Session 03

Bias in Survey Sampling

In survey sampling, **bias** refers to the tendency of a sample statistic to systematically over- or under-estimate a population parameter.

Bias Due to Unrepresentative Samples

A good sample is **representative**. This means that each sample point represents the attributes of a known number of population elements.

Bias often occurs when the survey sample does not accurately represent the population. The bias that results from an unrepresentative sample is called **selection bias**. Some common examples of selection bias are described below.

- **Undercoverage**. Undercoverage occurs when some members of the population are inadequately represented in the sample. A classic example of undercoverage is the *Literary Digest* voter survey, which predicted that Alfred Landon would beat Franklin Roosevelt in the 1936 presidential election. The survey sample suffered from undercoverage of low-income voters, who tended to be Democrats.

  How did this happen? The survey relied on a convenience sample, drawn from telephone directories and car registration lists. In 1936, people who owned cars and telephones tended to be more affluent. Undercoverage is often a problem with convenience samples.

- **Nonresponse bias**. Sometimes, individuals chosen for the sample are unwilling or unable to participate in the survey. Nonresponse bias is the bias that results when respondents differ in meaningful ways from nonrespondents. The *Literary Digest* survey illustrates this problem. Respondents tended to be Landon supporters; and nonrespondents, Roosevelt supporters. Since only 25% of the sampled voters actually completed the mail-in survey, survey results overestimated voter support for Alfred Landon.

  The *Literary Digest* experience illustrates a common problem with mail surveys. Response rate is often low, making mail surveys vulnerable to nonresponse bias.

- **Voluntary response bias**. Voluntary response bias occurs when sample members are self-selected volunteers, as in voluntary samples. An example would be call-in radio shows that solicit audience participation in surveys on controversial topics (abortion, affirmative action, gun control, etc.). The resulting sample tends to overrepresent individuals who have strong opinions.

Bias Due to Measurement Error

A poor measurement process can also lead to bias. In survey research, the measurement process includes the environment in which the survey is conducted, the way that questions are asked, and the state of the survey respondent.

Response bias refers to the bias that results from problems in the measurement process. Some examples of response bias are given below.

- **Leading questions**. The wording of the question may be loaded in some way to unduly favor one response over another. For example, a satisfaction survey may ask the respondent to indicate where she is satisfied, dissatisfied, or very dissatified. By giving the respondent one response option to express satisfaction and two response options to express dissatisfaction, this survey question is biased toward getting a dissatisfied response.

- **Social desirability**. Most people like to present themselves in a favorable light, so they will be reluctant to admit to unsavory attitudes or illegal activities in a survey, particularly if survey results are not confidential. Instead, their responses may be biased toward what they believe is socially desirable.

Sampling Error and Survey Bias

A survey produces a sample statistic, which is used to estimate a population parameter. If you repeated a survey many times, using different samples each time, you would get a different sample statistic with each replication. And each of the different sample statistics would be an estimate for the *same* population parameter.

If the statistic is unbiased, the average of all the statistics from all possible samples will equal the true population parameter; even though any individual statistic may differ from the population parameter. The variability among statistics from different samples is called **sampling error**.

Suppose a population of 10 bolts has diameter measurements of 9, 11, 12, 12, 14, 10, 9, 8, 7, and 9 mm. The mean μ for that population would be 10.1 mm. If a sample of only three measurements—9, 14, and 10 mm—is taken from the population, the mean of the sample would be (9 + 14 + 10)⁄3 = 11 mm and the sampling error (E) would be

$$E = X - \mu = 11 - 10.1 = 0.9$$

Take another sample of three measurements—7, 12, and 11 mm. This time, the mean will be 10 mm and the sampling error will be

$$E = X - \mu = 10 - 10.1 = -0.1$$

If another sample is taken and estimated, its sampling error might be different. These differences are said to be due to chance.
We have seen in the example of the bolt diameters that the mean of the first sample was 11 mm and the mean of the second was 10 mm. In that example, we had 10 bolts, and if all possible samples of three were computed, there would have been 120 samples and means.

$${}_N C_n = \frac{N!}{n!\,(N-n)!} = \frac{10!}{3!(10-3)!} = 120$$

Exercise. Based on the population given in Table 3, what is the sampling error for the following samples: (9, 15), (12, 16), (14, 15), and (13, 15).

Table 3:

9	12	14	13	12	16	15

So if it is possible to make mistakes while estimating the population's parameters from a sample, how can we be sure that sampling can help get a good estimate? Why use sampling as a means of estimating the population parameters?

The Central Limit Theorem can help us answer these questions.