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Statistical Procedures for Audit Sample Selection

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STATISTICAL PROCEDURES FOR AUDIT SAMPLE SELECTION

by

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This independent study report submitted by Robert G. Halcrow in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

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ABSTRACT

STATISTICAL PROCEDURES FOR AUDIT SAMPLE SELECTION

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The independent study report here abstracted was written under the direction of Lyle C. Steinmeier and approved by R. O. Koppenhaver and Ludwick Kulas as members of the examining committee, of which Mr. Steinmeier was Chairman.

The auditor has long been using the sampling device to draw conclusions as to the characteristics of a mass of data. This is a necessity because of the voluminous data that must be considered in the course of an audit. The application of statistical theory to sampling in auditing, however, is a relatively new development. Statistical sampling holds much promise for the auditor, not only in improving his sampling methods, but also by furnishing a better gauge of the reliability of inferences made from the data.

This paper is intended to give the reader a basic understanding of the applications and limitations of the various statistical techniques now in use, as well as those which are still in the experimental stages.

CHAPTER I

INTRODUCTION

The origin of the traditional testing and sampling methods employed by auditors appears to have paralleled the development of business organization from the small proprietor to the large corporation of today. With the increasing importance of the corporate form of organization after 1900, the emphasis in auditing gradually shifted from engagements thought to require 100% inspection, such as the determination of individual proprietory interests, bankruptcy proceedings and the administration of trust estates, to the examination of large enterprises for the purpose of expressing an opinion on financial statements. The vastness of the many enterprises today has made it possible for them to establish elaborate systems of internal control, so it is no longer always necessary to employ outside auditors to balance the books and check all the detailed postings as had formerly been the case. Also, emphasis on the detection of fraud, which as late as 1914 was considered the primary purpose of an audit, has gradually been modified so that the primary purpose of an independent auditor's examination is now viewed as the expression of an opinion as to the reliability of the financial statement.

References to test checks appear frequently in literature of the 1890's and early 1900's, but seldom is there any mention made to the extent of the test checks considered desirable or the method to be used in making a selection. An article published in 1905 ("Detail Checking" by W. Strachan, "The Incorporated Accountant's Journal," December 1905) mentions a preference for an extensive test of one month's transactions as opposed to a less thorough review of all transactions recorded during the period. Another writer (Richard A. Willy in "The Incorporated Accountant's Journal," December 1905) advocated the selection "in a hap--hazard manner" of items to be subjected to a thorough check.

Little progress was made in the definition of testing and sampling until the emergence of statistical or probability testing. Perhaps the first article advocating the application of statistical sampling techniques to test checking by auditors was "The Efficacy of Tests" by Lewis A. Carman, which was published in "The American Accountant" in December 1933. In recent years many such articles have appeared with increased frequency.[1]

Due to the increasing interest in the subject, in 1955 the New York Society of Certified Public Accountants formed an Advisory Committee on Application of Statistical Sampling to Accounting and Auditing. In the same year, the Committee on Auditing Procedure of the American Institute of Accountants (predecessor of the AICPA) undertook and published a study of current sampling practices, "A Case Study on the Extent of Audit Samples." The Committee concluded:

> Although there was some degree of similarity among the views expressed as to the extent of sampling necessary with respect to most items on the financial statements, no clear cut pattern resulted.[2]

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[1]James T. Johnson and S. Herman Brasseau, Readings in Auditing (Cincinnati: Southwestern Publishing Co., 1960), p. 477.

[2]American Institute of Accountants, A Case Study on the Extent of Audit Samples (New York: American Institute of Accountants, 1955), pp. 7-8.

The AICPA has since 1955 issued other reports dealing specifically with statistical sampling. In 1962 a report was issued dealing with the applicability of statistics to auditing. The following was the concluding paragraph of this report:

> A broader education in and knowledge of statistical sampling and further research as to its applicability on the part of the profession is desirable.[1]

In December 1963 the Committee on auditing procedure issued "Auditing Standards and Procedures (Statement on Auditing Procedure No. 33), which included the following comments concerning statistical sampling:

> In determining the extent of a particular audit test and the method of selecting items to be examined, the auditor might consider using statistical sampling techniques which have been found to be advantageous in certain instances. The use of statistical sampling does not reduce the use of judgment by the auditor, but provides statistical measurements as to the results of audit tests, which measurements may not otherwise be available.[2]

The subject of statistical sampling is also receiving attention in other countries as is evidenced by the fact that the Swedish Foundation for accounting and auditing research work has granted funds for a scientific investigation of the use of statistical methods for selection of tests in connection with auditing.

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[1]American Institute of Certified Public Accountants, "Statistic Sampling and the Independent Auditor," <u>The Journal of Accountancy</u>, CXIII (February, 1962), p. 66.

[2]American Institute of Certified Public Accountants, <u>Auditing Standards and Procedures - Bulletin No. 33</u>, (New York: American Institute of Certified Public Accountants, 1963), p. 37

CHAPTER II

STATISTICAL APPROACH TO TESTING

Definition of Statistical Testing - Due to the large volume of data accumulated and processed by most enterprises, it is usually impossible or inefficient in terms of cost-value relationships to accomplish testing any large per cent of the material. Therefore, we are required to sample test a smaller percentage. The sample may be derived by either of two methods: subjective reasoning, or objective statistics.

In the former method, the auditor would rely on his experience, judgment and intuition. The statistical approach allows him to rely on mathematical probability.

To sample is to select something from a mass which is less than the whole from which it was taken. The objective of the sample is to obtain information about the mass without examining it in its entirety. Statistical sampling is based on the mathematical theory of probabilities, which indicates that a number of items taken from the large mass, if chosen at random, will with a high degree of certainty, contain the characteristics of the whole. The sample must be chosen at random, since randomness relates to the characteristics common to each unit in the mass as having a preassigned and known probability of being selected from the sample. Statistical sampling aids the auditor in determining the size of the sample, how to select the individual sample items, and how to evaluate the results of the sampling process.

Statistical sampling has certain advantages. They are:

1. An efficient and economical sample size may be readily determined. The auditor does not have the problem of facing unarmed the dilemma

of doing too much inefficient audit work or so little that he is out-of-line with professional standards.

2. Audit time may be accurately timed and budgeted since the sample size is often determined before entering the field.
3. Percentages can be used to specify the desired accuracy.
4. The auditor can demonstrate his position easily. He has positive evidence of how much work he did and the level of confidence he has in the conclusions. In other words, the auditor can prove that he acted in accordance with generally accepted professional standards.
5. The audit working papers for an upcoming audit can be prepared well in advance, since the auditor often knows the total number of documents (and document numbers) to be examined in a given area.
6. Usually the amount of detailed work may be lessened through the use of a statistical sample. This is not to say, however, that the quality of the information will in any way be affected.
7. Statistical sampling does away with much of the vagueness and generality usually connected with testing. As a result, if generally adopted, we may see a new more definite set of auditing standards established.
8. Often unintentional bias enters the testing process due to subjective reasoning employed by the auditor. Statistical sampling curtails the availability of this since it is based on objective reasoning.

Statistical sampling requires more care and rigorous application than do other methods of sampling. The auditor must be acquainted with and apply a series of steps in order to achieve his objective. The general nature of these required steps are outlined as follows:

1. A statement of the objective of the test.

   As we will see later, each type of test accomplishes a certain and different objective.

2. Definition and delineation of the mass or universe from which the sample is to be extracted
3. Definition of the sample unit
4. Determination of the required sample size
5. Actual selection of the sample
6. Interpretation of the sample results[1]

Before relating these steps or problems to statistical sampling, it is appropriate that we have an understanding of certain terms to be used in and throughout the remainder of this paper.

The universe (often called population or lot) is the mass from which the sample is to be selected. For example, assume that the auditor is faced with the problem of confirming 125,000 open accounts with an aggregate dollar value of $2,500,000. The total number of this account would be called the universe.

Using the case above, the auditor will select a sample from the 125,000 accounts. Upon testing he will desire the sample to afford him information concerning the probable error present in the universe. We call this degree of adherence precision. Assume the sample estimate disclosed a probable error present, since the total was not reviewed.

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[1]Joseph H. Silvoso and Royal D. M. Brauer, Auditing, (2nd Ed; Cincinnati: Southwestern Publishing Co., 1965), pp. 137-138.

Precision is a statistical means of measuring the maximum probable difference between the sample estimate of the error and the true, but unknown, amount of errors. Precision is usually stated in terms of a plus or minus range around the sample estimate. The precision limits are set prior to the testing on the basis of auditor judgment, and are incorporated in the formula for determining the sample size. For example, if the auditor set precision limits of plus or minus $3,000, he would be able to say that the actual error would fall somewhere between $17,000 to $23,000. From this he would be able to judge the materiality involved with some degree of confidence.[1]

Confidence or confidence level is a statement of the probability that the true error value of the universe will be contained within the sample precision limits. In most cases the auditor is satisfied to be 95% confident and thus incorporates this degree into his formulae. In the statement above the probable error was found to be $20,000 plus or minus $3,000. Assuming this, then the auditor would be able to say that although he is not absolutely certain, the error is within $17,000 to $23,000, he is 95% certain that it is. Stated another way, the auditor could say that there is a 5% chance that the error is out of the range.[2]

The precision limits and confidence levels are set loosely or tightly in accordance with the auditor's judgment of materiality,

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[1] Ibid.

[2] T. J. Cogan, "Considerations Relating the Applicability of Statistical Sampling to Auditing," The New York Certified Public Accountant, XXXIII (November, 1963), p. 769.

internal control, and on past experience. It is appropriate to further stress here, that audit judgment must be expressed in two important ways: first, in the design and preparation of the sampling plan; and second, in the evaluation of the final results. The auditor usually has more of a problem in designing the sample test than he has in measuring results.

The auditor often finds himself puzzled by the fact that precision and risks may be correlated and measured in percentages. However, upon studying the problem a little, we find that it is not new to make judgments concerning these elements. Auditors have been making these judgments for years. In the past these judgments were always made subjectively without much thought given to quantification.

Applicability of Audit Standards - Upon embarking on a study of statistical sampling methods, one must bear in mind the generally accepted auditing standards as they apply to statistical sampling. The standards most directly related are the three standards of field work:

1. The work is to be adequately planned and assistants, if any, are to be properly supervised.
2. There is to be a proper study and evaluation of the existing internal control as a basis for reliance thereon, and for the determination of the resultant extent of the tests to which audit procedures are to be restricted.
3. Sufficient competent evidential matter is to be obtained through inspection, observation, inquiries and confirmations to afford a reasonable basis for an opinion

regarding the financial statements under examination.[1]

Due to the fact that each of these standards has as its objective the establishment of a "reasonable basis for an opinion", I will discuss each in reverse order.

Third Standard-Evidential Matter - As we all know, the auditor in performing an examination has as his goal the ability to state that the financial statements present fairly the financial position and results of operations in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceeding year. Implied in this concept is a certain degree of uncertainty combined with a necessarily quite positive attitude concerning the materiality of the items involved.

Precision when stated in monetary terms should be related to the auditors concept of materiality. For example, if the precision limits are established to be $20,000 plus or minus $3,000 the auditor will be very interested in the higher $23,000 limit to determine just how material a possible maximum overstatement may be.

Often times precision will be stated in number of deviations, rather than in monetary terms. When such is the case the auditor can make positive evaluation in terms of the reliability of the records being accurate enough to disallow material effects.

Judgments concerning reliability and materiality are made in the light of determination of a reasonable basis for acquiring an opinion, and are direct results of the auditors statistical sampling applications.

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[1]AICPA (Bulletin No. 33), p. 16

Competence, however, is not so directly obtained, for competence of the evidential matter is solely a matter of auditing judgment, and is not comprehended in the statistical design and evaluation of the audit sample. In a strict sense, the statistical evaluation relates only to the probability that items having certain characteristics in terms of monetary amounts, quantities, errors or other features of interest will be included in the sample-not to the auditors treatment of such items. Consequently, use of statistical sampling does not directly affect the auditors decisions as to the auditing procedures to be performed, the acceptability of the evidential matter obtained with respect to individual items in the sample, or the action which might be taken in the light of the nature and cause of particular errors.

Second Standard-Internal Control - The extent of tests necessary will vary inversely with the auditors reliance on internal control. As the following exerpt from "Auditing Standards and Procedures" (Statement on Auditing Procedure No. 33) indicates, the evaluation of internal control involves two phases: (1) evaluating the internal control, and (2) relating the extent of tests to his evaluation.

> Adequate evaluation of a system of internal control requires knowledge and understanding of the procedures and methods prescribed and a reasonable degree of assurance that they are in use and are operating as planned.[1]

Statistical sampling is not applicable to the first phase. The auditor must use inquiry or written instructions to gain knowledge concerning the procedures prescribed by the client. His understanding of

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[1]Ibid., p. 32.

their function and limitations is based on his training, experience, and judgment.

The second phase is usually adaptable to statistical sampling. If an audit trail is left by documentary evidence the adherence to internal control procedures may very well be statistically tested.

Sometimes no audit trail is left as in cases where internal control procedures depend primarily on appropriate segregation of duties. When such is the case, the auditor necessarily depends on inquiries and observation of office personnel and routines.

<u>First Standard-Audit Planning and Supervision</u> - The foregoing discussion of matters to be considered in applying statistical sampling and correlating it with other aspects of auditing indicates that much audit planning and supervision is required.

<u>Identifying Sample Objectives</u> - Prior to undertaking any application of sampling, the specific objectives desired to be accomplished by the test must be clearly defined. Once the objectives are defined and understood, the sampling method most useful will usually be easily chosen. The reason for requiring a positive definition of objectives is not only to aid the auditor in selecting a sampling method, but also to provide him with an overview of the work he is to perform. For example, if the test is to confirm accounts receivable, the auditor must determine if the objective of the test is to determine what type of errors exist, or to make some quantative estimate of the total value of the errors. If the test is to accomplish a quantitive analysis of the value of errors present, the auditor must then define materiality in terms of what he

will accept or reject as the case may be. Once definitions are made, less experienced personnel may accomplish the actual examination using the guides (definitions) provided them.

The specific approaches to statistical sampling and the general areas of application may be summarized as follows:

Method	When Used
Acceptance Sampling	1. To evaluate internal accounting controls.
	2. To test clerical accuracy.
Estimation Sampling	1. To estimate proportion of error which exists.
	2. To estimate average or aggregate values.
Discovery Sampling	1. To test internal accounting effectiveness.
	2. To test for clerical errors.
	3. To test for defalcations.[1]

<u>Defining the Universe</u> - As was indicated earlier, the universe is the mass from which a sample will be chosen. Upon determining the universe, it is necessary to define its homogeneity and size.

The universe should be reasonably uniform throughout, both as to the content as well as its method of processing. Auditors usually partially eliminate this problem of uniformity by excluding for examination items which differ materially from the other members of the universe.

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[1]Silvoso, p. 140

Determining the size of the universe presents no problem. In the case of numbered documents, it is simply the difference between the first and last numbers, plus one. If the documents are not pre-numbered, the auditor can determine the size of the universe by studying internal information usually made available by the bookkeeping department. There are occasional cases, however, where no such information is available. In cases like this the auditor would have to assume the universe to be of infinite size and choose a rather liberal sample size.

Often times as the auditor is planning his selection of a sample, he will determine that the universe has certain heterogeneous characteristics which can be broken down into homogeneous groups. For example, it may be desirable to divide inventory into classes or groups by dollar value and sample each group separately. This process of universe division is known as stratification.[1]

Random Selection of the Sample Unit - A sample unit, is the individual items which in aggregate comprise the universe. Once the universe is defined, it is simple to determine a sample unit, for it is any item in this universe. For example, if the problem is confirming accounts receivable, each account would be a sample unit.

As mentioned earlier, the auditor must necessarily choose the sample units on a random basis when applying statistical procedures. The primary requirement of a probability sample, if it is to be statistically valid, is that each item - invoice, freight billing, voucher, salescheck, etc. --in the universe has a known and constant mathematical

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[1]Silvoso, p. 141

probability of being drawn into the sample. Thus, for example, in using an unrestricted random sample (with replacement), the probability of selection would be exactly equal and independent for every item in the universe.

In nonprobability or nonscientific sample selection methods, the auditor has available to him, the possibility of allowing personal bias, intuition or prior knowledge to enter his selection. The auditor usually considers a selection made in this manner to be satisfactory, and often times it is. However, the fact remains that unless some random method of choosing is used the sample cannot be considered to yield mathematically valid results.

When a representative sample of a universe is to be drawn, it is appropriate to use an unrestricted random selection procedure. In such a case, each item, person or document should have the same chance of being drawn into the sample as any other item, person or document. This means location in a file drawer will have no bearing upon the probability of selection providing an objective and impersonal device, which cannot be mistreated, is used.[1]

Of the available mechanical devices the random numbers table is the easiest to use. This table consists of a series of numbers usually arranged, for convenience, in columns of two.

In using the table, the first number may be determined at any point. The user will then proceed by following a pre-established pattern, which may be to select items by moving up, down, sideways,

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[1]Robert W. Johnson, "The Use and Significance of Random Samples in Audit Tests," The Journal of Accountancy, CIV (December, 1957), p. 44.

or diagonally. So long as he follows the pattern, the auditor will necessarily choose a random sample.

To insure that nothing short of pure chance is operating, the tables are put to rigorous statistical tests for randomness before issuance for general use.

The number of items contained in the universe being studied has no bearing on whether or not a table may be used. It can be used to determine a sample from any size universe. Just as size is no limitation, neither is manner of use. A table of random numbers can be used in whatever manner is simplest and most flexible in the situation.

To illustrate the use of a table of random numbers (see table 5 appendix) assume a file drawer contains 3,000 paid vouchers, which are filed in numerical order. Assume further that the auditor has decided to examine a sample of 300 items for evaluation of the internal control system.

The sample of 300 items may be selected in the following manner: Enter the table in the upper left hand column and read down the numbers. The objective is to find 300 items whose numbers range from 0001 to 3000. We must use the first two columns in order to have the necessary four digits available at all times. The first number we see is 1562; this is acceptable since it is between 1 and 3,000. However, the second number 7781 is out of the range or more than 3000, so it is rejected. This in no way affects the randomness of the subsequently selected numbers. This accepting and rejecting is continued to the bottom of the page. Since the column is exhausted, we move to the top of the page and simply apply the rule of transfer, which is to move one column (two digits) to the right, and again read down the page. The first 4 numbers 6238, 8115, 8705, and 5853 are rejected for extending beyond the range. The succeeding acceptable numbers are 0779, 1305, 2723, 0993, and so forth.

When 300 unduplicated numbers between 0001 and 3000 are selected, they are listed in ascending order. Then by simply going through the drawer and extracting the number on the voucher which corresponds to the list a random sample is chosen.

Often times the documents to be selected are not pre-numbered and filed numerically. In this case the auditor may count through the drawer and implicitly number each item from 1 to 3000. Sometimes groups of documents are filed in folders within a drawer, in which case the auditor may define his sample unit in terms of these folders and extract folders rather than individual items. The simplest most efficient method should usually be employed so long as it is congruent with the requirements of randomness.

The second basic form of random sample selection is systematic selection. This method is usually simpler to use than the preceeding form, however special care must be taken to assure that statistically valid results will be obtained. A systematic sample is one in which there is a constant interval between individual items selected. This means that, for example, the auditor will extract every tenth item for examination. Of course, to select every tenth item is not in itself random, however when combined with the so called "random start" it fulfills the requirements.

The term "random start" means just as it implies; the first item selected is a random number within the range of the interval. For example, assume the interval to be 10. To determine the item from which to apply the interval one simply refers to the table and selects the first number, in a predetermined column, which is between 1 and 10.

Systematic sample selection is not confined to numerical intervals. In cases where there are a large number of items of uniform thickness; e.g., IBM cards, the selection may be made by extracting one item every inch or fraction of an inch, depending on the size of the sample desired. Again, the card to be selected first would be selected from a table of random numbers; succeeding cards would then be selected by measuring off the inches from the first selected card.

As is apparent, systematic selection is very efficient in cases where the total number of items in the universe is unknown. The auditor need only know the approximate size of the universe and the approximate proportion of which he desires to examine. Probably not so apparent is the necessity for essentially random displacement of items throughout the universe with no reference given to order other than that of randomness. In cases where classes or types of items are concentrated in one or a few areas, the use of a systematic process may be prohibited or at best restricted to selection from stratified homogenious groups.

The particular method of sample selection for any given case will depend upon the relative administrative simplicity of drawing a sample, the relative statistical efficiency of the various methods, and in most cases upon the judgment of the person drawing the sample with respect to certain dangers which may exist.[1]

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[1]*Ibid*, p. 48

Acceptance Sampling - The acceptance sampling approach was borrowed from industrial quality control inspection of incoming lots of materials. The essence of this approach is the decision-making device which allows the auditor to accept or reject a universe on the basis of the number of disparities contained within the sample.[1]

In order to make use of this method of sampling the auditor must determine or establish the maximum acceptable level of frequency of error. There is no clear-cut method of doing this, it is largely a matter of judgment. Materiality is probably the most important single aspect to be afforded consideration.

To simplify the explanation of this sampling method, consider the use of this approach in investigating the number of departures from the internal control system requirements. For instance, let it be assumed that it is desired that the auditor assure himself that a universe of 2000 vouchers were handled in a manner consistent with the internal control requirements. By referring to Table 4 in the appendix, we see that a sample of 150 items must be chosen at random and examined. Assume the auditor will be satisfied and accept the universe if it contains no more than 4% errors. The table shows us that the maximum number of errors permissible is 11 and that anything over this will require rejection of the universe. The decision to reject will either require the auditor to make a 100% inspection, or instruct the client to rework the universe, in which case the sampling procedure would be initiated again.

In cases where the inherent quality of the work is neither notably good nor bad, either double or multiple acceptance sampling plans can be

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[1]Johnson, p. 490

used. The double plan can be illustrated as follows:

	Sample Size	Cumulative Sample Size	Acceptance Number	Reject Number
First Sample	100	100	7	14
Second Sample	200	300	13	14

The auditor first selects a sample of 100 items and examines them. If the number of errors is 7 or less the universe may be accepted at this point, or if 13 or more rejected at this point. Usually however, the number of errors will be between 7 and 14, in which case the second sample of 200 will be drawn making the sample cumulative total 300. The auditor now has done sufficient testing to form a conclusion. He will accept the universe if less than 14 errors are found and reject it if more than 13 are found.[1]

Multiple sampling works exactly the same way as double sampling except more steps are provided for the auditor to make a decision in the former.

Acceptance sampling has certain advantages:

1. Less experienced persons may be utilized in performing the actual tests, since the judgment of the senior, in the form of accept or reject levels, will oversee the work.
2. Acceptance sampling requires a clear statement of acceptable error.
3. Sample sizes are relatively small compared to other forms of sampling.
4. Extreme accuracy or inaccuracy will be apparent to the auditor and thus early termination of testing, not otherwise possible, may be affected.

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[1]Silvoso, p. 142

Acceptance sampling has two basic disadvantages:

1. Often the auditor does not know what is an acceptable error rate prior to testing. Acceptance sampling gives the auditor an aggregate percentage of errors, but does not give the composition or types of errors present.

2. It is restricted to use in those areas where error rate determination is the objective of the sampling process. Acceptance sampling is not readily adaptable to dealing with absolute dollar amounts.[1]

Acceptance sampling has not received much favor in the past, however due to its applicability to procedural testing we may find it gaining favor as business develops in adoption of electronic data processing equipment.

<u>Discovery Sampling</u> - Any auditing examination has as its object the development of a reasonable basis for an opinion regarding the financial statements. To develop this reasonable basis the auditor must make a thorough review of the internal control. His conclusion on the internal control will provide a basis for the extent of testing necessary, as well as the method of test best fitted to the situation.

Evidence of numerous clerical errors, inadherence to the internal control system, or defalcations will render a necessity to either invoke further examination and/or offer a negative opinion.

The Codification of Statements on Auditing Procedure states, "The ordinary examination incident to the issuance of an opinion regarding financial statements is not designed and cannot be relied upon to

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[1]*Ibid.*, p. 143-144.

disclose defalcations and other similar irregularities."[1] Most auditors however, are much concerned with defalcations, since they feel the possibility always exists that the financial statements may be extremely misleading should fraud be present. In addition to the area of general fraud detection, the auditor may be primarily employed to detect fraud as in the case of a special examination. In this instance, he will desire to use every possible means of examination available to him.

Discovery auditing is primarily associated with the detection of three types of disparities: (1) violations of the internal control system; (2) inadvertant clerical errors; (3) evidence of fraud or manipulation.[2]

Usually the auditors objective in performing tests is to determine the frequency, dollar value, and types of errors which exist. In which case he would apply acceptance or estimation sampling techniques. However, many auditors have as additional objectives, the desire to turn up at least one example error. His interest is channeled along these paths because he has decided in advance that upon discovery other procedures would be initiated to determine the materiality of the errors.

When using a statistical or probability sample, it is possible to calculate the probability that at least one example of a given event will occur in a sample drawn from a field provided the field contains

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[1]American Institute of Certified Public Accountants, Codification of Statements on Auditing Procedure (New York: American Institute of Certified Public Accountants, 1951), p. 12.

[2]Johnson, 1965, p. 485

the event and it occurs with a given frequency in that field. Of course, no method short of 100% examination will turn up a "needle in a haystack." The concern of the auditor is directed to the events which happen more often than this. The systematic fairly frequent violation is the type of most consequence.[1]

Tables are available which give these probabilities for statistical samples. Table one in the appendix was selected to be used in explaining the use of this method of sampling.

To illustrate one application of discovery sampling, assume the following: 10,000 transactions are to be tested on a sampling basis to determine if any of the transactions (prior to approval of cash disbursements for expenses) were processed through the system without adhering to the system requirements.

The auditor will approach this problem with the reasonable assurance of discovering an example if several (in this case say 10) such situations exist. Before referring to the table, some quantitive analysis must be made concerning the concept of reasonable assurance. Reasonable assurance can be made as high or as low as desired, however, the higher the assurance, the larger the sample and the higher the cost.

For instance, if he decides that he desires a 90% probability of finding an example, and in this field of 10,000 it occurs as often as 10 times, the table indicates that a sample of about 2,000 is necessary for the test (89.3% of probability). If on the other hand, an 80% probability is deemed sufficient, a sample size of about 1,500 would be used.

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[1] Ibid., P. 488

Of course, if the number of actual errors in the field is more than 10 the probability of selecting one for the sample is actually higher.

The table indicates that it is nearly useless to use small samples from large fields. For example, if the field contained 100,000 and we chose a sample of 500, we would attain a 22.2% probability of locating one error even if the field contained 50 such errors.

While the auditor will have to judge for himself the usefulness of a probability percentage such as 22.2% above, it is my opinion that to choose such a sample would be a complete waste of time.

Another interpretation of a random sample drawn in accordance with sample sizes dictated by this table is that if the sample does not turn up an example, it is probable that less than the number specified actually exists in the field.

For example, using the illustration above, if a sample of 2,000 with a probability rating of 89.3% assuming 10 errors do exist, does not yield one example, the number of errors actually existing has an 89.3% probability of being less than 10.

It is interesting to note that as in acceptance sampling and unlike estimation sampling, it is the absolute sample sizes in discovery sampling that counts with little relation to the field size except when the sample size is relatively large and the field size is quite small.

As is true of other forms of statistical sampling, discovery has certain advantages and disadvantages. Some advantages are:

1. The sample size required is usually relatively small.

2. The sampling may be stopped immediately upon disclosing one or more

errors and have stated confidence that the error rate is in excess of the permissible maximum.

3. A clear definition of material error is required prior to sampling.

Two disadvantages are:

1. The discovery method deals exclusively with error rate and is not easily adaptable to dollar values.

2. One cannot estimate error rates; discovery sampling merely determines whether or not the error rate actually existing exceeds the predetermined acceptable rate.[1]

Estimation Sampling - The objective of estimation sampling is to make some quantitive estimate of the specific characteristics of a universe. It is possible to estimate the average dollar value of the universe, and the proportion or rate of errors which exists.

In estimating the relative frequency of error the auditor must determine:

1. the size of the universe
2. the confidence desired
3. the precision required
4. the maximum error rate which exists.

The size of the universe is determined as in acceptance sampling.

The determination of confidence levels and precision limits must be made by the auditor relying upon his judgment. The precision specified is the maximum variance allowed between the actual error and the sample error. The confidence level is the assurance that the auditor has in the actual error being somewhere within the precision limits set. For example, assume the auditor sets 3% precision limits and assumes a

[1]Silvoso, p. 150

confidence level of 90%. If the sample error is found to be 2%, the auditor may conclude that he is 90% confident that the actual error will be not less than 1% nor more than 5% of the total universe.[1] In actuality, due to the fact that error rates disclosed by a series of samples from one universe will tend to be distributed normally around the actual unknown error rate, the samples drawn under a plus or minus 3% specification will come much closer to the true error than 3%.

The auditor must also make some estimation of the probable maximum error actually existing in the universe. He may use one or two methods to determine this; past experience, or by running trial samples. In running a trial sample, the auditor will chose at random some small number of items (usually about 50 or more depending on the size of the universe) and determine the error rate occuring in the trial. He will then use this as a basis for estimating the maximum error rate.

At first the use of a trial sample seems like extra work, but if this sample is chosen at random it may be used as the first group of items of the total sample to be drawn. In effect, the auditor will simply start testing before he knows how many items he will examine.

If there is any reason to suspect a higher error rate than usual, the auditor should increase his estimate of the maximum error rate in order to provide a tighter sampling plan.

With reference to Table 2 in the appendix, the following example will be used to illustrate the workings of the basic form of estimation sampling whose objective is the determination of the frequency of errors.

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[1] Ibid., P. 145

Suppose, for instance, that the auditor wished to determine the relative frequency of occurrence of departures from some aspect of the internal control system and that he decides that he will be satisfied if he can estimate with 95% confidence, this occurrence to within 2% (precision) of the true but unknown occurrence of error in the 4,000 documents to be tested. Assume further, that the auditor expects the maximum probable error will not exceed 10%. From the table we find that 711 items will be selected and upon examination will either confirm or oppose the auditors assumption that the universe does not contain more than 10% errors. It will further afford him information concerning the probable true error rate, in this case within a plus or minus 2%.

A problem may arise if the sample estimate of error is larger than the maximum error rate set. If such a situation develops, the auditor may consider it prima facie evidence that the sample size was too small, in which case he will adjust the maximum error rate upward to allow for a larger sample to be examined. This situation may usually be averted by establishing a liberal expected maximum error rate.

The second basic objective is determining the average of aggregate dollar value of a universe. To do this, the auditor must determine:

1. the size of the universe
2. the confidence desired
3. the precision required for the estimate
4. the approximate measure of variability of the values of the sample units within the universe. (Statisticians refer to this variability as standard deviation).

The size of the universe and the confidence levels are determined in the same way as they were for estimation of error rates. Precision is similarly determined, except it may be stated in absolute values rather than in percentages.

Determining the degree of variability is a somewhat different concept than has been used before in this paper. Variability simply means the differences in dollar amounts of the items contained within a universe.[1]

Once this information is determined, the auditor may simply refer to tables to make determinations concerning sample sizes. An example of one such table may be seen in the appendix as Table 3.

To illustrate the ideology behind this method of sampling assume the auditor determines the universe to be 10,000. After making his judgments concerning precision, confidence, and variability, he determines from a table that the sample size necessary to be 1,000 items. Upon examining the items he finds their average dollar value to be $50. This value would then be converted to the value of the universe by virtue of a ratio calculation. In this case the value of the universe would be $50,000 ($50 X 1,000 items). The auditor would then compare this to the dollar value of the universe as represented by management in the accounting records.

Estimation sampling, because of its quantitative characteristics, has received more attention from auditors than the other two forms of statistical sampling, It is felt that this method of sampling has five basic advantages.

1. The specific estimate of an error rate is provided. It is not stated, as in other methods, in terms of "more-than" or "less-than" some predetermined acceptable rate.

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[1] *Ibid.*, p. 146

2. The auditor can sample first, estimate the error rate, and then decide a course of action.
3. Dollar values as well as error rate estimates may be made.
4. Results of the sampling process tie in more directly with the audit objectives.
5. The precision desired may be stated in either absolute or relative terms.

The advantages of estimation sampling much outweigh the disadvantages, which are:

1. The test must be completed prior to making any measurable estimates.
2. Sample sizes are usually relatively larger than those of other methods.

CHAPTER III

CONCLUSION

In the past thirty years the subject of statistical sampling has been given much thought. Auditors have experimented with and used this method of reasoning quite extensively in the very recent years. Many problems do not lend themselves to application of scientific methods. However, when there are large numbers of transactions with some common attribute subject to testing, statistical sampling may be efficiently used.

As we all know, the auditor has always been plagued with the problem of selecting a proper sample for thorough examination. Statistical sampling in many cases may be considered a partial panacea in that it provides the auditor with a means for determining an efficient unbiased sample. In this way, confidence is gained in the audit work performed.

The auditor in attempting to use statistical sampling would be wise to assume the same position in learning the theory as he does in learning the law. Just as he is not interested in becoming an attorney, he should not be overly concerned with, and become involved in, the sophisticated statistical theory. All he need understand is the general implications of sampling theory and the methodology of application.

I believe the following quotation by Alden C. Smith is very apropos in concluding this paper:

One of the misunderstandings which many auditors have with respect to statistical sampling is that it comtemplates supplanting the judgment factor in an auditor's work by statistics. Even a cursory study of this subject would tend to dissipate this viewpoint. While statistical sampling does, in certain areas, take the place of what the auditor has commonly referred to as the exercise of judgment, it may place a greater premium on this factor than is presently being exercised. While the need to determine a proper field may arise from the theory of statistical sampling, the determination of the field is a matter of judgment. The choice of the samples to be tested may be determined by statistical methods, but the number is a matter of judgment. Even the most ardent advocate of statistical methods has to use judgment to define the risk he is willing to accept. The analysis of the result of the test place a great responsibility on the judgment of the auditor in that he must determine whether it satisfies the purpose of the audit step or whether supplemental procedures are required. Statistical sampling, in eliminating biased or haphazard selection serves as a tool of judgment and not as a replacement therof.[1]

Alden C. Smith, "The Accounting Profession's Growing Interest in Statistical Sampling," The New York Certified Public Accountant, XXVII (July, 1957), pp. 454-469.

APPENDIX

Table 1

Probability in Percent of Finding at Least One Example of an Event, if the Total Number of Events in the Field Is as Indicated

Sample size	Number of Errors in Field: 1	2	3	10	50	100
			When Field Size is 200			
10	5.0	9.8	14.3	40.9	94.8	99.9
20	10.0	19.0	27.2	66.0	99.8	100.0
50	25.0	43.8	58.0	94.8	100.0	100.0
100	50.0	75.1	87.7	99.9	100.0	100.0
200	100.0	100.0	100.0	100.0	100.0	100.0
			When Field Size is 2,000			
50	2.5	4.9	7.3	22.4	72.2	92.6
300	15.0	27.8	38.6	80.4	100.0	100.0
400	20.0	36.0	48.8	89.3	100.0	100.0
600	30.0	51.0	65.7	97.2	100.0	100.0
2000	100.0	100.0	100.0	100.0	100.0	100.0
			When Field Size is 5,000			
50	1.0	2.0	3.0	9.6	39.6	63.8
200	4.0	7.8	11.5	33.5	87.1	98.4
500	10.0	19.0	27.1	65.2	99.5	100.0
1000	20.0	36.0	48.8	89.3	100.0	100.0
2000	40.0	64.0	78.4	99.4	100.0	100.0
			When Field Size is 10,000			
50	0.5	1.0	1.5	4.9	22.2	39.6
300	3.0	5.9	8.7	26.3	78.3	95.3
500	5.0	9.8	14.3	40.1	92.4	99.4
1500	15.0	27.8	38.6	80.3	100.0	100.0
2000	20.0	36.0	48.8	89.3	100.0	100.0
			When Field Size is 100,000			
50	0.1	0.1	0.1	0.5	2.5	4.9
300	0.3	0.6	0.9	3.0	14.0	26.0
500	0.5	1.0	1.5	4.9	22.2	39.4
1500	1.5	3.0	4.4	14.0	53.0	78.0
2000	2.0	4.0	5.9	18.3	63.6	86.8

Table II

TABLE OF SAMPLE SIZES REQUIRED FOR SPECIFIED CONFIDENCE LEVELS AND RELIABILITY LIMITS FOR SAMPLING ATTRIBUTES IN FINITE POPULATIONS

FOR RANDOM SAMPLES ONLY

95% Confidence Level

Number of Items in Field	1%	2%	3%	4%	5%	10%
	Sample Size for Reliability of:					
500			217	151	108	32
1,000		464	277	178	121	33
1,500		548	306	189	127	34
2,000		603	322	195	129	34
2,500		642	333	199	131	34
3,000		671	340	201	132	34
3,500	1739	693	346	203	133	34
4,000	1854	711	350	205	134	34
4,500	1955	725	354	206	134	34
5,000	2044	737	357	207	135	34
6,000	2193	755	361	208	135	34
7,000	2314	769	364	210	136	34
8,000	2413	780	366	210	136	34
9,000	2497	788	368	211	136	34
10,000	2568	795	370	211	136	34
15,000	2809	817	374	213	137	34
20,000	2947	828	377	214	137	35
25,000	3036	835	378	214	137	35
50,000	3233	849	381	215	138	35
100,000	3341	857	383	216	138	35

To be used only where expected error does not exceed 10%.

TABLE 3

RANDOM SAMPLE SIZES NECESSARY TO ESTIMATE

MEAN AND AGGREGATE VALUES

Confidence Level 90%

Coefficient of Variation .50

Size of Universe	Precision Required							
	1/2%	1%	2%	3%	4%	5%	10%	25%
50	50	50	49	47	45	43	29	9
100	100	99	95	89	81	74	41	10
200	199	195	179	158	136	115	51	11
300	297	288	255	215	176	143	56	11
400	395	378	324	262	206	162	58	11
500	491	466	386	301	230	176	60	11
600	587	552	443	334	249	187	61	11
700	683	635	496	363	264	196	62	11
800	778	716	544	388	277	203	63	11
900	872	795	588	410	288	209	63	11
1,000	965	872	629	430	298	213	64	11
1,100	1,058	947	667	447	306	218	64	11
1,200	1,150	1,020	702	463	313	221	65	11
1,300	1,241	1,091	735	477	320	224	65	11
1,400	1,332	1,160	766	490	325	227	65	11
1,500	1,422	1,228	795	501	330	230	65	11
2,000	1,863	1,544	917	547	349	239	66	11
2,500	2,289	1,826	1,009	578	362	245	66	11
3,000	2,701	2,079	1,082	601	371	249	67	11
4,000	3,485	2,514	1,189	633	383	254	67	11
5,000	4,221	2,875	1,264	654	390	257	67	11
10,000	7,302	4,035	1,447	700	406	264	68	11
15,000	9,650	4,662	1,520	716	412	266	68	11
20,000	11,500	5,055	1,560	725	414	267	68	11
25,000	12,994	5,324	1,584	730	416	268	68	11
50,000	17,556	5,958	1,636	741	420	270	68	11
100,000	21,295	6,336	1,663	746	421	270	68	11
1,000,000	26,343	6,719	1,689	751	423	271	68	11

TABLE 4

SAMPLE SIZE CODE LETTERS*

Lot Size	Inspection Levels		
	I	II	III
2 to 8.	A	A	C
9 to 15	A	B	D
16 to 25.	B	C	E
26 to 40.	B	D	F
41 to 65.	C	E	G
66 to 110	D	F	H
111 to 180.	E	G	I
181 to 300.	F	H	J
301 to 500.	G	I	K
501 to 800.	H	J	L
801 to 1,300.	I	K	L
1,301 to 3,200.	J	L	M
3,201 to 8,000.	L	M	N
8,001 to 22,000	M	N	O
22,001 to 110,000	N	O	P
110,001 to 550,000.	O	P	Q
550,001 and over.	P	Q	Q

*Sample size code letters given in body of table are applicable when the indicated inspection levels are to be used. Inspection level II is for normal sampling: inspection levels I and III are for reduced and tightened levels, respectively.

TABLE 4 (continued)

MASTER TABLE FOR NORMAL AND TIGHTENED INSPECTION
(SINGLE SAMPLING)

Sample Size Code Letter	Sample Size	Acceptable Quality Levels (normal inspection)												
		0.015	0.035	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑
D	7	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓
E	10	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2
F	15	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3
G	25	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4
H	35	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6
I	50	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	4 5	6 7
J	75	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	4 5	6 7	9 10
K	110	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	4 5	6 7	8 9	12 13
L	150	↓	↓	0 1	↑	↓	1 2	2 3	3 4	4 5	5 6	8 9	11 12	17 18
M	225	↓	0 1	↑	↓	1 2	2 3	3 4	4 5	5 6	8 9	11 12	17 18	24 25
N	300	0 1	↑	↓	1 2	2 3	3 4	4 5	5 6	7 8	10 11	14 15	20 21	32 33
O	450	↑	↓	1 2	2 3	3 4	4 5	5 6	7 8	10 11	14 15	20 21	29 30	43 44
P	750	↓	1 2	2 3	3 4	4 5	6 7	8 9	11 12	15 16	20 21	31 32	45 46	68 69
Q	1500	1 2	2 3	3 4	5 6	7 8	9 10	13 14	18 19	25 26	35 36	56 57	81 82	124 125
		0.035	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10.0
		Acceptable Quality Levels (tightened inspection)												

TABLE 5

Example of a Table of Random Numbers*

15 62 38 72 92	03 76 09 30 75	77 80 04 24 54	67 60 10 79 26	21 60 03 48 14
77 81 15 14 67	55 24 22 20 55	36 93 67 69 37	72 22 43 46 32	56 15 75 25 12
18 87 05 09 96	45 14 72 41 46	12 57 46 72 02	59 06 17 49 12	73 28 23 52 48
08 58 53 63 66	13 07 04 48 71	39 07 46 96 40	20 86 79 11 81	74 11 15 23 17
16 07 79 57 61	42 19 68 15 12	50 21 59 12 07	04 99 88 22 39	75 16 69 13 84
54 13 05 46 17	05 51 24 53 57	46 41 14 39 17	21 30 89 07 35	47 87 44 36 62
95 27 23 17 39	80 24 44 48 93	75 94 77 09 23	48 75 91 69 03	55 53 09 74 47
22 39 44 74 80	25 95 28 63 90	41 19 48 46 72	51 12 97 39 83	35 83 23 17 29
69 95 21 30 11	98 81 38 00 53	41 40 04 16 78	67 29 83 41 18	30 90 44 37 64
75 75 63 97 12	11 57 05 86 52	82 72 47 72 14	37 72 60 75 48	72 21 52 41 81
08 74 79 30 80	70 11 66 79 25	88 01 94 52 31	38 47 98 71 62	12 56 61 01 54
04 88 45 98 60	90 92 74 77 87	40 18 65 87 37	08 68 62 39 52	84 74 90 68 18
97 35 74 05 75	42 13 49 48 38	74 19 06 42 60	20 79 90 81 77	18 51 71 27 27
53 09 93 28 29	80 19 68 30 45	94 49 49 71 21	93 93 71 30 34	52 65 83 40 13
26 36 68 48 09	37 69 26 22 80	23 34 10 45 70	83 51 07 37 44	62 96 74 42 64
49 16 57 15 79	56 63 22 94 28	11 39 69 55 38	53 06 97 20 42	09 14 90 43 48
03 51 79 78 74	75 23 73 75 98	47 85 07 25 02	61 28 01 22 16	14 12 15 67 22
21 88 87 28 48	23 44 03 03 80	53 89 07 87 93	30 17 84 17 74	16 53 31 39 01
56 41 73 33 41	59 16 59 50 98	24 24 87 06 75	99 52 09 88 05	86 25 43 60 94
72 39 19 70 17	01 04 01 22 33	04 84 63 27 65	84 39 45 55 31	95 88 93 90 37
97 28 25 81 49	71 69 22 04 51	56 46 56 15 10	69 49 99 60 29	33 40 16 93 09
18 87 02 72 08	74 52 16 03 82	20 19 77 23 62	37 51 04 89 31	32 19 59 85 57
53 40 11 75 45	13 46 85 31 37	09 17 71 96 79	39 50 79 27 62	71 14 95 53 03
60 49 03 41 56	78 33 77 28 92	21 90 10 62 01	97 06 45 01 19	95 12 24 18 52
09 16 12 75 04	39 69 95 00 48	26 85 28 73 08	66 92 10 66 75	62 61 27 82 57
64 20 19 87 54	88 15 12 54 24	06 99 57 07 28	51 34 54 98 50	70 88 02 86 48
31 28 07 58 77	03 98 26 76 09	10 44 57 61 28	60 29 85 70 79	89 20 19 98 92
80 04 28 47 76	35 73 67 78 28	09 39 88 63 74	41 26 92 42 33	06 80 06 33 84
24 60 22 51 19	34 54 08 24 73	86 72 11 44 69	76 90 81 17 85	57 47 35 16 84
59 16 11 26 29	18 97 78 44 43	58 92 78 70 80	09 65 32 68 26	65 73 90 50 46
58 54 29 98 27	40 51 92 07 13	58 41 59 56 94	16 32 51 42 54	77 37 13 85 19
20 18 34 22 73	57 40 67 17 28	63 57 74 36 18	65 55 25 50 68	35 90 00 03 38
53 90 46 56 19	50 58 33 84 53	14 74 17 40 73	86 11 04 02 04	02 28 49 62 36
97 16 03 94 65	70 95 95 83 20	91 42 57 95 63	00 86 29 02 53	02 27 86 70 95
72 55 71 70 92	04 22 53 19 29	67 29 13 56 70	45 73 45 04 05	32 43 30 93 41
99 19 72 58 35	49 09 26 00 74	26 42 94 52 02	83 31 85 65 66	31 97 67 42 15
48 21 49 72 97	79 19 64 81 82	78 92 51 96 51	28 79 13 20 82	34 81 39 46 86
52 37 68 15 53	22 98 30 16 31	83 24 87 69 29	24 85 44 24 50	75 62 83 95 41
97 50 52 53 52	25 78 21 68 69	57 79 42 40 89	55 81 75 24 52	51 32 79 97 04
36 05 09 18 11	71 01 63 17 60	11 65 19 43 07	44 86 19 58 92	23 71 32 96 19
20 79 70 09 30	81 14 53 80 93	71 94 10 18 14	83 69 76 53 25	27 36 65 65 05
13 07 89 72 08	00 37 75 14 94	83 85 06 72 66	07 47 30 17 11	16 02 63 97 30
94 26 82 37 43	34 23 00 14 50	96 85 41 17 71	69 20 15 98 82	79 69 68 50 31
13 55 88 38 43	75 37 43 83 85	53 74 54 62 99	58 93 74 43 95	06 26 79 78 87
02 44 24 97 71	97 93 12 70 89	42 52 33 24 91	05 87 53 15 77	49 92 83 97 80
34 90 96 63 54	22 84 36 38 99	85 25 36 03 27	49 24 72 10 50	95 14 18 26 64
13 67 06 34 98	04 20 80 12 54	01 18 54 20 76	92 10 47 04 65	54 45 82 42 90
18 75 55 82 66	34 77 27 71 79	67 65 65 92 68	16 43 83 18 74	12 48 68 87 22
91 25 52 57 15	21 54 40 05 50	67 51 66 45 69	84 72 74 32 30	17 70 40 90 24
76 24 00 14 92	14 29 12 17 73	77 46 44 24 30	48 50 36 30 24	93 08 01 39 37

*Taken from Statistical Tables and Formulas, by A. Hald, New York, John Wiley & Sons, Inc., 1952.

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