\quad m_1 \log (m_1 + 1) & = & 0.783834 \\
\quad m_2 \log (m_2 + 1) & = & 13.228592 \\
\quad \text{colog } (m_1 + m_2 + 2)^{m1+m2} & = & 3.636442 - 20 \\
\quad \log \Gamma\ (m_1 + m_2 + 2) & = & 11.748828 \\
\quad \text{colog } \Gamma\ (m_1 + 1) & = & 9.786466 - 10 \\
\quad \text{colog } \Gamma\ (m_2 + 1) & = & 1.407314 - 10 \\
\hline
\qquad\qquad \log y_e & = & 1.314693
\end{array}$$

Thus, $y_e = 20.64$

Having found y_e, we can now solve for the frequency y, using (4).

The following table shows the computation of y:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
X (Mid-pt.)	Frequency	$1 + \frac{x}{A_1}$	$1 - \frac{x}{A_2}$	log (2)	log (3)	m_1 X (4)	m_2 X (5)	log y = (6) + (7) + log y_e	y_x	y
250	4	.108000	1.191442	$\bar{1}.033424$	0.076058	$\bar{2}.288298$	.906328	0.509319	3.23	4
750	17	.407329	1.127200	1.609910	0.052001	$\bar{1}.309193$	0.619658	1.243544	17.52	17
1250	26	.706658	0.998715	1.849210	0.026492	$\bar{1}.732967$	0.315686	1.363346	23.08	23
1750	17	1.005986	0.998715	0.002598	$\bar{1}.999439$	0.004601	$\bar{1}.993315$	1.312609	20.54	19
2250	17	1.305316	0.934473	0.115710	$\bar{1}.970570$	0.204910	$\bar{1}.649304$	$\bar{1}.168907$	14.76	13
2750	11	1.604645	0.870231	0.205367	$\bar{1}.939634$	0.363683	$\bar{1}.280662$	0.959038	9.10	9
3750	2	1.903974	0.805988	0.279667	$\bar{1}.906330$	0.495260	$\bar{2}.883802$	0.693755	4.94	5
3250	4	2.203303	0.741746	0.343074	$\bar{1}.870258$	0.607547	$\bar{2}.453958$	0.376198	2.38	2
4250	1	2.502632	0.677504	0.398391	$\bar{1}.830909$	0.705507	3.985065	0.005265	1.01	1
4750	1	2.801961	0.613261	0.447468	$\bar{1}.787645$	0.792417	$\bar{3}.469519$	1.576629	0.38	—

where Col. (10) is obtained by using

$$\int_{-\frac{1}{2}}^{\frac{1}{2}} y_x d_x = \frac{1}{2_x}(y_{-1} + 22y_o + y_1)$$

Comparing the expected frequency, col. (10), with the actual frequency, col. (1), we see a very close fit between the two. The χ^2 test for goodness of fit between the observed y's and the expected y's gives us:

$$\chi^2 \text{ computed} = \Sigma \frac{(O_i - E_i)^2}{E_i} = 2.47$$

Since the χ^2 (7) tabulated (with α = .05) = 16.01 is greater than 2.47, we conclude that the Pearsonian Type I distribution gives a good fit to Filipino family expenditure.

b. *Fitting the Pareto Distribution*

The method we shall use here to see whether or not expenditure follows a Pareto distribution will be that described by Lange (7).

We have earlier given the Pareto curve to be:

$$Y = a X^b \tag{16}$$

Here, Y, the dependent variable, will denote the frequency of families with X income or greater.

Using logs to (16),

$$\log Y = \log a + \log X \tag{17}$$

Considering this as a simple linear regression, we can thus solve for the parameters b and log a by the method of least squares.

The following table will aid in the computation of the parameters

Expenditure Level	X (Lower Limit)	log X	Y (Frequency)	log Y
250—499	250	2.39794	100.00	2,00000
500—999	500	2.69897	96.00	1.98227
1,000—1,499	1,000	3.00000	79.00	1.89763
1,500—1,999	1,500	3.17609	53.00	1.72428
2,000—2,499	2,000	3.30103	36.00	1.55630
2,500—2,999	2,500	3.39794	19.00	1.27875
3,000—3,499	3,000	3.47712	8.00	0.90309
3,500—3,999	3,500	3.54407	4.00	0.60206
4,000—4,499	4,000	3.60206	2.00	0.30103
4,500—4,999	4.500	3.65321	1.00	0.00000
TOTAL		32.24843		12.24541

$$\text{Thus, } b = -1.51489$$
$$\log a = 6.10982$$

We can now solve for the expected frequencies using the computed parameters. Thus,

$$\log Y = 6.10982 - 1.51489 \log X$$

By substituting for log X, we get the corresponding log Y's and consequently, the expected proportion of families with X expenditures or greater.

The following table shows this computation:

log X	*b* Log X	Expected log Y	Expected Y	Observed Y
2.39794	—3.63261	2.47721	300.01	100.00
2.69892	—4.08864	2.02118	105.00	96.00
3.00000	—4.54467	1.56515	36.75	79.00
3.17609	—4.81143	1.29839	19.87	53.00
3.30103	—5.00070	1.10912	12.86	36.00
3.39794	—5.14751	0.96231	9.17	19.00
3.47712	—5.26745	0.84237	6.96	8.00
3.54407	—5.36888	0.74094	5.51	4.00
3.60206	—5.45672	0.65310	4.50	2.00
3.65321	—5.53421	0.57561	3.76	1.00

We do not have to make a complete χ^2 test of goodness of fit to see how close are the expected Y's to the observed Y's.

Just looking at the data will tell us that they are very different from each other. Just from the 1*st* values, we get

$$\frac{(100.00 - 300.01)^2}{300.01} = 133.00$$

We note that χ^2 (7) ($\alpha = .05$) = 16.01, from the χ^2 table. Thus, we may conclude that expenditure does not follow that Pareto distribution.

c. *Fitting the Lognormal Distribution*

We have eariler given the frequency curve of the lognormal distribution as (18).

Using the method of probits, we need to know the mean θ, and the standard deviation λ in order to compute the expected frequencies Q(X) given earlier as (19).

Since $\theta = -A\lambda$ and $\lambda = \frac{1}{B}$ we can get the values of θ and λ after we have gotten the parameters A and B, where A and B are the parameters of the linear regression,

$$\eta = A + B \log X$$

Thus,

$$B = \frac{\Sigma(\eta \log X) - \frac{\Sigma\eta\,\Sigma \log X}{n}}{\Sigma(\log X)^2 - \frac{(\Sigma \log X)^2}{n}}$$

$$A = \bar{\eta} - B \log X$$

The following table shows the computation of A and B.

Expenditure Level	Lower Expt. X	log X	% Frequency	Cumulative Frequency Q (x)	η
250— 499	250	2.39794	4.00	100.00	-3.49
500— 999	500	2.69897	17.00	96.00	-1.75
1,000—1,499	1,000	3.00000	26.00	79.00	-0.81
1,500—1,999	1,500	3.17609	17.00	53.00	-0.08
2,000—2,499	2,000	3.30103	17.00	36.00	0.36
2,500—2,999	2,500	3.39794	11.00	19.00	0.88
3,000—3,499	3,000	3.47712	4.00	8.00	1.41
3,500—3,999	3,500	3.54407	2.00	4.00	1.75
4,000—4,499	4,000	3.60206	1.00	2.00	2.05
4,500—4,999	4,500	3.65321	1.00	1.00	2.33
5,000 and over	5,000	3.69897	0.00	0.00	3.49
TOTAL		35.94740	100.00		6.14

$$B = 3.98153$$

$$A = -12.45322$$

Thus

$$\lambda = \frac{1}{B} = .2511597$$

$$\theta = A\lambda = 3.127747$$

Thus the expected cumulative frequencies Q(X), can be obtained by:

$$Q(X) = \Phi\left(\frac{\log X - .25116}{3.12775} \right)$$

The following table shows the computation of the expected Q(X) and its test for goodness of fit:

log X	$\frac{\log x - \theta}{\lambda}$	$\phi\left(\frac{\log x - \theta}{x}\right)$ = Expected θ (X)	Observed Q (X)
2.39794	–2.901	99.81	100.00
2.69897	–1,707	95.64	96.00
3.00000	–0.508	69.50	79.00
3.17609	0.192	42.47	19.00
3.30103	0.689	24.51	53.00
3.39794	1.075	14.01	36.00
3.47712	1.391	8.23	8.00
3.54407	1.657	4.85	4.00
3.60206	1.888	2.94	2.00
3.65321	2.092	1.83	1.00
3.69897	2.270	1.16	0.00

Since the computed $\chi^2 = \frac{\Sigma\ (O_i - E_i)^2}{E_i} = 12.72$ is lesser than the tabulated χ^2 (5) ($\alpha = .05$) = 12.83, we have reason to believe that expenditure follows the lognormal distribution.

The Distribution of Saving

a. *Fitting the Pearsonian Type I Distribution*

As before, we first get the moments by making the following table of sums:

Saving Level	Frequency	1st Sum	2nd Sum	3rd Sum	4th Sum
-1,000 to -501	3	100	429	1329	3,524
- 500 to - 1	12	97	329	900	2,195
o to 499	27	85	232	571	1,295
500 to 999	20	58	147	339	724
1,000 to 1,499	16	38	89	192	385
1,500 to 1,999	6	22	51	103	193
2,000 to 2,499	9	16	29	52	90
2,500 to 2,999	4	7	13	23	38
3,000 to 3,499	1	3	6	10	15
3,500 to 3,999	1	2	3	4	5
4,000 to 4,499	1	1	1	1	1
TOTAL		429	1329	3524	8,465

Thus,

$$S_2 = 4.29$$

$$S_3 = 13.29$$

$$S_4 = 35.24$$

$$S_5 = 84.65$$

$$d = 4.29$$

$$v_2 = 3.8869$$

$$v_3 = 7.024878$$

$$v_4 = 56.373243$$

$$\hat{\mu}_2 = 3.802567$$

$$\hat{\mu}_3 = 7.024878$$

$$\hat{\mu}_4 = 54.459459$$

Since μ_3 is positive, we know that the curve is skewed to the right.

$$\hat{\beta}_1 = 0.897525$$

$$\hat{\beta}_2 = 3.766341$$

κ_1 the criterion for determining to which type of Pearsonian curve the data will best fit is given as (11).

$$\kappa = -\ 0.105875$$

Since κ is negative, the proper type of curve to use is the Pearsonian Type I.

Now,

$$\begin{aligned}
r &= 9.667181 \\
m_1 &= 0.711570 \\
m_2 &= 6.955611 \\
A_1 + A_2 &= 16.685151 \\
A_1 &= \frac{A_2\ (m_1 + 1)}{(m_2 + 1)}
\end{aligned}$$

Therefore,

$$\begin{aligned}
\frac{A_2\ (m_1 + 1)}{(m_2 + 1)} + A_2 &= 16.685151 \\
A_2 &= 13.731052 \\
A_1 &= 2.954099
\end{aligned}$$

We can now solve for y_e, where y_e was defined as (2).

Using logs,

$$\begin{aligned}
\log N &= 2.000000 \\
\text{colog}\ (A_1 + A_2) &= 8.777674 - 10 \\
m_1 \log\ (m_1 + 1) &= 0.166064 \\
m_2 \log\ (m_2 + 1) &= 6.264732 \\
\text{colog}\ (m_1 + m_2 + 2)^{m_1 + m_2} &= 2.445519 - 10 \\
\log \Gamma(m_1 + m_2 + 2) &= 5.239564 \\
\text{colog}\ \Gamma(m_1 + 1) &= 9.807309 - 10 \\
\text{colog}\ \Gamma(m_2 + 1) &= 6.341266 - 10 \\
\hline
\log y_e &\quad 1.042128
\end{aligned}$$

Therefore,

$$y_e = 11.02$$

Thus, the following table shows the computation of y.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
X quency	(Mid-pt.) Fre-	$1 + \frac{X}{A_1}$	$1 - \frac{X}{A_2}$	log (2)	log (3)	m_1 X (4)	m_2 X (5)	log y_x	y_x	y
-750.5	3	-.10273	1.237237	$\bar{1}.011697$	0.092440	$\bar{1}.296753$	.642977	0.981858	9.58	9
-250.5	12	.23245	1.165128	1.366330	0.066363	$\bar{1}.549099$	.461595	1.052822	11.18	11
249.5	27	.56762	1.093026	1.754056	0.038620	$\bar{1}.824994$	.268625	1.135747	13.54	13
749.5	20	.90280	1.020911	1.955592	0.008983	$\bar{1}.968300$	.062482	1.072910	11.83	12
1249.5	16	1.23797	0.948803	0.092721	$\bar{1}.977175$	0.065977	$\bar{1}.841238$	0.949343	8.90	9
1749.5	6	1.57315	0.876695	0.196756	1.942846	.140006	$\bar{1}.602459$	0.784593	6.09	6
2249.5	9	1.90833	0.804586	0.280647	$\bar{1}.905575$	.199700	$\bar{1}.343216$	0.585044	3.85	4
2749.5	4	2.24350	0.732478	0.350926	1.864796	.249708	$\bar{1}.059573$	0.351409	2.25	2
3249.5	1	2.57868	0.660369	0.411401	$\bar{1}.819787$	.292741	$\bar{2}.746508$	0.081377	1.21	1
3749.5	1	2.91385	0.588261	0.464460	$\bar{1}.769569$	.330496	$\bar{2}.397212$	$\bar{1}.769836$	0.58	1
4249.5	1	3.24903	0.516152	0.511750	$\bar{1}.712776$	.364146	$\bar{2}.002181$	$\bar{1}.408455$	0.25	—

To test for goodness of fit, we compare cols (1) and (10). We notice that there is a great disparity between the values, specially in the lower savings level.

The χ^2 test for goodness of fit gives us a computed χ^2 equal to 38.19. Since the tabulated χ^2 equals 17.53 (with $\alpha \doteq .05$), a number lesser than the computed χ^2, we conclude that saving does not follow the Pearsonian Type I curve.

b. *Fitting the Pareto Distribution*

Similarly, we first get the parameters log a and b by the method of least squares:

Saving Level	Lower Saving	X (2) 8,000	log X	Cum. freq. Y	log Y
-1,000 to -501	-1,000	7,000	3.84510	100.00	2.00000
-500 to - 1	500	7,500	3.87506	97.00	1.98677
0 to 499	0	8,000	3.90309	85.00	1.92942
500 to 999	500	8,500	3,92942	58.00	1.76343
1,000 to 1,499	1,000	9,000	3.95424	38.00	1.57978
1,500 to 2,499	1,500	9,500	3.97772	22.00	1.34242
2,500 to 2,999	2,500	10,500	4.02119	7.00	0.84510
3,000 to 3,499	3,000	11,000	4.04139	3.00	0.47712
3,500 to 3,999	3,500	11,500	4.06070	2.00	0.30103
4,000 to 8,000	4,000	12,000	4.07918	1.00	0.00000

$b = -9.05434$

$\log a = 37.15656$

Thus, $\log Y = 37.15656 - 9.05434 \log X$

To get the expected cumulative frequency Y:

log X	b log X	Expected log Y	Expected Y	Observed Y
3.84510	-34.81484	2.34172	219.60	100.00
3.87506	-35.08611	2.07045	117.60	97.00
3.90309	-35.33990	1.81666	65.56	85.00
3.92942	-35.57830	1.57826	37.87	58.00
3.95424	-35.80303	1.35353	22.57	38.00
3.97772	-36.01563	1.14093	13.83	22.00
4.02119	-36.40922	0.74734	5.59	7.00
4.04139	-36.59212	0.56444	3.67	3.00
4.06070	-36.76696	0.38960	2.45	2.00
4.07918	-36.83428	0.22228	1.67	1.00

Here, we can easily observe that the observed Y's differ greatly from the expected Y's. The first expression alone gives us,

$$\frac{(100.00 - 219.60)^2}{219.60} = 65.14$$

which is much larger than the χ^2 (7) ($\alpha = .05$) $= 16.01$ from the table. Thus, we conclude that saving also does not follow the Pareto distribution.

c. *Fitting the Lognormal Distribution:*

Again, using the method of probits, we first get the parameters A and B. We have the following table:

Saving Level	Lower Saving	X (2) 8,000	log X	Freq. (%)	Cum. Fr. Freq.	Q(X)	η
–1,000 to – 501	–1,000	7,000	3.84510	3	100		–3.49
–500 to – 1	–500	7,500	3.87506	12	97		–1.88
0 to 499	0	8,000	3.90309	27	85		–1.04
500 to 999	500	8,500	3.92942	20	58		–0.20
1,000 to 1,499	1,000	9,000	3.95424	16	38		0.31
1,500 to 2,499	1,500	9,500	3.97772	15	22		0.77
2,500 to 2,999	2,500	10,500	4.02119	4	7		1.48
3,000 to 3,499	3,000	11,000	4.04139	1	3		1.88
3,500 to 3,999	3,500	11,500	4.06070	1	2		2.05
4,000 to 8,000	4.000	12.000	4.07918	1	1		2.33

Thus,

$$\lambda = .043743$$

$$\theta = 3.959042$$

since

$$B = 22.86126$$

$$A = -90.50871$$

Thus the expected cumulative frequency

$$Q(X) = \phi\left(\frac{\log X - 3.959042}{.043743}\right)$$

The following table shows the computation of the expected Q(X)

log X	$\frac{\log X-\theta}{\lambda}$	Expt'd Q(X) $\frac{(\log X-\theta)}{\lambda}$	Observed Q(X)
3.84510	−2.605	99.55	100.00
3.87506	−1.920	97.26	97.00
3.90309	−1.279	85.97	85.00
3.92942	−0.678	75.49	58.00
3.95424	−0.110	54.38	38.00
3.97772	0.427	33.36	22.00
4.02119	1.427	7.78	7.00
4.04139	1.883	3.01	3.00
4.06070	2.324	1.02	2.00
4.07918	2.746	0.30	1.00

The test shows that $\Sigma \frac{(O_i - E_i)^2}{E_i} = 15.77$

But χ^2 (7) ($\alpha = .05$) = 16.01 from the χ^2 table.

Since $15.77 < 16.01$, we may conclude that saving is also distributed as a lognormal.

Conclusion

The Pearsonian Type I distribution gave a bad fit to saving, even if it gave a good fit to expenditure.

The Pareto distribution gave a bad fit to both saving and expenditure. Nevertheless, we note that the disparity between the expected and the observed frequencies of both saving and expenditure occurs largely in the lower saving and expenditure brackets. In the higher brackets, the fit is good.

The lognormal distribution, on the other hand, made a good fit to both saving and expenditure.

Thus, according to our study, the expenditure of the families surveyed by the PVTA follows the Pearsonian Type I and the lognormal distributions, and saving follows only the lognormal distribution.

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The Philippine Statistician
Vol. XVIII, Nos. 3 and 4, 1969

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The undersigned, CESAR M. LORENZO, editor of THE PHILIPPINE STATISTICIAN published quarterly in English at Rizal Hall, Padre Faura, Manila, after having been duly sworn in accordance with law, hereby submits the following statement of ownership, management, circulation, etc, which is required by Act 2580, as amended by Commonwealth Act No. 201.

Name	*Address*
Editor CESAR M. LORENZO	Liberty Mines Incorporated
Business Manager JOSE S. GUTIERREZ ..	U.P. Statistical Center
Owner Philippine Statistical Association, Inc.	P. O. Box 3223, Manila
Publisher — do —	— do —
Printer U.S.T. Press	España, Manila

Office of Publication — Rizal Hall, Padre Faura St. Manila

If publication is owned by a corporation, stockholders owning one per cent or more of the total amount of stocks: — None —

Bondholders, mortgagees, or other security holders owning one per cent or more of total amount of security: — None —

In case of daily publication, average number of copies printed and circulated of each issue during the preceding month of ...., 19....

In case of publication other than daily, total number of copies printed and circulated of the last issue dated June 1968

1.	Sent to paid subscribers	477
2.	Sent to others than paid subscribers	48
	TOTAL	525

CESAR M. LORENZO
Editor

SUBSCRIBED AND SWORN to before me this 25th day of April, 1969, at Manila, the affiant exhibiting his Residence Certificate No. A-309128 issued at Manila on January 13, 1970.

Doc. No. 824
Page No. 66
Book No. VI
Series of 1969

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