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The Institute of Internal Auditors Australia

Whitepaper

Internal Audit Sampling

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Background

Purpose

This White Paper is designed to outline the purpose for, and approaches to, statistical sampling as a part of internal audit testing. It provides a general guide and is not a substitute for the professional assistance that will be needed.

Background

1. *Audit sampling is used to provide factual evidence and a reasonable basis to draw conclusions about a population from which a sample is selected. The internal auditor should design and select an audit sample, perform audit procedures, and evaluate sample results to obtain sufficient, reliable, relevant, and useful audit evidence to achieve the engagement's objectives. Sufficient, in that the information is factual, adequate, and convincing so that a prudent, informed person would reach the same conclusions as the auditor. Reliable, in that the information is the best attainable information through the use of appropriate engagement techniques. Relevant, in that the information supports engagement observations and recommendations and is consistent with the objectives for the engagement. Useful, in that the information helps provide assurance that the organization will meet its goals.*[1]

It is not always necessary to sample a population. For example, analytical and computer techniques may mean all items in a population can be subjected to testing[2]. What is critical at the outset is defining the information that is required.

Having a clear statement of the purpose of the test is important in the process of developing a test. Statistical sampling can be used to answer questions of the form:

- What proportion of...?
- What is the estimated value of...?
- Is the error rate likely to be less than...?

Statistical techniques may be of value in answering other types of questions, but statistical sampling is not applicable.

2. *Audit sampling is defined as, the application of audit procedures to less than 100 percent of items within a class of transactions or account balance such that all sampling units have a chance of selection. Population is defined as, the entire set of data from which a sample is selected and about which the internal auditor wishes to draw conclusions. Sampling risk is defined as, the risk that the internal auditor's conclusion based on a sample may be different from the conclusion if the entire population were subjected to the same audit procedure.*

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Audit Testing

Issue

An internal auditor is customarily trying to establish whether or not a particular control or group of controls is working. This is called compliance testing: it is all about system operation and not whether or not the system is producing the right results. Testing the results of the system is done after the controls have been assessed: this is called substantive testing and, under some circumstances, might not be done.

Compliance Testing

In systems-based audit methodology, we attempt to establish how a system is operating. We build a model of the way it operates and then confirm that model by testing transactions for adherence to the model. This is called compliance testing. Sometimes the model is provided for us (for example, it is prescribed by legislation or it is a well-documented set of procedures). The testing which determines whether prescribed controls actually exist, and are being complied with, is also called compliance testing.

In the audit of a system under development, audit testing will be directed primarily at controls, since most of the code in a computer system exists to deal with illegal or erroneous data. Unless algorithms are particularly complex, very little testing will be needed to verify that they produce correct answers when given acceptable input.

Substantive Testing

There are times when we concern ourselves with actual results. If, for example, we are trying to estimate a true value of something (ie the effect of processing errors); or if we are attempting to reason backwards from actual processing errors to potential control problems. The testing which determines whether data includes a material amount of dollar-errors is termed substantive testing.

External auditors are the major users of substantive testing.

Sampling

Statistical and Non-statistical Sampling

3. *Statistical sampling (e.g., random and systematic) involves the use of techniques from which mathematically constructed conclusions regarding the population can be drawn. Statistical sampling allows the auditor to draw conclusions supported by arithmetic confidence levels (e.g., odds of an erroneous conclusion) regarding a population of data output. It is critical that the sample of transactions selected is representative of a population. Without ensuring that the sample represents the population, the ability to draw conclusions based on the review of the sample is limited, if not erroneous. The internal auditor should validate the completeness of the population to ensure that the sample is selected from an appropriate data set.*

4. *Non-statistical sampling is an approach used by the auditor who wants to use his or her own experience and knowledge to determine the sample size. Non-statistical sampling (e.g., judgmental) may not be based objectively and, thus, results of a sample may not be mathematically supportable when extrapolated over the population. That is, the sample may be subject to bias and not representative of the population. The purpose of the test, efficiency, business characteristics, inherent risks, and impacts of the outputs are common considerations the auditor will use to guide the sampling approach. Non-statistical sampling may be used when results are needed quickly and needed to confirm a condition rather than being needed to project the mathematical accuracy of the conclusions.*

To establish the existence of errors requires that only one error is found. If the auditor has, from other sources, knowledge of where the error is likely to be, then there is no need to undertake formal statistical sampling.

An auditor with a good understanding of a process might be able to see anomalies without formal analysis. If this is the case, then selecting by judgement is quite acceptable.

On the other hand, much time can be wasted on unreliable judgement and the nature of the question to answered might make non-statistical sampling inappropriate. The results of a non-statistical sample cannot be projected numerically across an entire population.

5. *In forming an audit opinion or conclusion, auditors frequently do not examine all available information, as it may be impractical and valid conclusions can be reached using audit sampling. When using statistical or Non-*

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statistical sampling methods, the auditor should design and select an audit sample, perform audit procedures, and evaluate sample results to obtain sufficient, reliable, relevant, and useful audit evidence.

6. *Techniques for audit sampling are varied. Examples of a few techniques include:*

These techniques/approaches are not mutually exclusive.

Random sampling — selection is not governed by predetermined considerations; every unit in the population has an equal chance of being selected.

This is, technically, "simple random sampling". There are many variations on this, including

- Random sampling with probability proportional to size.
- Ratio estimation.
- Error estimation – estimation of the size of errors in relation to a "trusted source" such as an account or an inventory.

Monetary unit sampling — used to identify monetary misstatement(s) that may exist in an account balance.

This is a form of systematic sampling; a variation on interval sampling. Interval sampling and its variations are powerful techniques for manual systems as they can produce good results with relatively small samples. They are designed around the concept of a ledger – where all transactions/items are listed in the order in which they presented.

Interval Sampling

Having selected the size of sample required, the population is divided by the sample size to determine a sampling interval (say i). A random starting point is then taken in the population (s | 1<=s<i) and every i^{th} item is selected. Obviously the population must be sequenced in some way and the sample consists of items numbered: s, s+i, s+2i, s+3i ...

Monetary Unit Sampling

This is very similar to interval sampling. Instead of counting and dividing members of the population, we count and divide the value of members of the population. Thus a member with value 5 is treated as five sampling units and a member with value 100 is treated as 100 sampling units. The mechanism is identical.

Stratified sampling — used to segregate the entire population into subgroups; usually a random selection from each of the subgroups is selected for review.

Stratified sampling breaks a population into groups and each group can be sampled independently (and with different techniques if required). There are, once again variations on this:

- Cluster sampling – if the population is conceptually in clusters (such as, for example, geographic centres) then a random set of clusters may be examined.
- Multi-stage sampling – individual clusters or strata may be subjected to further structural analysis before sampling takes place.

Many of these techniques are powerful but should not be applied without good reason. They are ways of using known structure of the population to assist in its analysis but they can be expensive. They would normally only be used with complex and large populations.

- Attribute sampling — used to determine the characteristics of a population being evaluated.

- Variable sampling — used to determine the monetary impact of characteristics of a population.

Attribute sampling answers the question: what proportion...? It assumes that the underlying test can be answered Yes/No.

Variable sampling answers the question: what is the value of...? It assumes that the answer to an underlying test is a number.

- Judgmental sampling — based on the auditor's professional judgment; meant to focus and confirm a condition that is reasonably thought to exist.

This is the primary form of non-statistical sampling used.

It will sometimes be the case that the population size is unknown, or that the nature of the work makes it impractical to take a sample of the size required by a statistical technique. Judgement sampling may be more appropriate in such circumstances. The principal limitation of judgment sampling is that it provides no mathematical basis for projecting sample results to the population. The auditor should never imply that

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conditions disclosed by judgement samples are necessarily representative of the entire population.

Even though the auditor, in using judgment sampling, determines the sample size without reference to statistical criteria, they should nevertheless try to use random sample selection techniques, unless the audit objective specifically call for a directed solution. Methods of obtaining such samples are described below (under attribute sampling). The limitations would seem to suggest that this technique has a limited application; on the contrary, it can be extremely useful. Some possible examples are:

- Sample all debts over $20,000.
- Controls may appear to be so bad that a small sample (say of half-a-dozen randomly selected items) may be all that is necessary to demonstrate the extent of the problem (especially if all six contain errors).
- If fraud is suspected the auditor may decide to only sample those items processed by a certain person(s) in the organisation.

- Discovery sampling — used where evidence of a single error or instance would call for intensive investigation.

More generally, this assumes that the error rate is small and a random sample is drawn to confirm whether the error rate is as expected. It is a variant of Stop-Go Sampling

This technique is fairly limited in its application, because it does not allow sampling for variables such as quantities, or dollar amounts. Nevertheless, it is a useful diagnostic tool.

No prior estimate or error rates are required; one simply samples 25 or 50 items - at random - regardless of the size of the population. If no errors are found, then the auditor is able to state that they are x% confident that the number of errors in the population is less than y%.

The formula for making this statement is:

$y = 1 - exp\ (ln\ (1 - x) / n)$ where n is the sample size.

This technique is frequently used to validate the auditor's assessment of controls and the sample is selected according to the number of items in the population. It is a rule-of-thumb test that is always used in conjunction with other information.

If the population has this many members	Choose a sample of this size
1	1
4	2
12–50	4
50–300	10% (ie 5 to 30)
More than 300	30

If no errors are found, then a satisfactory conclusion may be drawn from the test. In the event of errors the processes in Section 4 should be followed.

7. *When designing the size and structure of an audit sample, auditors should consider the specific audit objectives, the nature of the population, and the sampling and selection methods. The auditor should consider the need to involve appropriate specialists in the design and analysis of sampling methodology.*

8. *The sampling approach will depend on the purpose of the sample. For compliance testing of controls, attribute sampling is used typically, where the sampling approach is an event or transaction (e.g., a control such as an authorization on an invoice). For substantive testing, variable sampling is used often where the sampling unit is monetary.*

9. *Given that the population should be the entire set of data from which the auditor wishes to sample in order to reach a conclusion, the population from which the sample is drawn has to be appropriate and verified as complete for the specific audit objective.*

10. *To assist in the effective design of the sample, stratification may be appropriate. Stratification is the process of segregating a population into homogenous subpopulations explicitly defined so that each sampling unit can belong to only one sub-population depending on the criteria used for stratification.*

Tolerable and Expected Definitions

11. *When using a statistical sample, the auditor should consider concepts such as sampling risk and tolerable and expected errors. Sampling risk arises from the possibility that the auditor's conclusion may be different from the conclusion that would be reached if the entire population*

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were subjected to the same audit procedure. There are two types of sampling risk:

- Incorrect acceptance — the risk that the attribute or assertion tested is assessed as unlikely when, in fact, it is likely.
- Incorrect rejection — the risk that the attribute or assertion tested is assessed as likely when, in fact, it is not likely.

Tolerable errors are the maximum numbers of errors that the auditor is willing to accept and still reach a conclusion that the underlying assertion is correct. This is not always the auditor's decision and may be determined by the nature of the business, consultation with management or best practices. In some cases, an error of one will not be tolerable.

Expected errors are errors that the auditor expects in the population based on prior audit results, changes in processes, and evidence/conclusions from other sources.

12. *The level of sampling risk that the auditor is willing to accept, tolerable error, and the expected error all affect sample size. Sampling risk should be considered in relation to the audit risk approach and its components which include inherent risk, control risk, and detection risk.*

13. *Effective audit sampling procedures will increase the coverage, focus, and efficiency of audits and will allow the auditor to provide assurance on business processes that impact the organization's achievement of its goals and objectives. It is important that the auditor understand accepted guidance and standards on sampling along with the business processes and data he or she is working with when selecting the appropriate audit sampling technique.*

14. *Continuous auditing allows the internal auditor to test the whole population in a timely fashion, while audit sampling facilitates the selection of less than 100 percent of the population.*

15. *The internal auditor should analyze possible errors detected in the sample to determine whether they are actually errors and, if appropriate, the nature and cause of the errors. For those that are assessed as errors, it should be determined whether additional testing is required.*

16. *When the expected audit evidence regarding a specific sample item cannot be obtained, the auditor may be able to obtain sufficient audit evidence through performing alternative procedures on the item selected (see #6 above for examples of alternative procedures). If the auditor is unable to apply the designed audit procedures or alternative procedures to a selected item, the internal auditor should treat that item as a deviation from the prescribed control.*

17. *The internal auditor should project the results of the sample to the population with a method of projection consistent with the method used to select the sample. The projection of the sample may involve estimating probable errors or deviations in the population and estimating errors that might not have been detected because of the imprecision of the technique, together with the qualitative aspects of errors found. Consideration should be given to whether the use of audit sampling has provided a reasonable basis for conclusions about the population that has been tested.*

The results of a statistical sample involve an inbuilt uncertainty. They are not the results of an examination of the entire population and therefore there may be characteristics that have been missed. To be 100% confident, you would have to examine the entire population.

The confidence that the well-designed test allows in the result is expressed as a percentage. For example, 80% confidence means that there is a 20% probability that the projected result is not correct. If a higher confidence is required, then a larger sample is required.

The result of a statistical sample also has a precision which is closely associated with the confidence. The precision is expressed as an interval – the error is $8m±0.2m; the error rate is between 2% and 4% – or it can be expressed as an upper limit – the error rate is less than 1%. If greater precision is required, a larger sample is needed.

A fully expressed result of a statistical sample will be of the form: at 95% confidence, the failure rate is less than 0.01%.

18. *The auditor should consider whether errors in the population might exceed the tolerable error by comparing the projected population error to the tolerable error, taking into account the results of other audit procedures relevant*

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to the audit objective. When the projected population error exceeds the tolerable error, the auditor should reassess the sampling risk and, if that risk is unacceptable, consider extending the audit procedure or performing alternative audit procedures.

Documentation and Reporting

19. *The audit work papers should include sufficient detail to describe clearly the sampling objective and the sampling process used. The work papers should include the source of the population, the sampling method used, sampling parameters (e.g., random start number or method by which random start was obtained and sampling interval), items selected, details of audit tests performed, and conclusions reached.*

20. *When the internal auditor is reporting results of testing and the conclusion reached, sufficient information needs to be reported for the reader to understand the basis of the conclusion.*

The Sampling Process

There are several stages to this:

- Selecting an initial sample – the auditor estimates an appropriate sample size based upon their understanding of the population and the precision and confidence they require.
- Testing the sample – the selected sample is tested according to the predefined test criteria and the sample results calculated.
- Projecting the results – the implications for these results are projected across the population, providing a valid statistical estimate.
- Verifying the outcome – the auditor assesses whether the result has sufficient precision/confidence for their purposes and, if necessary, expands the sample.

It is best to start with a small sample and test it, expanding as necessary rather than to choose a sample that is too big. When a sample is selected, it must be tested in its entirety for the results to be valid.

If a member of the sample cannot be located, then it fails all relevant tests.

Sample Size

Simple Random Sample – Attribute Sampling

Selection of items at random from a large population can be used to estimate the error rate in that population. If we are reasonably certain that the error rate is less than a specific amount (say p) we can draw a sample for further examination. If the error rate in this sample is indeed less than p, then we have established this fact. The size of the sample we need to draw is determined in three stages:

1. Estimate the error rate p in the population from a small sample (say 30 items), from prior knowledge (past audits etc) or by discussion with experienced and knowledgeable people.

2. Make a first estimate of the sample size which will determine whether the error rate is indeed p±A:

$$n_e = \frac{Z^2 p(1-p)}{A^2}$$

where Z is the point on the Normal distribution for the desired level of confidence.

3. Make a more accurate estimate of the sample size to adjust for the fact that the population is a large finite number N rather than infinite:

$$n = \frac{n_e}{1+(n_e/N)}$$

The initial sample (if one is taken a stage 1) may be all that is needed.

Simple Random Sample – Variables Sampling

Most often in using this method, we will have a large population from which we are attempting to estimate a variable by sampling, and we will want to determine an appropriate sample size. There are three steps:

1. Estimate the population variance.
   To do this we extract a random collection of about 50 items and derive the variance of the sample (s^2).
2. Make a first estimate of the sample size n_e:

$$n_e = \frac{Z^2 s^2}{A^2}$$

where Z is the appropriate confidence point on the Normal distribution (See table A2)
A is the desired precision expressed in units of population (±A)

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3. Make an adjustment to the sample size to accommodate the fact that the population is not infinite but is rather N.

   $$n = \frac{n_e}{1+(n_e/N)}$$

   Once again, we might find that the initial sample is quite sufficient.

Interval Sampling

We start by deciding P, the upper error limit (ie the maximum error rate in the population which would be acceptable to management or the auditor). Taking P as 2.0% and the confidence level as 95%, then this particular sampling technique would allow the following statement to be made if no errors are found in the sample taken: "I am 95% confidence that the error rate in the population[3] does not exceed 2%".

Sample size (n) is easily determined if you have already decided on your precision limit (P), and your confidence level. Accept that if P and n are multiplied together we have what we call a Reliability Factor.

$R = n \cdot P$ or $n = R/P$

The values for R are based on the Poisson distribution, the technicalities of which need not concern us here.

The sampling process is then straightforward, but all items selected must be tested. The process assumes that no errors are detected. While the result can be adjusted for errors found, the adjustment process is not simple and is not included here.

This technique relies heavily on two things: assured random entry, and assured random distribution of the items concerned. The object of the random start is to ensure that no bias creeps in to sample selection; each member of the population has to have an equal chance of selection. The random distribution assumption is that there is no cyclical occurrence in the data that has the same interval as the sample.

1. Identify the sampling interval from the sample size (n) and the population size (N). The interval i is given by:

   $$i = N/n$$

2. Choose a random starting point (s) that is less than or equal to *i*.
3. Select items s, s+*i*, s+2*i*...

Monetary Unit Sampling

As mentioned earlier, this is a variation of interval sampling. It differs from it in two aspects: firstly, every monetary unit in a population is considered to be a sampling unit, and secondly, it can be used to produce an estimate in dollars. This technique is known by a number of names including: 'monetary unit sampling' (MUS); 'combined attributes variables' (CAV), and 'cumulative money amount' (CMA) sampling.

As with interval sampling, the character of the population being sampled must be understood. With MUS sampling, you will also need to know the total value of the population. So, a 'population' of invoices totalling $1 million is considered to be made up of 1,000,000 different dollars. Since many of these dollars would be 'attached' to others in an invoice for $2,700, the entire invoice stands a very good chance of being selected for examination. So, whilst sampling techniques in MUS sampling treat all monetary units as having an equal chance of selection, if these monetary units bunch together in a few very high-value invoices, then those invoices stand a better chance of being selected. This is a useful benefit of the MUS technique.

The application of MUS sampling parallels the application of interval sampling: the internal auditor assessed the condition of essential controls, sets a confidence level and a precision limit, determines the reliability factor, and calculates sample size.

Having determined sample size, the sample itself has to be taken. As with attribute sampling, it requires random-entry into the population, followed by systematic interval sampling, (using the monetary amount sampling interval'. This interval, defined as J is calculated as follows.

$J = M \cdot P/R$ where:
M = monetary value of the population
J = the monetary sampling interval
R = the reliability factor
P = Precision Limit

Adjustments can be made for errors detected, but the process is not included here.

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Evaluation of Results

The results of a simple random sample can be project across a population in a straightforward manner.

Simple Random Sample – Attribute Sampling

If a sample of n is selected and e errors are found, then the estimated error rate is *p=e/n*. Taking into account the uncertainty in sampling, the error rate is properly expressed as:

At 95% confidence the error rate is $p \pm t_{n-1}\sqrt{p \cdot (1-p)/n}$

Where t_{n-1} is the 95% point on the t-distribution with *n-1* degrees of freedom.

This can be done readily in Excel:

Lower bound = $p - TINV(1-0.95, n-1) * SQRT(p*(1-p)/n)$

Upper bound = $p + TINV(1-0.95, n-1) * SQRT(p*(1-p)/n)$

Simple Random Sample – Variables Sampling

Similarly, if we have a collection of observations {x_1, x_2, x_3, ... x_n}. Then:

1. The sample mean $\bar{x}$ is $\sum_{i=1}^{n} \frac{x_i}{n}$, and ... <mean>
2. The variance s^2 is $\frac{1}{(n-1)}\sum_{i=1}^{n}(x_i - \bar{x})^2$

   or equivalently $\frac{1}{(n-1)}\sum_{i=1}^{n} x_i^2 - n\bar{x}^2$ ... <var>

The estimate of the value of the mean of the population is:

$$\mu = \bar{x} \pm t_{n-1}\frac{s^2}{n}$$

where t_{n-1} is an appropriate value on the t-distribution with n-1 degrees of freedom.

This can be done readily in Excel (for 95% confidence):

Lower bound = <mean> - TINV (1 - 0.95, n-1) * SQRT (<var>/n)

Upper bound = <mean> + TINV (1 - 0.95, n-1) * SQRT (<var>/n)

Some Statistical Tables

Poisson Distribution

Confidence Level	R Factor
99%	4.61
95%	3.00
90%	2.30
85%	1.90
80%	1.61
75%	1.39
70%	1.20
65%	1.05
60%	0.92

Normal Distribution

Confidence Level	Z Factor
60%	0.84
90%	1.64
95%	1.96
98%	2.33
99%	2.56

Conclusion

Audit sampling is a useful tool for application in the testing of systems and processes. Statistical sampling is one approach that allows conclusions about an entire population to be drawn from analysis of a portion of it.

Good practice is to use the testing technique that best suits the problem to be solved:

- Data analysis techniques – where the data is in a suitable form.
- Statistical sampling – to enable the projection of tests across a population.
- Non-statistical sampling – to obtain examples.

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As the chief advocate of the Internal Audit profession, the IIA serves as the profession's international standard-setter, sole provider of globally accepted internal auditing certifications, and principal researcher and educator.

The IIA sets the bar for Internal Audit integrity and professionalism around the world with its 'International Professional Practices Framework' (IPPF), a collection of guidance that includes the 'International Standards for the Professional Practice of Internal Auditing' and the 'Code of Ethics'.

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