UNIT 17 SAMPLING THEORY

Structure

17.0 OBJECTIVES

After going through this unit, you will be able to answer the following:

- what is sample survey and what are the advantages of it over the total enumeration;
- how to design a sample and what the probable biases that can occur in conducting sample survey;
- different types of sampling and their relative merits and demerits;
- a brief idea of parameter, statistic and standard error; and
- expectations and standard deviation of sample mean and proportion.

17.1 INTRODUCTION

Before giving the notion of sampling, we'll first define population. In a statistical investigation interest generally lies in the assessment of the general magnitude and the study of variation with respect to one or more characteristics relating to individuals belonging to a group. The group of individuals under study is called population or universe. Thus, in statistics, population is an aggregate of objects, animate or inanimate, under study. The population may be finite or infinite.

It is obvious that for any statistical investigation complete enumeration of the population is rather impracticable. For example, if we want to have an idea of the average per capita (monthly) income of the people in India, we will have to enumerate all the earning individuals in the country, which is rather a very difficult task.

If the population is infinite, complete enumeration is not possible. Also if the units are destroyed in the course of inspection (e.g., inspection of crackers, explosive materials etc.), 100% inspection, though possible, is not at all desirable. But even if the population is finite or the inspection is not destructive, 100% inspection is not taken recourse to because of multiplicity of causes viz., administrative and financial complications, time factor, etc.; in such cases, we take the help of sampling.

A finite subset of statistical individuals in a population is called a sample and the number of individual in a sample is called the sample size.

For the purpose of determining population characteristics, instead of enumerating the entire population, the individuals in the sample are only observed. Then the sample characteristics are utilized to approximately determine or estimate the population. For example, on examining the sample of a particular stuff we arrive at a decision of purchasing or rejecting that stuff. The error involved in such approximation is known as sampling error and is inherent and unavoidable in any sampling scheme. But sampling results in considerable gains, especially in time and cost not only in respect of making observations of characteristics but also in the subsequent handling of the data.

Sampling is quite often used in our day-to-day practical life. For example, in a shop we asses the quality of sugar, wheat or any other commodity by taking a handful it from the bag and then decide to purchase or not. A housewife normally tests the cooked products to find if they are properly cooked and contain the proper quantity of salt.

17.2 ADVANTAGE OF SAMPLE SURVEY

Sample survey has some significant advantages over doing complete enumeration or census study. The following are the some of the advantages of sample survey:

i) Reduction of cost: Since size of the sample is far less than the entire population, so to do the sample survey less number of staff and time is required that reduces the cost associated with it.

ii) Better scope for information: In the sample survey, the surveyor has the scope of interacting more with the sample households, thus can have better information in any particular issue than that in census method. In the census method due to time constraint and financial inadequacy, the surveyor cannot afford much time to any particular household to get better information.

iii) Better quality of data: In the census method, due to time constraint, we do not get good quality of data. But in sample survey, one can have a better quality of data as the survey consists of all the information related to objective of the study.

iv) Gives an idea of the error: For the population, we do not have a standard error, but for the sample we do have a standard error. Given the information of the sample mean and standard error, we can construct the limit within which almost all the sample value will lie.

v) Lastly, the population may be hypothetical or infinite. So to avoid the problems associated with complete enumeration, sample survey is the best alternative to do any statistical analysis.

17.3 SAMPLE DESIGNS

Two things to be required to plan a survey – one is validity, i.e., we must review the valid answers to the questions that we are looking at. And the second is optimising cost and efficiency. It is very obvious that cost increases with the sample size. Whereas efficiency, which is measured by inverse of variance of the estimator (e.g., $v(\bar{x}_n) = \sigma^2/n$) decreases with the sample size. If the sample size increases, then values tend to stick around a central value, thus variance decreases. Now from the cost point of view less number of samples is desirable while from efficiency point of view large number of samples is desirable. So given these two opposite facts, we have to design the sample in order to collectively optimise the constraints.

Sample survey is done in three different stages. The first and the foremost is the planning stage which includes –

- **Defining the objective:** the prime most important thing is to determine the objective of the survey, otherwise, the process cannot be initiated.
- **Defining the population:** It is necessary to define the population of which sample is to be collected so as to make the survey easier otherwise, extra cost will be incurred for an expanded sample set.
- **Determination of the data to be collected:** Before starting the survey the target group has to define, otherwise, the sample collected would not be the representative one.
- **Determining of the method of collecting data:** There can be two methods of collecting data; questionnaire method and interview method. Both of these methods have some demerits. In the questionnaire method the responder may not respond at all or may respond partly. In that case, those observations have to be excluded for better analytical results though there can be a risk of inadequate sample observations.
- **Choice of the sampling units:** Sampling unit has to be chosen on the basis of the objective so that surveying can be done easily.
- **Designing the survey:** It has two parts, (i) conducting a pilot survey, where small scale survey is done before the original survey so as to have a brief idea about the survey; and (ii) deciding on the flexible variables, where target group should be chosen so as to capture the exact information as far as possible.
- **Drawing the sample:** The easiest way to draw a sample is to identifying each sample unit with a given number; then putting the numbers in a urn and mix them up and draw out the required number of sample size.

17.4 BIASES IN THE SURVEY

There can be two types of biases in the sample survey –

i) **Procedural bias:** Procedural bias can be in the form of response bias, where people do not tend to respond properly; observational bias, where sample chosen are not representative of the population. Very often either of the two occurs. There can be other types of procedural biases also, like, non-response bias, where people do not respond at all; and interviewer bias, where the interviewer collects the information with a biased frame of mind.

ii) **Sampling bias:** There can be three types of sampling biases: (i) wrong choice of type of sampling, where collected information may not have statistical significance; (ii) wrong choice of the statistic, where test statistic chosen is not statistically correct; and (iii) wrong choice of the sampling units, which could make the sampling difficult to conduct.

Check Your Progress 1

1) List the advantages of sample survey.

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2) What do you mean by sample designs?

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3) What could be the types of bias you face in sample survey?

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17.5 TYPES OF SAMPLING

Some of the commonly known and frequently used types of sampling are:

(i) Purposive sampling, (ii) Random sampling, (iii) Stratified sampling, and (iv) Systematic sampling.

Let us explain these terms precisely.

***Purposive sampling*:**

Purposive sampling is one in which the sampling units are selected with definite purpose in view. For example, if we want to show that the standard of living has increased in the city, New Delhi, we may take individuals in the sample from rich and posh localities and ignore the localities where low-income group and the middle class families live. This sampling suffers from the drawback of favouritism and nepotism and does not give a representative sample of the population.

***Stratified sampling*:**

Here the entire heterogeneous population is divided into a number of homogeneous groups, usually termed as '*strata*', which differ from one another but each of these groups is homogeneous within itself. Then units are sampled in random from each of these stratum, the sample size in each stratum varies accordingly to the relative importance of the stratum in the population. The sample, which is the aggregate of the sampled units of each of the stratum, is termed as stratified sample and the technique of drawing this sample is known as stratified sampling. Such a sampling is by far the best and can safely be considered as representative of the population from which it has been drawn.

***Random sampling*:**

In this case, the sample units are selected at random and the drawback of purposive sampling, viz., favouritism or subjective element, is completely overcome. A random sample is one in which each unit of population has an equal chance of being included in it. Suppose we take a sample of size n from a finite population of size N. Then there are $^{N}C_{n}$ possible samples. A sampling technique in which each of the $^{N}C_{n}$ samples has an equal chance of being selected is known as random sampling and the sample obtained by this technique is termed as random sample.

Proper care has to be taken to ensure that the selected sample is random. Human bias, which varies from individual to individual, is inherent in any sampling scheme administered by human beings. Fairly good random samples can be obtained by the use of *Tippet's random numbers tables* or by throwing of a dice, draw of a lottery, etc. The simplest method, which is normally used, is the lottery system; it is illustrated below by means of an example.

Suppose we want to select r candidates out of n. we assign the numbers 1 to n, one number to each candidate and write this numbers (1 to n) on n slips which are made as homogeneous as possible in shape, size, etc. These slips are then put in a bag and thoroughly shuffled and the r slips are drawn one by one. The r candidates corresponding to the number on the slips drawn will constitute the random sample.

Note: *Tippet's random number tables* consist of 10400 four-digit numbers, giving in all 10400 × 4, i.e., 41600 digits, taken from the British census reports. These tables have proved to be fairly random in character. Any page of the table is selected at random and the number in any row or column or diagonal selected at random may be taken to constitute the sample.

***Simple sampling*:**

Simple sampling is random sampling in which each unit of the population has an equal chance, say 'p', of being included in the sample and that this probability is independent of the previous drawings. Thus, a simple sample of size n from a population may be identified with a series of n independent trials with constant probability 'p' of success for each trial.

Note: It should be noted that random sampling does not necessarily imply simple sampling though, obviously, the converse is true. For example, if an urn contains 'a' white balls and 'b' black balls, the probability of drawing a white ball at the first draw is [a/(a+b)] = p_1 (say) and if this ball is not replaced the probability of getting a white ball in the second draw is [(a-1)/(a+b-1)] = $p_2 \neq p_1$. This sampling is not simple, but since in the first draw each white ball has the same chance, viz. a/(a+b), of being drawn and in the second draw again each white ball has the same chance, viz. (a-1)/(a+b-1), of being drawn, the sampling is random. Hence in this case, the sampling, though random, is not simple. To ensure the sampling is simple, it must be done with replacement, if population finite. However, in case of infinite population no replacement is necessary.

17.6 PARAMETER AND STATISTIC

In order to avoid verbal confusion with the statistical constants of the population, viz., mean (μ), variance (σ^2), etc., which are usually referred to as 'parameters', statistical measure computed from the sample observations alone, e.g., mean $(\bar{x})$, variance (s^2), etc., have been termed by Professor R. A. Fischer as 'statistic'.

In practice, parameter values are not known and the estimates based on the sample values are generally used. Thus, statistic, which may be regarded as an estimate of parameter, obtained from the sample, is a function of the sample values only. It may be pointed out that a statistic, as it is based on sample values and as there are multiple choices of the samples that can be drawn from a population, varies from sample to sample. These differences in the values of a 'statistic' are called 'sampling fluctuations'. The determination of the characterisation of variation (in the values of the statistic obtained from different samples) that may be attributed to chance or fluctuations of sampling is one of the fundamental problems of the sampling theory.

Note: Now onwards, μ and σ^2 will refer to the population mean and variance respectively while the sample mean and variance will be denoted by $\overline{x}$ and s^2 respectively.

Check Your Progress 2

1) List the important types of sampling.

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2) Distinguish between random and stratified sampling.

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3) Differentiate between the parameter and statistic.

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17.7 SAMPLING DISTRIBUTION OF A STATISTIC

If we draw a sample of size 'n' from a given finite population of size 'N', then the total number of possible samples is:

$$^{N}C_{n} = N!/\{n!\,(N-n)!\} = k, \text{(say)}.$$

If for each sample, the value of the statistic is calculated, a series of values of the statistic will be obtained. If the number of sample is large, these may be arranged into frequency table. The frequency distribution of the statistic that would be obtained if the number of samples, each of the same size ('n'), were infinite is called the 'sampling distribution' of the statistic. In the case of random sampling, the nature of the sampling distribution of a statistic can be deducted theoretically, provided the nature of the population is given, from considerations of probability theory.

Like any other distribution, a sampling distribution may have its mean, standard deviations and moment of higher orders. Of particular importance is the standard deviation, which is designated as the 'standard error' of the statistic. As an illustration, in the next section we derive for the random sampling the means (expectations) and standard errors of a sample mean and sample proportion.

Some people prefer to use 0.6745 times the standard error, which is called the 'probable error' of the statistic. The relevance of the probable error stems from the fact that for a normally distributed variable x with mean μ and s.d σ,

$P[\mu - 0.6745\sigma \le x \le \mu + 0.6745\sigma] = 0.5$ (approximately).

17.8 STANDARD ERROR

The standard deviation of the sampling distribution of a statistic is known as its 'standard error', abbreviated as S.E. The standard errors of some of the well known statistics, for large samples, are given below, where 'n' is the sample size, σ^2 is the population variance, and P is the population proportion, and Q = 1-P. n_1 and n_2 represent the sizes of two independent random samples respectively drawn from the given population(s).

Sl. No.	Statistic	Standard Error
1.	Sample mean: $\bar{x}$	$\sigma/\sqrt{n}$
2.	Observed sample proportion: '*p*'	$\sqrt{\frac{PQ}{n}}$
3.	Sample s.d: '*s*'	$\sqrt{\sigma^2/2n}$
4.	Sample variance: s^2	$\sigma^2\sqrt{2/n}$
5.	Sample quartile	$1.36263\,\sigma/\sqrt{n}$
6.	Sample median	$1.25331\,\sigma/\sqrt{n}$
7.	Sample correlation coefficient	$(1-p^2)/\sqrt{n}$, *p* being the population correlation coefficient
8.	Sample moments μ_3	$\sigma^3\sqrt{96/n}$
9.	Sample moments μ_4	$\sigma^4\sqrt{96/n}$
10.	Sample coefficient of variation (*v*)	$\frac{v}{\sqrt{2n}}\sqrt{1+\frac{2v^3}{10^4}} \approx \frac{v}{\sqrt{2n}}$
11.	Difference of two sample means: $(\bar{x}_1 - \bar{x}_2)$	$\sqrt{\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2}}$
12.	Difference of two sample s.d.'s: (s_1-s_2)	$\sqrt{\frac{\sigma_1^2}{2n_1}+\frac{\sigma_2^2}{2n_2}}$
13.	Difference of the two sample proportions: (p_1-p_2)	$\sqrt{\frac{P_1Q_1}{n_1}+\frac{P_2Q_2}{n_2}}$

17.8.1 Utility of Standard Error

S.E plays a significant role in the large sample theory and forms the basis of the testing of hypothesis.

i) The magnitude of the standard error gives an index of the precision of the estimate of the parameter. The reciprocal of the standard error is taken as the measure of reliability or precision of the statistic.

ii) S.E. enables us to determine the probable limits within which the population parameter may be expected lie.

Check Your Progress 3

1) What are the mean and standard deviation of the sampling distribution of the mean?

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2) What is a standard error and why is it important?

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3) In a random sample of 400 students of the university teaching departments, it was found that 300 students failed in the examination. In another random sample of 500 students of the affiliated colleges, the number of failures in the same examination was found to be 300. Find out the S. E of the difference between proportion of failures in the university teaching departments and that of in the university teaching departments and affiliated colleges taken together.

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17.9 EXPECTATION AND STANDARD ERROR OF SAMPLE MEAN

Suppose a random sample of size 'n' is drawn from a given finite population of size 'N'. Let X_α (α = 1, 2, ..., N) be the value of the variable x for the α^{th} member of the population. Then the population mean of x is $\mu = (1/N)\sum_\alpha X_\alpha$,

and the population variance is $\sigma^2 = (1/N)\sum_\alpha (X_\alpha - \mu)^2$.

Again, let us denote by x_i (i=1, 2, ... , n) the value of x for the i^{th} member(i.e., the member selected at the i^{th} drawing) of the sample. The sample mean of x is then $\overline{x}=\frac{1}{n}\sum_{i=1}^{n}x_i$. For deriving the expectation and standard error of $\overline{x}$, we may consider two distinct cases:

***Case I: Random sampling with replacement*:**

For further correspondence, let us recall the following two theorems of the probability theory; (i) If y = bx, then E(y) = bE(x), and (ii) If x and y be two random variables and z a third random variable such that z = x + y, then E (z) = E(x) + E(y).

So from the above two results, it can be written that

$$E(\overline{x})=\frac{1}{n}\sum_{i=1}^{n}E(x_i) \text{ and } var(\overline{x})=E\{\overline{x}-E(\overline{x})\}^2$$

$$=(1/n^2)\,E\,[\sum_i\{x_i-E(x_i)\}]^2$$

$$=(1/n^2)\sum_i E\,\{x_i-E(x_i)\}^2+(1/n^2)\sum_{\substack{i,j\\ i\neq j}} E\,\{x_i - E(x_i)\}\{x_j-E(x_j)\}$$

$$=(1/n^2)\sum_i var(x_i)+(1/n^2)\sum_{\substack{i,j\\ i\neq j}}cov(x_i,x_j)$$

To obtain E (x_i) and var (x_i), we note that x_i can assume the values X_1, X_2, … , X_n, each with probability (1/N).

Hence $E(x_i)=\sum_\alpha X_\alpha\, P[x_i=X_\alpha]=\sum_\alpha X_\alpha \times (1/N)=\mu$ and

$var(x_i)=E(x_i-\mu)^2=P[x_i=X_\alpha]=\sum_\alpha(X_\alpha-\mu)^2\times(1/N)=\sigma^2$ for each i

Again $cov(x_i, x_j)=E(x_i-\mu)(x_j-\mu)$

$$=\sum_{\alpha,\alpha'}(X_\alpha-\mu)(X_{\alpha'}-\mu)\,P[x_i=X_\alpha, x_j=X_{\alpha'}]$$

Since in sampling with replacements the composition of the population remains the same throughout the sampling process, x_j can take any one of the values X_1, X_2, … , X_N, with probability (1/N), irrespective of the value taken by x_i. In other words, for $i\neq j$, x_i and x_j are independent, so that

$$P[x_i=X_\alpha, x_j=X_{\alpha'}]=P[x_i=X_\alpha]\,P[x_j=X_{\alpha'}]=(1/N^2)$$

Hence, $cov(x_i, x_j)=(1/N^2)\sum_{\alpha,\alpha'}(X_\alpha-\mu)(X_{\alpha'}-\mu)$

$$=(1/N^2)\sum_{\alpha}(X_\alpha-\mu)\sum_{\alpha'}(X_{\alpha'}-\mu)=0$$

For each i,j ($i\neq j$), since $\sum_{\alpha}(X_\alpha-\mu)=\sum_{\alpha'}(X_{\alpha'}-\mu)$, being the sum of the deviations of X_1, X_2, … , X_n from their mean is zero.

Hence, we have, finally, $E(\overline{x})=(1/n)\times n\,\mu=\mu$

and $var(\overline{x})=(1/n^2)\,n\sigma^2+(1/n^2)\,n(n-1)\times 0=\sigma^2/n$

The standard error of $\bar{x}$ is, therefore, $\sigma_{\bar{x}} = \sigma/\sqrt{n}$

Case II: Random sampling without replacement:

As before for each i, $E(x_i) = \mu$ and $var(x_i) = \sigma^2$,

since here too x_i can take any one of the values $X_1, X_2, \ldots, X_N$, with the same probability (1/N). The covariance term, however, needs special attention.

Here, for $i \neq j$

$$P[x_i = X_\alpha, x_j = X_{\alpha'}] = P[x_i = X_\alpha]\, P[x_j = X_{\alpha'} \mid x_i = X_\alpha]$$

$= (1/N)(1/(N-1))$ if $\alpha \neq \alpha'$ [since x_j can take any value except X_α, the value which is known to have been already assumed by x_i, with equal probability $1/(N-1)$]

$= 0$ if $\alpha = \alpha'$

Hence, $cov(x_i, x_j) = (1/N(N-1)) \sum_{\substack{\alpha,\alpha' \\ \alpha \neq \alpha'}} (X_\alpha - \mu)(X_{\alpha'} - \mu)$

$$= (1/N(N-1)) \sum_{\alpha} (X_\alpha - \mu)\{\sum_{\alpha'} (X_{\alpha'} - \mu) - (X_\alpha - \mu)\}$$

$$= (1/N(N-1)) \{\sum_{\alpha} (X_\alpha - \mu) \sum_{\alpha'} (X_{\alpha'} - \mu) - \sum_{\alpha} (X_\alpha - \mu)^2\}$$

$$= -(1/N(N-1))\, N\sigma^2 = -\sigma^2/(N-1)$$

Thus, in this case we have $E(\bar{x}) = (1/n)\, n\, \mu = \mu$

and $var(\bar{x}) = (1/n^2) \times n\sigma^2 + (1/n^2) \times n(n-1) \times (-\sigma^2/(N-1))$

$$= (\sigma^2/N)\{1 - (n-1)/(N-1)\}$$

$$= (\sigma^2/N)\{(N-n)/(N-1)\}$$

Hence the standard error of $\bar{x}$ is $\sigma_{\bar{x}} = (\sigma/\sqrt{n})\sqrt{1 - \frac{N-n}{N-1}}$

In both the cases, the standard error decreases with increasing n. The standard error of the mean in sampling without replacements is, however, smaller than that in sampling with replacements. But the difference become negligible if N is very large compared to n. Also, in sampling without replacements, the standard error of the sample mean vanishes if n = N, which is to be expected because the sample mean now becomes a constant, i.e., the same as the population mean. However, this is not the case with sampling with replacements.

17.10 EXPECTATION AND STANDARD ERROR OF SAMPLE PROPORTION

Suppose in population of N. there are Np members with a particular character A and Nq members with the character not-A. Then p is the proportion of members in the population having the character A. Let a sample of size n be drawn from the population, and let f be the number of members in the sample having character A. To find the expectation and standard error of the sample proportion f/n, we adopt the following procedure.

We assign to the α^{th} member of the population the value X_α, which is equal to 1 if, this member possesses the character A and equal to 0 otherwise. Similarly, to the i^{th} member of the sample we assign the value x_i, which is equal to 1 if this member possesses A and is equal to 0 otherwise.

In this way, we get a variable x, which has population mean $(1/N)\sum_\alpha X_\alpha = p$

and the population variance $(1/N)\sum_\alpha X_\alpha^2 - p^2 = p - p^2 = pq$

The sample mean of the variable x, on the other hand, is $\frac{1}{n}\sum_{i=1}^{n} x_i = f/n$

Hence we find, on replacing $\bar{x}$ by f/n, μ by p and σ^2 by pq in the expressions $E(\bar{x})$ and $\sigma_{\bar{x}}$ given in preceding sections,

$E(f/n) = p$ [in case of random sampling with replacement]

$= p$ [in case of random sampling without replacement]

$\sigma_{f/n} = pq/\sqrt{n}$ [in case of random sampling with replacement]

$= \sqrt{\frac{pq}{n}\left(1 - \frac{N-n}{N-1}\right)}$ [in case of random sampling without replacement]

The comments made in connection with the standard error of the mean apply here also.

Check Your Progress 4

1) Discuss the meaning of random sampling with replacement and without replacement.

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2) Write the standard error of sample proportion.

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17.11 LET US SUM UP

Throughout this unit we have learnt the basic concepts of sampling theory. It tells about different types of sampling along with the method of drawing sample. Moreover, one can also be able to understand the concept of standard error and mean & standard deviation of sample mean and sample proportion.

17.12 KEY WORDS

Population: In statistics, population is an aggregate of objects, animate or inanimate, under study. The population may be finite or infinite.

Purposive Sampling: Purposive sampling is one in which the sampling units are selected with definite purpose in view.

Random Sampling: A random sampling is one in which each unit of population has an equal chance of being included in it.

Sample: A finite subset of statistical individuals in a population is called a sample and the number of individual in a sample is called the sample size.

Standard Error: The standard deviation of the sampling distribution of a statistic is known as its 'standard error', abbreviated as S.E.

Stratified Sampling: Here the entire heterogeneous population is divided into a number of homogeneous groups, usually termed as *strata*', which differ from one another but each of these groups is homogeneous within itself.

17.13 SOME USEFUL BOOKS

Goon A.M, Gupta M.K & Dasgupta B. (1971), *Fundamental of Statistics*, Volume I, The World Press Pvt. Ltd., Calcutta.

Freund, John E. (2001), *Mathematical Statistics*, Fifth Edition, Prentice-Hall of India Pvt. Ltd., New Delhi.

Das, N.G. (1996), *Statistical Methods*, M.Das & Co. (Calcutta).

17.14 ANSWER OR HINTS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) See Section 17.2
2) See Section 17.3
3) See Section 17.4

Check Your Progress 2

1) See Section 17.5
2) See Section 17.5
3) See Section 17.6

Check Your Progress 3

1) See Section 17.7
2) See Section 17.8
3) [Hint: n_1 =400 and n_2 =500, p_1 =300/400 =0.75, p_2=300/500=0.6
   $p = (n_1p_1+n_2p_2)/(n_1+n_2) = 0.67$, $q = 1-p$; S. E $(p-p_1) = \sqrt{[((pq)/(n_1+n_2))(n_2/n_1)]} = 0.018$]

Check Your Progress 4

1) See Section 17.9
2) See Section 17.10

17.15 EXERCISES

1) A random sample of 500 pineapples was taken from a large consignment and 65 were found to be bad. Show that S.E. of the proportion of bad ones in a sample of this size is 0.015 and deduce that the percentage of bad pineapples in the consignment almost certainly lies between 8.5 and 17.5.
2) How does one get from a sample statistic to an estimate of the population parameter?
3) What is sampling error?
4) What is random sampling error?
5) What is a systematic error?
6) How is the sampling error or standard error determined?
7) What is sample size important?
8) What is sample size?
9) What is bias?