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A great deal has been written during the past few years on the application of statistical sampling techniques in the accounting and auditing field. The growth of interest in this subject is evidenced by the fact that both the American Institute of Certified Public Accountants and The Institute of Internal Auditors have recently organized committees on statistical sampling. Industry also is giving serious consideration to the use of statistical sampling techniques in the area of accounting and auditing and some companies are already using them.

Before proceeding further, it may be well to define the term "sampling." Sampling is the examination of a part of anything presented for inspection purporting to represent the aggregate. It may be said that this is not a new concept in the auditing field since in auditing we rely on test-checking of transactions, vouchers, payrolls, etc., instead of total examination. Test-checking is a recognized and accepted auditing procedure. References to it first appeared in accounting literature in the 1890s and early 1900s. In the booklet entitled "Generally Accepted Auditing Standards" issued by the American Institute of Certified Public Accountants, frequent references are made to the application of audit procedures by tests and the "testing technique."

Recent discussion of this subject has centered not around sampling or testing as such but rather around the methods and techniques for selecting a sample. It is charged that accountants' selection of a sample is empirical and intuitive and not scientific. It is argued that since decisions based on sampling are actually decisions based on some kind of probability, the selection of the sample should be through the more objective and scientific methods of the statistician in which probability is a key factor.

I do not intend to discuss in great length the divergent views of accountants and statisticians as to the applicability of statistical sampling to accounting and auditing. I would like, however, to examine briefly the main area of disagreement, or perhaps I should say the main area of miscomprehension.

In auditing, the extent of test-checking and other auditing procedures is determined by evaluation of the adequacy and effectiveness of the system of internal control and the degree of reliance which the auditor considers he is entitled to place thereon. In evaluating the system of internal control, the auditor uses judgment based on his experience and knowledge of the business. His opinion with respect to the financial statements is not based on any single test or series of tests or the evaluation of the system of internal control; it is derived from testing, examining, and reviewing many interrelated transactions, functions, and controls, and from his evaluation of their significance based on his knowledge and experience. The element of judgment which is needed in selecting the area and extent of test-checks cannot be supplanted by statistical sampling techniques.

The statistician has developed methods and mathematical formulae for selection of samples, calculation of sampling risks, calculation of the relative frequency or probability of departure or variance from a fixed standard, and the probable degree of error. He works on the probability concept of sample representation. He sets a degree of tolerance for error and by means of mathematical formulae he establishes to a specified degree of confidence that if the entire population was examined or checked, the result would not vary plus or minus X dollars from the amount indicated by his sample.

While it is true that the auditor cannot with statistical sampling techniques supplant the long-used and accepted method of test-checking based on judgment and evaluation of the system of internal control and other control techniques, such as budgets, standard costs, etc., there are areas in auditing where statistical sampling can be used to good advantage and with resulting savings in time and expense.

We auditors should not dismiss statistical techinques as inapplicable to our work. The temptation may be great to do so especially when we study the language and hieroglyphics of mathematical formulae with which the statistician works. But as a growing profession we should be ready to examine constructive criticism of our methods and procedures and not be afraid of change and innovation when and where needed.

Experiments with application of statistical sampling techniques have been made in many areas of accounting and auditing work. While experience is limited, the few cases on record show that inventory valuations can be tested and statistically determined with a high degree of accuracy and at considerable savings in cost. At least one company, the Minneapolis-Honeywell Regulator Company, has used statistical sampling in taking the work-in-process inventory at one of its plants. Mr. Allan L. Rudell, Chief Accountant of Minneapolis-Honeywell, wrote about it in the October 1957 issue of the National Association of Accountants' Bulletin. This is a presentation of their application of statistical sampling as a case history.

The idea of using statistical sampling in valuing inventories was first proposed by the company's statisticians who had been successfully using sampling techniques for quality control. According to Mr. Rudell, the accounting people were somewhat skeptical at first but sufficiently intrigued by the possibilities to be willing to try it.

The plan took almost three years to develop. It started with the company's annual physical inventory of 1953. An assembly department with approximately 5,000 items was selected to be tested by the statistical method. A complete physical count of the department's inventory had been made previously as part of the annual inventory. By random selection of approximately 500 of the 5,000 items contained in the departmental inventory, a dollar value was determined for the total inventory of the department which was within 1/10th of one per cent of the physical count.

Based on this successful test, plans were made to apply statistical sampling to the entire work-in-process inventory in the summer of 1954. The 1954 inventory contained 37,000 individual lots. Again by a random selection of 3,300 of these lots, a dollar value was determined for the entire inventory which was within predetermined and acceptable limits of error.

The two tests had shown that statistical sampling could be applied successfully in valuation of inventories; the company personnel set about to develop and refine their plan. Dr. W. Edward Deming, one of the foremost statisticians in the country, was engaged as consultant. Dr. Deming reviewed the methods developed by the company's own statisticians and, after careful review of the make-up of the inventory, added certain refinements. Subsequently, several meetings were held in New York and Minneapolis attended by Dr. Deming, company representatives, and representatives of my firm to develop the plan and to evaluate the results of the many tests made theretofore. As a result of these meetings it was decided to test the plan completely during the 1955 physical inventory.

The characteristics of the 1954 inventory were studied. A frequency distribution of the inventory lots by value classes was made.

The term "lot" is significant in the plan and is defined as ". . . any group of identical parts or assemblies which are physically touching, either by crates, bins, or skids. The lot might include only one crate or a number of crates if they contain identical parts and the crates are in physical contact." The 1954 inventory of work-in-process was approximately $4,600,000; the total inventory at the Minneapolis plant was approximately $12,000,000; and company's total inventory, including consolidated subsidiaries, was $60,000,000.

The frequency study showed that only six per cent of the inventory lots had a value of over $500 each but this six per cent accounted for 54.6 per cent of the total value of the inventory. Based on this and on cost estimates (costs of taking a physical inventory), the cut-off point between "high-value" and "low-value" lots was set at $500. It was decided that a 100 per cent count of "high-value" lots, but only a sample count of the "low-value" lots, would be made. The statistically computed sample size was slightly under ten per cent. In order to make sampling easier, a straight ten per cent sample was decided upon. In addition, the inventory contained certain ordnance lots which, because of governmental rquirements, would be counted 100 per cent.

The separation of the inventory into "high-value" and "low-value" lots had the effect of narrowing the range from the highest to the lowest value lot in that part of inventory which was to be sampled and contributed toward a more accurate inventory with a smaller sample size.

Statistical tables have been worked out and are available from which the size of a sample for a given population may be determined. The size of the sample will depend, in addition to the size of total population, on two other factors—the desired degree of accuracy or precision and the level of confidence to be had in the sample. The higher the required degree of accuracy and the level of confidence, the greater the size of the sample. Let me illustrate. Assuming a population of 10,000 inventory items, a sample of 2,568 items should produce a result which will be within one per cent of the true but unknown total value at a 95 per cent confidence level, but only 795 items would need to be tested if we were willing to accept a two per cent margin of error at the same confidence level. We can vary not only the margin of error factor but also the confidence level factor, sometimes called the sampling risk. In the first instance, where 2,568 items were sampled, we selected a sample that should give us an answer within one per cent of the true but unknown value of the inventory, and the chances are 95 out of 100 that the estimate will not vary by more than one per cent from actual, while most likely it will be less.

With these refinements the company proceeded to test its 1955 work-in-process inventory. Based on a random sample of 4,200 items out of a population of approximately 40,000 (plus the "high-value" and ordnance lots), a value was established for the inventory which was within .8 per cent of the value determined by the 100 per cent physical count.

Sufficient confidence was now established in the method that it was decided to proceed with preparations for taking the 1956 inventory by the sampling method. The question which came up now was whether the procedures so far developed would work with shop personnel and under shop conditions. It was, therefore, decided to test the procedures in the shop in two departments. Shop crews were selected and trained for this purpose. The test was made in February 1956 and, according to Mr. Rudell, proved to be satisfactory and extremely worth while.

You may be interested in a comparison of the hours spent in and the cost of taking the inventory of the two departments in 1955 and in February of 1956. Total hours: 1955—1,347, 1956—719. Cost: 1955—$2,670, 1956—$2,275. You will note that while there was a reduction of 628 hours, almost 50 per cent, the dollar savings were considerably less. This situation, however, I understand was much improved in the 1956 annual inventory.

Being satisfied with the shop testing of procedures, the company's next step was to prepare and write instructions and schedules, and design and obtain the necessary forms and supplies. An intensive training program was carried out for some 700 people who would do the job. The training included lectures, demonstrations, use of projected slides, study of written procedures, and simulated inventory activities. Foremen were specially instructed in the processes of lot segregation, lot identification and random selection, with the help of statisticians.

The following is an outline of the steps followed in the actual taking of the physical inventory of 1956 which was done entirely on a sampling basis and was not supported by a complete physical count as was done previously. I am again indebted to Mr. Rudell and his article in which he so clearly set down the procedures which were followed.

All inventory lots estimated to be over $500 in value ("high-value") were segregated. This was done by the department supervisor and an accountant. The foremen had previously been furnished with a catalogue listing in numerical order all of the parts, assemblies, and products at various stages of completion. Opposite each identification number in the catalogue the quantity of that part or assembly which would place it in the "high-value" category is shown. With the catalogue as a guide, each foreman checked all skids, bins, and crates in his department. If, for example, the foreman found 10 crates of part number 12345, completed through operation 3, and estimated that there were approximately 80,000 pieces in the lot and his catalogue reference showed the item was a "high-value" item, he placed a large red card on the lot which identified it as a "high-value" lot. He also placed masking tape across the 10 crates. The lot thus identified as a "high-value" lot was excluded from the random sample. The foreman continued through his entire department in this manner. All lots estimated to be under the $500 value were ignored, as they would be included in the sampling procedure.

Having completed the segregation of "high-value" lots, the inventory crew began the counting phase. The actual physical count included all ordnance items, which had been separately identified, all of the "high-value" lots, and ten per cent of the lots in the "low-value" category.

The crews were furnished with brown-colored inventory cards, serially numbered, which were used for inventorying the "high-value" lots, and green-colored inventory cards for recording the "low-value" lots to be sampled. All "high-value" and ordnance lots were counted 100 per cent and recorded on the appropriate ticket. The tickets were priced and extended mechanically in the accounting department and the total value of the tickets represented the "high-value" and the ordnance segment of the inventory.

The inventory crews were also supplied with pads of identification tickets and several numbered and sealed envelopes. Each pad contained twenty identification slips numbered 1 through 20. One numbered slip was placed on each "low-value" lot as it was encountered. The entire inventory of "low-value" items was taken in lots of 20 and slips identified the lots included in the sample. Each sealed envelope contained two numbers each, ranging from 1 through 20. The two numbers identified which two lots in the group of twenty were to be sampled. The numbers in the envelopes were taken from tables of random digits selected by statisticians.

The counters placed the serial number of the first sealed envelope on each of the twenty identification slips, entered the extent of the first lot on the first identification slip and moved on to the second lot until twenty identification slips had been written out and placed on twenty lots.

At this point the first sealed envelope was opened and the two numbered slips removed and the two lots identified by the numbers on the slips counted. For example, if the numbers on the slips in the first envelope were 8 and 14, lots 8 and 14 were counted. The part name, part number, operation completed, and quantity were recorded on the green inventory ticket. These two sample lots, in effect, would determine the value of all twenty lots, by multiplying their value by 10. As a further refinement, to determine the statistical accuracy of the inventory, one of the two numbers in the envelope was designated as a Y sample and the other as the Z sample. The designation of Y and Z was done ahead of time. The sum total of all Y samples and the sum total of all Z samples, when multiplied by 20, each represented an estimate of the total inventory of "low-value" lots. The difference between these two estimates established the maximum error which could be expected to exist in the inventory value arrived at on the basis of both.

During the physical count of the samples the accountants checked to see that the established procedures were being followed, that the inventory-takers were counting the lots designed by the sealed envelopes, etc. After inventorying the sample lots and "high-value" lots, a crew of quality control personnel selected a random sample of 30 lots in each department. The lots were from amongst those written up by the regular inventory crews. These 30 lots were recounted and reidentified as a further check of the inventory operation. If discrepancies or differences were discovered in the count or identification, it was assumed that other errors existed in the inventory. If these discrepancies in a department exceeded a predescribed limit, that portion of the inventory was rejected and had to be recounted by the inventory-takers. The inventory was complete only when the quality control department certified to its accuracy.

It may be asked, "What was achieved or accomplished by this method which could not have been accomplished by or was an improvement over a complete physical inventory?" First, in many departments the inventory was completed in eight hours. The entire inventory was completed by the end of the 16-hour period. This compared with previous inventories which used to last five days.

Second, Mr. Rudell ascribes the following advantages to the statistical sampling method:

1. Greater accuracy.
2. Known limits of error.
3. The ability to take the inventory at any time of the year to coordinate with accounting books.
4. All vacation schedules can coincide with plant shut-down.
5. Lower total cost to take inventory.