

DUS An Efficient, Effective Sampling Method

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Abstract

Dollar unit sampling (DUS) is a statistical sampling method which is easy to understand and simple to apply on audit engagements. This article gives guidance on preliminary determinations that must be made in order to use DUS. It also illustrates how to figure sample size and select the sample members. Techniques to use in evaluating the results of DUS tests are provided. Finally, there is a discussion of factors to consider in deciding if DUS is the most appropriate sample method in a particular audit situation.

As an aid in making objective decisions in a number of audit areas, auditors use statistical sampling techniques. Attributes sampling and variables sampling are two broad types of techniques that are frequently employed: attributes sampling is typically used in testing compliance with internal control and variables sampling when the auditor wants conclusions in dollar terms. Dollar unit sampling (DUS) is a statistical sampling method that not only combines many advantages of both attributes and variables plans but also enjoys advantages unique among sampling plans. The method is modern and easy to apply, and is cost efficient and effective in locating errors in the financial statements. By using DUS, auditors reach statistically valid conclusions in an audit area while performing less work.

OVERVIEW OF DUS AND ADVANTAGES

How DUS defines the sampling units differentiates it from other sampling plans. In traditional methods, the sampling units are defined as the physical items in the population. Under DUS, the sampling units are the individual dollars. For example, a population of 1000 invoices totaling \$84,000 contains 84,000 dollar units and 1000 physical units. The dollar units, not the physical units, are selected for testing under DUS, and the results of the evaluation are given in dollar terms. The results indicate, at the specified confidence level, the amount of possible dollar error in the population. To decide whether to accept or reject the book value of the population as being fairly stated, the auditor compares materiality, also given in dollar terms, to possible error in the population.

One advantage of DUS is that the method tends to automatically include large book value items in the sample.¹ While each dollar unit in DUS has the same chance of being chosen, the probability of selecting the physical unit is proportional to the dollar size of the unit. In the example above, suppose there is an \$8,400 invoice in the population of 1000 invoices totalling \$84,000. Under traditional sampling methods, each physical unit has an equal chance of being selected; there is a 1/1000th chance of selecting the \$8,400 invoice. Under DUS, each one-dollar unit in the invoice could be chosen, so there is a 8,400/84,000, or 10%, chance that the invoice is selected. If the auditor believes that material errors are in the larger items, DUS is a good sampling method to use. The method automatically satisfies the population and

selects many of the larger physical units for the sample.

A second advantage of DUS is that it is an efficient statistical technique. Because DUS tends to choose large dollar value items, the method usually tests more total dollars of a population than an attribute or variables sampling plan of the same sample size.

A further advantage of DUS is that the method allows several asset or several liability accounts to be considered as one population for statistical sampling. For example, several current asset accounts might be considered together and one DUS test used to audit them all. All sampling plans require the population members to be homogeneous. Under traditional sampling methods, various current asset accounts cannot be tested together because the populations are different. With DUS, however, the sampling unit is the dollar, and so homogeneity of the sampling units is maintained when adding accounts together.²

The ability to begin DUS work at interim dates is another favorable aspect of the method. Auditors can start testing even before the book value of the population is known. The work in the audit area can then be completed at year-end.

Several other advantages of DUS exist; they are pointed out in the following sections. Selection of the DUS sample is discussed first, followed by a section on evaluating the results. Concerns with the appropriateness of DUS in particular situations are presented, and a brief discussion concludes the paper.

SELECTION OF A SAMPLE

One of the initial steps in a DUS test is selecting the units to be included in the sample. Before choosing the actual dollar units in the population which will be tested, however, the auditor must make several preliminary determinations.

Preliminary Determinations

In planning any statistical sampling test, the auditor decides on the objectives of the test and defines the population and the errors. As an example, the objective of the test of the sales revenue account might be to establish the occurrence of sales and to determine whether sales revenue is fairly stated. DUS can then be used to select individual invoices for testing and to evaluate the results. The population would be defined as the sales invoices for the year, and an error might be a discrepancy between the book and true amounts.

The confidence level, which is the complement of sampling risk, is also specified at this early stage. Sampling risk is the risk of concluding that the population does not contain material error when, in fact, there is material error in the population. (Material error or materiality is discussed below.) Sampling risk is generally set at some low level, such as 5% or 10%. For these levels of sampling risk, the corresponding confidence levels are 95% and 90%.

Materiality for the population being tested is also established. Materiality is the amount of uncorrected error remaining in the audit area which would cause the accounting information to be misleading. The auditor is required by Statement on Auditing Standards 47 to consider preliminary estimates of materiality when planning audit procedures.³ Materiality is typically set in relation to a total of the financial statements (i.e., 10% of net income or 5% of total assets). To determine materiality for a specific audit area, the

auditor estimates the amount of uncorrected error in the area being tested which, when combined with errors in other areas, would cause the accounting information to be misleading. This materiality amount is used in figuring sample size.

Before sample size is computed, two final items are determined. First, the auditor estimates the number of errors expected in the sample. Referring to prior years' work or performing a preliminary sampling plan of about 30 items may help the auditor estimate the number of expected errors. Second, the auditor establishes the book value of the account or group of accounts being tested. (Later, a DUS selection method is introduced in which the book value does not have to be known in order to start testing.)

Sample Size

Once the auditor has determined confidence level, materiality, number of expected errors, and population book value, the sample size is computed by using the following formula:

$$n = \frac{\text{UEL factor} \times \text{BV}}{M}$$

where:

- n = sample size
- UEL factor = upper error limit factor (from Table 1)
- BV = book value of population
- M = materiality for population

The UEL (upper error limit) factor is obtained from Table 1. The upper error limit is the amount of possible error in the population. That is, even if no errors are found in the sample, the possibility still exists that there are errors in the population. The UEL factor is read from the table by finding the intersection of the number of expected errors (rows) and the confidence level (columns). An example involving a population of sales invoices illustrates how to use Table 1 and how to compute n.

Assume:

Book value of sales invoices	\$84,000
Number of sales invoices	1,000
Confidence level	90#
Number of expected errors in the sample	0
Materiality for sales invoices	# 2,500

The UEL factor for zero expected errors and a 90% confidence level is 2.31. The sample size is then computed:

$$n = \frac{2.31 \times 84,000}{2500} = 78$$

Seventy-eight dollar units are selected from a population of 84,000 dollar units. Note that there is a possibility that fewer than 78 invoices will be selected for testing, as two or more dollar units may fall within the same invoice.

Table 1
Upper Error Limit Factor Table

Number of errors	Confidence Levels			
	90%		95%	
	UEL factor	PGW factor	UEL factor	PGW factor
0	2.31	-	3.00	-
1	3.89	.58	4.75	.75
2	5.33	.44	6.30	.55
3	6.69	.36	7.76	.46
4	8.00	.31	9.16	.40
5	9.28	.28	10.52	.33
6	10.54	.26	11.85	.33
7	11.78	.24	13.15	.30
8	13.00	.22	14.44	.29
9	14.21	.21	15.71	.27
10	15.41	.20	16.97	.26
11	16.60	.19	18.21	.24
12	17.79	.19	19.45	.24
13	18.96	.17	20.67	.22
14	20.13	.17	21.89	.22
15	21.30	.17	23.10	.21
20	27.05	.14	29.07	.19
25	32.72	.13	34.92	.16
50	60.34	.09	63.29	.12
75	87.37	.08	90.89	.10
100	114.07	.06	118.07	.08

Source: Leslie, Donald A., Albert D. Teitlebaum,
and Rodney J. Anderson. Dollar-Unit Sampling,
Toronto, Copp Clark Pitman, 1979, back cover.

Fixed Interval Sample Selection

Once the sample size is known, the dollars to be tested can be selected. The fixed interval selection method is a simple one to use to choose sample members.

To apply the fixed interval method, the auditor determines the average sampling interval (ASI). ASI is the number of dollars between the dollar units selected for testing. It equals the book value of the population divided by the sample size: $ASI = BV/n$. In the example, $ASI = 84,000/78 = 1077$. Every 1077th dollar in the population of sales invoices is selected for testing. In addition to computing ASI, the auditor must obtain a listing of the population members. The listing should have a cumulative dollar total after each. With

current computer abilities and availability, the client should easily be able to supply the auditor with a listing of the cumulative totals.

To begin the selection of the sample, the auditor selects a random number between 1 and ASI. The dollar corresponding to the random number is chosen as the first unit in the sample. ASI is added to the random number to determine the second dollar member of the sample. The remaining sample dollar units are determined by adding ASI to the previous total until the population is exhausted. An example of fixed interval selection is presented in Table 2.

Table 2
Example of
Fixed Interval Selection Method

<u>Sales Invoice Number</u>	<u>Amount of Sales Invoice</u>	<u>Cumulative Total</u>	<u>Sales Invoice Selected</u>	<u>Cumulative Dollar Selected</u>
1	\$2,000	\$ 2,000	✓	1000 (random number)
2	50	2,050		
3	200	2,250	✓	2077 (1000+1077)
4	4,000	6,250	✓	3154 (2077+1077)
				4231 (3154+1077)
				5308 (4231+1077)
5	50	6,300		
⋮	⋮	⋮	⋮	⋮
998	10	82,875		
999	1,075	83,950	✓	83,929(1000+77x1077)
1000	50	84,000		

Note: Fixed interval or ASI equals 1077.

In the example shown in Table 2, assume the auditor chooses 1000 as the random number between 1 and ASI; the first dollar selected is the 1000th dollar of the population. Since the first invoice is for \$2,000, the 1000th dollar unit falls in that invoice, and it is selected for inclusion in the sample.

The second dollar unit to be selected is 2077 (1000 + 1077). The Cumulative Total column in Table 2 shows that invoice 2 contains cumulative dollars 2001 through 2050 and that the cumulative dollars in invoice 3 are 2051 through 2250. Thus, dollar 2077 falls in invoice 3.

The next three dollar units selected are 3154, 4231, and 5308 (see Table 2

for calculations). These three dollar units fall in the same physical unit, sales invoice 4. This distribution is perfectly acceptable and illustrates why DUS is an efficient sampling method. Although 78 dollar units are selected for testing in this example, no more than 76 sales invoices are examined. The example also illustrates that large invoices have a high probability of being chosen. In fact, any invoice totalling \$1077 or more is automatically included in the sample.

Additional dollar units are selected for the sample by adding ASI, 1077, to the previous cumulative total and proceeding through the population. In this example, the final dollar selected is 83,929 (1000 + 77 x 1077).

Interim Testing

Because of the rush of year-end work, auditors often try to perform as many audit procedures as possible before year-end. DUS samples can be started at an interim date even though the auditor cannot determine the total sample size or finish the work until year-end.

In the formula given above, the auditor needs the book value of the population to determine sample size. Unfortunately, the final book value is not known at an interim date. Still, ASI can be computed before year-end and used to select sample members even though the total sample size is not known until later.

Recall that:

$$ASI = \frac{BV}{n} \text{ or } n = \frac{BV}{ASI} \text{ and that } n = \frac{UEL \text{ factor} \times BV}{M}$$

$$\text{Therefore, } \frac{BV}{ASI} = \frac{UEL \text{ factor} \times BV}{M} \text{ and } ASI = \frac{M}{UEL \text{ factor}}$$

Thus, ASI can be determined without knowledge of the book value of the population. It is then used as in Table 2 to select units for testing.

In the sales invoice examples, ASI is computed for use in interim testing by dividing materiality of 2500 by 2.31, the UEL factor. The result, 1082, is quite close to the ASI of 1077 computed earlier. After selecting a random number corresponding to a dollar unit between 1 and 1082, the auditor chooses every 1082th dollar for testing. This continues until the dollars comprising the book value of sales invoices at the interim date are exhausted. At year-end, the remaining invoices are added to the interim group and the auditor continues testing through the entire population. At that time, the final sample size is known.

EVALUATING THE RESULTS

Once the DUS sample is selected, the auditor performs the test procedures. The results are evaluated when the entire sample has been tested. The achieved upper error limit (achieved UEL), the auditor's best estimate of the possible amount of error in the population, is then calculated. By comparing achieved UEL to materiality, the amount of error the auditor is willing to tolerate in the population, the auditor can decide whether to accept the client's assertion that the book value of the population is fairly stated. To illustrate the evaluation of the results, suppose that, in independent cases, the auditor

discovers no errors, one large (100%) error, one moderate (less than 100%) error, and two moderate errors in the sample.

No Errors

Assume that no errors are found in the sample in the sales invoice example. Although the sample has no errors, there may still be error in the untested remainder of the population. The amount of error must be estimated. The amount of possible error in the population when zero sample errors are found is termed basic precision (BP). BP equals achieved UEL when no errors are located in the sample.

Achieved UEL is calculated by multiplying the appropriate UEL factor in Table 1 by ASI. In the sales invoice example, the UEL factor for 90% confidence and zero errors is 2.31. Thus:

Factor	x	ASI	=	Achieved UEL
2.31	x	1077	=	2488

Although no errors were found in the sample, there may be, at 90% confidence, as much as \$2,488 in error. The auditor may conclude:

Based on the sample results, and at a confidence level of 90%, the errors in the sales invoice population do not exceed \$2,488.

One Error--100%

Assume now that the auditor finds one \$100 invoice that is completely erroneous; it is 100% overstated. There are two ways to calculate achieved UEL for one 100% error. In the first, the achieved UEL is calculated by multiplying the UEL factor for one error at 90% confidence by ASI. The calculation is:

UEL				
Factor	x	ASI	=	Achieved UEL
3.89	x	1077	=	4190

Achieved UEL can also be computed by breaking it down into three components: basic precision, most likely error, and precision gap widening. Each is discussed below, and Figure 1 summarizes their relationships.

Basic precision (BP) was explained above. It remains the same regardless of the number of errors found in the sample. At 90% confidence, BP is 2.31 (UEL factor) x 1077 (ASI). For our example population, for any number of errors, BP is \$2,488.

Most likely error (MLE) is an estimate, based on the errors found in the sample, of the dollar amount of error in the population. MLE is calculated by multiplying the number of sample errors times ASI. In the example with one error, then, we have:

Number of Sample Errors	x	ASI	=	MLE
1	x	1077	=	1077

Figure 1
Components of Achieved UEL

Component	How to Calculate ¹	Example ²
BP (basic precision) -the amount of possible error in the population when zero errors are found in the sample.	UEL factor ³ for 0 errors and selected confidence level x ASI	$2.31 \times 1077 = \$2488$
MLE (most likely error) -estimation, based on errors in the sample, of the dollar amount of error in the population.	$1.00 \times \text{ASI}$	$1.00 \times 1077 = \$1077$
PGW (precision gap widening)-amount achieved UEL is increased because errors are found in the sample.	PGW factor ³ for one error and selected confidence level x ASI	$.58 \times 1077 = \$ 625$
Achieved UEL (achieved upper error limit) -the amount of possible error in the population	Sum of the three components	$\$4190$

¹For one 100% error.

²One 100% error, book value of population = \$84,000, 90% confidence, ASI = 1077.

³From Table 1.

One error was found in a sample of 78 one-dollar units. Since the population is 1077 times as large as the sample, it is most likely that 1077 one-dollar units are in error.

Precision gap widening is the amount by which the achieved UEL must be increased because errors are found. As more errors are located, the measure of the possible error in the population becomes less precise. It follows that error is easier to estimate in an accurate population than in one that contains many errors. PGW is calculated by multiplying the PGW factor from Table 1 by ASI. For the invoice example, the PGW factor for 90# confidence and one error is .58 and PGW is:

PGW					
factor	x	ASI	=	PGW	
.58	x	1077		625	

To calculate achieved UEL, the auditor sums BP, MLE, and PGW as shown in Table 3 and Figure 1. The result, \$4,190, is identical to achieved UEL found by multiplying the UEL factor by ASI.

Table 3
Achieved UEL for One 100% Error

	<u>Factor*</u>	x	<u>ASI</u>	=	<u>Dollar Conclusion</u>
BP	2.31		1077		\$2488
MLE	1.00		1077		1077
PGW	.58		1077		625
Achieved UEL	3.89		1077		\$4190

*At 90% confidence

One Error--Less than 100%

Suppose that, in the sample of 78, one overstatement error of \$25 in an invoice of \$100 was found. In DUS samples, units in error are said to be "tainted." A tainting factor (t) is computed by dividing the error amount by the book value of the sample item for each item in error. In this example, t is .25 (\$25/\$100).

The tainting factor is taken into account when calculating two of the three components of achieved UEL: MLE and PGW. BP is not affected by tainting. The MLE and PGW factors are multiplied by t and then by ASI in finding a dollar conclusion. Table 4 shows the calculation.

Table 4
Achieved UEL for of One 25% Error

	<u>Factor*</u>	x	<u>t</u>	x	<u>ASI</u>	=	<u>Dollar Conclusion</u>
BP	2.31		1.00		1077		\$2488
MLE	1.00		.25		1077		269
PGW	.58		.25		1077		<u>156</u>
Achieved UEL							\$2913

*At 90% confidence

Two points about this calculation should be noted. First, when computing the achieved UEL for zero errors or for only 100% errors, the auditor does not have to determine BP, MLE, and PGW individually. Achieved UEL can simply be figured by multiplying the UEL factor in Table 1 by ASI. In cases where the tainting factor differs from 1.00 (a 100% error), however, BP, MLE, and PGW must be computed since the tainting factor affects the results. Second, compare Tables 3 and 4, which show the calculations of achieved UEL for one 100% error and for one 25% error, respectively. Intuitively, one would expect that the total estimated error would be higher in a population in which the sample revealed one 100# error in an invoice of \$100 than in a population in which one 25% error in an invoice of the same size was found. Note that this is true; the sample of one 100# error has an achieved UEL of \$4,190, and the one 25% error sample shows an achieved UEL of \$2,913.

Two Errors

For DUS samples in which more than one error is found, all errors are considered when calculating achieved UEL. The errors are ranked in descending order by the tainting factor. For example, assume two errors with tainting factors of .50 and .25 are found. BP remains the same regardless of the number of errors or the tainting factors. MLE and PGW each involve two calculations: one for each error. The PGW factors are applied to the tainting factors in order. That is, the PGW factor for one error is multiplied by the largest tainting factor (.50), and the PGW factor for two errors is multiplied by the second tainting factor (.25). Table 5 shows the calculation.

Comparing Achieved UEL and Materiality

After computing the achieved UEL, the auditor compares the figure to materiality. By considering the best estimate of the possible extent of error in the population with the amount of tolerable error, the auditor can decide whether to accept the book value of the population as fairly stated or not. If achieved UEL exceeds materiality, the auditor may request that the client adjust the book value for the audit area.

Table 5
Evaluation of Two Errors
Taintings of .50 and .25

	<u>Factor*</u>	x	<u>t</u>	x	<u>ASI</u>	=	<u>Dollar Conclusion</u>	<u>Total of UEL Component</u>
BP	2.31		1.00		1077		2488	\$2488
MLE	1.00		.50		1077		539	
	1.00		.25		1077		269	\$ 808
PGW	.58		.50		1077		312	
	.44		.25		1077		118	<u>\$ 430</u>
Achieved UEL								\$3726

*At 90% confidence

Note: Tainting factors (t) must be evaluated in descending order.

IS DUS APPROPRIATE?

Despite the ease of application and the several advantages of DUS, there may be situations in which another technique should be used. The warnings below are meant to aid the auditor in determining if DUS is the best method in a particular audit situation, not to discourage its use. DUS is especially effective in finding overstatement errors; it is not as well suited to locating understatement errors. Large accounts, which may be erroneously stated because of overstatements, have a high chance of being selected for testing. In contrast, small accounts, which may be small because of understatement errors, have a proportionately smaller chance of being chosen for a DUS sample. If the auditor is concerned with understatement errors, a sampling method based on physical unit selection is more effective.

Another concern with DUS, closely related to the first, is that DUS fails to locate errors in accounts with zero balances. This problem is not unique to DUS; it is found in other sampling techniques as well. Auditors utilize methods other than sampling to find large understatement errors. For example, if there is concern over unrecorded liabilities, the auditor might confirm accounts with zero balances currently but which had a balance at the prior year-end.

A further aspect of DUS that should be considered is the assumption that material errors are hidden in the large accounts.⁴ If the auditor thinks many small errors are incorporated in small accounts which, when added together, may be material, traditional sampling techniques using physical units are more appropriate.

A final concern with DUS is associated with one of its primary advantages: the results are stated monetarily. In some instances, error rate conclusions may be needed, and an attribute method should be employed.

DISCUSSION AND CONCLUSION

This article presents an introduction to dollar unit sampling. Although it may appear at first that the auditor must make many determinations in

applying DUS, several of the decisions are common to all sampling methods. The objectives of the test, definitions of the population and of errors, materiality, confidence level, book value of the population, number of physical units in the population, and number of expected errors are all specified in traditional sampling plans as well as in DUS. The principle difference between DUS and other statistical sampling methods is in the definition of the sampling units as one-dollar units rather than as physical units. Other important differences are the formal inclusion of materiality in planning the sample and the use of tainting factors in the evaluation process.

DUS is easily understood and it is simple to use. The method is efficient; it automatically selects large physical units for the sample and often tests more dollars of a population than other methods of the same sample size. Under DUS, several accounts can be audited together. Interim testing is easily implemented and coordinated with year-end audit procedures. The conclusion regarding the fairness of the book value of the population is given in dollar terms and is statistically valid and objective. Because of the ease in understanding and applying DUS, auditors should strive to utilize this statistical tool on their audit engagements.

FOOTNOTES

1. Anderson, R. J. and A. D. Teitlebaum. "Dollar-Unit Sampling: A Solution to the Audit Sampling Dilemma," C.A. Magazine, April, 1973, p. 36.
2. Guy, Dan M. An Introduction to Statistical Sampling in Auditing, New York, John Wiley & Sons, Inc., 1981, p. 183.
3. Auditing Standards Board, Statement on Auditing Standards 47, "Audit Risk and Materiality in Conducting an Audit," AICPA, December, 1983.
4. Glenn, E. Grifton, III. "Dollar-Unit Sampling," Georgia Journal of Accounting, Spring, 1981, p. 184.