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MOST ACCOUNTANTS, whether in private or public practice, have somewhere in their clothes closet an old suit they have used for participation in the taking of physical inventories. These inventory suits have become symbolic of one of the more disenchanting aspects of accounting. Many a New Year's Eve party has been missed because it was necessary to work in a dirty warehouse, often under dim light, clambering over stock piles in order to make a complete count of all physical inventory items at the end of the year.

COMPLETE PHYSICAL COUNT

In the earlier days, the year-end complete physical count was an absolute necessity, as this was the only way that income for the year could be determined. When perpetual inventories became a fairly general practice, the year-end count no longer was a necessity. The physical inventory was taken and observed at some time preceding, but generally not more than one or two months before the year end. Reconciliation of the physical counts with the perpetual records gave an indication of the degree of reliability that could be placed on the perpetual records at the year end and for interim accounting reports. The introduction of cyclical counting, in which a certain number of items would be counted weekly or monthly, and adjusted if necessary, helped to ensure a closer reconciliation between the physical count and the perpetual inventory records all through the year.

STATISTICAL SAMPLE

The requirement for an annual complete physical count was to remain until 1966, when the Auditing Committee of the AICPA issued its Statement on Auditing Procedure No. 36 which recognizes inventory sampling as a permissible substitute for complete physical counts. The statement says:

> In recent years some companies have developed inventory controls or methods of determining inventories, including statistical sampling, of sufficient reliability to make an annual physical count of each item of inventory unnecessary in certain instances. The purpose of this statement is to recognize this development.

To meet the need for a sound approach to inventory sampling, a statistical program was designed as part of the AUDITAPE system,* for the specific purpose of estimation sampling. When applied to inventory, the program eliminates the need of making a complete physical count for financial statement purposes each year. The use of this program does save time, and does lead, in some cases, to improvement in the accounting records.

Although statistical sampling has been a common audit tool for a number of years, the inventory sampling features differ in some important respects from the statistical plans used in other audit phases. In fact, the statistical estimation of physical inventories by computer, where a perpetual inventory is maintained on a computer, presents a new field of application for accounting and statistical concepts.

A specific application of this program was made recently by one of our clients to an inventory of material and supplies comprising 2500 types of items at 44 different locations. The perpetual records were maintained on a computer at the company headquarters. The dollar value of the inventory to be sampled was approximately $2,500,000. Use of the AUDITAPE program resulted in the selection of 211 items which represented slightly over 8 per cent of the total number of items and almost one-half of the dollar value of the amount to be estimated. From this relatively small sample it was possible to obtain a stratified regression estimate of the value of the physical inventory. Our experience indicates that stratified regression estimates are more satisfactory than other types of estimates in that they provide tighter precision.

NATURE OF THE ESTIMATE

The estimate from a statistical sample is simply an extrapolation or projection of the results obtained from the sample and is similar to the estimate that would ordinarily be made intuitively from a non-statistical

*A system formulated by Haskins & Sells involving a collection of special programs designed to operate on a specified format under which data may be extracted from records in other formats for further processing.

sample. For example, if a sample consisted of one out of every ten inventory parts numbers, the total physical inventory value of the items in the sample would be multiplied by 10 to obtain the estimate of the total inventory value for the population. The unique feature of statistical sampling is that it provides a means for measuring the degree of assurance or conversely of uncertainty associated with the sample estimate. These measurements are based on the mathematical concepts of probability and are expressed in terms of reliability and precision.

SAMPLING PROCEDURE

The procedures for making an inventory sampling application consist of the three stages of design, selection, and evaluation of the sample. The statistical principles and procedures employed may be found in the standard statistical textbooks or authoritative literature. The unique characteristic of this program is the way in which a number of these statistical concepts have been put together in an accounting-oriented approach to obtain sufficiently precise estimates of asset or liability values for financial statement purposes.

The use of AUDITAPE releases the accountant from a considerable burden of computation that is inherent in estimates of this nature. In fact, regression estimates, which are a corner-stone of this estimating procedure, as explained later, would be virtually impossible to compute without the availability of an electronic computer. Regression estimates seem to provide more precise estimates of these types of accounting populations than do other types of estimates.

To design a sample it is necessary to identify the population to be sampled, define the sampling unit and the related feature of sampling interest, specify the desired reliability and precision, determine the basis for any stratification to be used, and compute the approximate sample size. The reliability and precision to be used in designing the sample is a matter for management decision based on consideration of the relative degrees of assurance and the related costs. Some indication of these relationships may be obtained by simulation based on previous computer records.

SAMPLE SIZE

The sample size required is a function of the reliability and precision specified, the stratification to be used, and the characteristics or condition of the population with respect to the feature of sampling interest. The effect of the last factor may be illustrated by contrasting an extreme situation with a realistic one. If it were known that the relationship between the perpetual inventory and the physical inventory for every part number in the population were the same, it is apparent that a sample of one item would provide a perfect estimate of the population. Conversely, it is apparent that a variation in such relationships would result in corresponding variations in the estimate.

The extent of these variations as disclosed by the sample is computed through the statistical formulas used for the final sample evaluation. Some preliminary estimates of the extent of variability to be expected in the sample must also be made in order to compute the approximate sample size required. This preliminary estimate of variability could be based on the results of a previous complete inventory, if such is available, or on the results of a previous sample. The next best thing is to make an analysis of the most recently available perpetual record and to introduce some conservatism into the precision parameter to provide for the unknown and perhaps unexpected relationship between the books and physical inventory. In this connection, general experience with other inventories, believed to be roughly comparable to this one, is helpful in the design stage.

Since the preliminary estimate of variability to be expected is necessarily based on earlier and possibly incomplete data, the reliability and precision obtained in the evaluation of the actual sample results is likely to differ somewhat from that specified in designing the sample and computing the sample size. In practice, particularly until further experience is available with respect to specific inventories, some deliberate conservatism in the preliminary precision parameter used for computing sample size ordinarily is desirable.

Several of the procedures incorporated in the design stage have been included so as to improve the estimate and tighten the precision surrounding the estimate. Among these are the type of estimate used, the stratification employed, and the manner in which the upper cutoff for each stratum is determined. It may be well to discuss each of these briefly at this point as each of these procedures works in different ways to minimize the degree of possible error in the estimate.

REGRESSION ESTIMATES

Both on theoretical and on empirical grounds it appears that regression estimates provide better estimates and tighter precision than either ratio estimates or mean estimates. The standard deviation from the line of regression tends to be smaller than the standard deviation from a ratio or the standard deviations from a mean. One of the reasons for this is that the principal feature of sampling interest is the over-all relationship between the book and physical inventory, which may be thought of as a line of regression. The least squares line, or line of best fit, is designed mathematically to minimize the sum of the squared deviations around such a line. It should be emphasized that both the book values and the physical values are required to make this computation, and unless a previous complete physical inventory is available, together with the related book inventory, this calculation cannot be readily made in the design stage. It is possible, however, to make such a calculation from a previous sample and to use this information in the sample design as a substitute for more complete information.

STRATIFICATION

A second technique for tightening the precision is stratification, which has been used extensively in audit sampling programs. As most accounting populations contain a small number of items of large dollar value, counting completely all items above a given dollar amount will eliminate the variance entirely for this group of items and eliminate a great part of the sample variance. Stratification divides the total variance into a number of smaller variances, which may be classified in two ways —variances within strata and variances between strata. The variances between strata are eliminated completely from the calculation of the sample variance. In those cases, such as the top stratum wherein the stratum is counted completely, the variance within the stratum is also eliminated from the calculation.

The more stratification, the more variances between strata that are eliminated and the smaller the total variance will become. Beyond a certain point, however, the additional gain from this procedure may not be worth the additional effort, and other complications arise from the smaller number of items in each stratum. We have concluded that 20 strata are adequate for estimates of accounting populations and that a smaller number of strata may be sufficient when sample sizes are small.

EXPONENTIAL STRATA LIMITS

A third way in which the variance may be reduced is through the determination of the upper limits of each stratum. The distribution of a materials and supplies inventory or other accounting population which we may want to estimate is likely to be exponential. That is to say, there is likely to be a large number of small extended values and a small number of large extended values. Rather than choose the strata limits arbitrarily, it is logical that they should be chosen with due reference to the exponential distribution. Formulas are available by which to achieve optimum stratification once the nature of the distribution is known. An initial step in the program therefore is to determine the strata limits on the basis of the number of items and the total value, assuming an exponential distribution. If for any reason this exponential assumption is not valid, different strata limits may be prescribed.

SAMPLE STRATIFICATION

The basic population data must be in AUDITAPE format. For those not familiar with the AUDITAPE system, it should be explained that AUDITAPE is a collection of special programs designed to operate on a specified format. Data may be extracted from records in other formats and placed into this format to permit further processing. It frees the accountant or auditor from the necessity of special programming to obtain data from existing computer records. If only quantity and price were available, for instance, the AUDITAPE mathematical routine could be used to obtain extended values. Similarly, information may be printed or punched from the AUDITAPE format.

The program operates on variable format so that these data may be in any of the six numeric fields of the AUDITAPE. Each item in the population is read, classified according to stratum and the necessary calculations are made. On the basis of the precision and reliability specified by the user, the approximate sample size is determined and adjusted for sampling without replacement. When the size of the sample has been determined, the sample is allocated among the various strata in such a way as to further tighten the precision.

When the size of the sample in each stratum has been determined, the intervals for selection are calculated and the design stage is completed. An option permits the program to terminate at this point. If this election is made, the necessary data to continue at a later date, including strata limits and intervals, will be punched into cards. If this option is not elected, the program will continue into the selection stage.

SAMPLE SELECTION

The decisions and computations required for designing the sample also determine the sampling rates or intervals to be used in selecting sample items. If these were computed in a separate run, these intervals are introduced into the computer at this time. Otherwise, the intervals determined in the design stage are carried forward into the selection stage. The selection procedure used is systematic selection within each stratum based on a random start for each stratum. The single six-digit random number introduced into the program is used to determine a random number for the first stratum. This random number is used to determine the starting selection within the first interval. Beyond the first item, each item is selected if it equals or exceeds one interval from the first item selected. A new random number is computed from the previous random number for each successive stratum, and a different random start is determined within each stratum.

The computer tape is processed sequentially. Each item is taken as it comes, allocated to a stratum based on the dollar value, compared with the random start for that stratum, and selected or rejected on that basis. Those items so selected are passed to the output tape and at the conclusion of the selection process, the item counts and totals for the population and the sample are printed for the record. The individual items on the sample output tape may be printed and punched to provide a convenient record for recording the sample counts.

SAMPLE EVALUATION

In most cases, the tape from which the selection is made is a perpetual inventory record of at least a few days earlier than the actual date on which the selection is made and the selection run may precede, for logistical reasons, the actual date of the physical count. This introduces a somewhat awkward accounting procedure, which is nevertheless essential to the correct evaluation of the sample.

The "as of" selection date is the controlling date for the sample. This is the date on which the items were stratified and the basis on which they were selected. It is necessary therefore to adjust the physical counts which are made as of a later date back as far as the selection date, by adding algebraically the transactions between the two dates. The sample output tapes from the selection run contain the book balances for the selection date. Let us say that the selection date is June 15. The balances for the same items should be obtained from the inventory tape as of the actual count date. Let us say that the count date is June 30. The difference in book value for each of the sample items between these two dates, i.e., June 15 minus June 30, can be algebraically added to the extended physical values to obtain a physical value comparable to the selection date book value.

Any significant differences between the counts and perpetual records should be investigated so as to resolve insofar as possible errors in physical counts or bookkeeping transactions. The unresolved differences for each sample item are used as the input to another computer program that computes a stratified regression estimate and determines the precision surrounding the estimate for a given reliability.

ACCOUNTING USE OF SAMPLE RESULTS

The unresolved differences between the perpetual records and the physical counts for the sample items should be recorded in the accounting records. As to the remaining difference between the sample estimate and the perpetual records for the entire population, two possible approaches might be taken.

Under the first approach, the sample estimate of the total inventory would be used exactly as if a complete physical inventory had been taken and the inventory control account would be adjusted accordingly. The portion of such difference that could be identified with specific items would be adjusted within the perpetual inventory records. The remaining difference that could not be so identified would be carried in the perpetual inventory records as an unallocated inventory adjustment account. After the first sampling application, this account would be increased or decreased, as necessary, to reflect the results of subsequent samples. Inventory differencces found as a result of subsequent cyclical counts could be considered as part of this unallocated inventory adjustment account and corrected accordingly.

Under the second approach, the inventory sample would be regarded primarily as a test of the acceptability of the existing records rather than as a substitute for a complete physical inventory. Accordingly, the inventory records would be considered acceptable if the balance in the inventory control account were between the upper and lower precision limits for the sample estimate. The unidentified differences relating to the specific sample items would be adjusted, but no unallocated adjustment would be recorded.

SUMMARY

A sampling estimate taken on the basis described above is a reliable and acceptable alternative to a complete physical count for financial statement purposes. It is likely that more and more companies will want to follow this approach in the coming years. The reduction in counting, pricing, and extending will be a welcome relief from a burdensome clerical work load. The speed with which such a sample may be taken will reduce down-time in manufacturing or processing operations.

On this latter point, it should be made clear that where the computer-based inventory is used for order entry or other operational or control purposes, some regular procedure of reconciling the perpetual records to physical quantities will be required. The complete physical count will no longer serve this purpose, and there may be some question as to whether it ever did. This reconciliation of individual balances may be done at re-order time or through a regular program of cyclical counting in off-peak hours.

Statistical estimation of inventories appears to be most effective when applied to an inventory of parts or supplies which may be counted without resort to weighing or measuring. In this way a reliable estimate of the relationship of the book records to the physical quantities may be obtained. Differences represent actual gains or losses rather than the possible reflection of errors in measurement or conversion. Counts may be rechecked to eliminate counting error and to improve the reconciliation.

It is unlikely that there will be any substantial incremental cost savings through a sampling approach. There may be a saving of previously paid overtime from not having to make a complete count within a short period of time. It is likely that customer service may be improved by avoiding a complete shutdown for several days where this is the normal practice. It is possible that profits might be improved by avoiding a complete shutdown and much of the pre-planning for inventory-taking. In some plants the normal routine may be disrupted for one or two weeks prior to taking of the inventory by rearranging parts and supplies to facilitate the actual count.

What is clear is that the accounting department will not be as pressed for time. There will be time to count, price, and extend carefully and time to check back on apparent discrepancies. There is a good reason to believe that statistical estimates may, in fact, be as close to the true physical value as some complete physical counts have been in the past.