Pacific Training on Sampling Methods for Producing Core Data Items for Agricultural and Rural Statistics

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Module 2: Review of Basics of Sampling Methods
Session 2.7: Standard Errors & Bias

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Topics Covered

- Things which contribute to the error of an estimate
  - Sampling error
  - Non-sampling error
- Examples of Sampling error formulas
- What is Bias?
  - Impact on estimates

How accurate are the estimates

* There are two main sources of error which impact on the quality of our estimates
  * Sampling error
  * Non-sampling error

* Sampling error – the error attributed to the fact that a sample of units were selected for the survey as opposed to a census
* Non-sampling error – all other errors associated with the results

Non-sampling errors

* Some common forms of non-sampling error include:
  * Field enumeration error
  * Respondent error
  * Questionnaire design problems
  * Data processing errors
  * Sample selection and response bias
  * etc

Sampling error

- As discussed, this is the error in the estimates, generated by taking a sample of units as opposed to complete enumeration
- Unlike the non-sampling error, which is extremely difficult to measure, we can estimate a measure for the magnitude of the sampling error if we know things like:
  - Population size
  - Sample size
  - Sample selection methodology
  - Degree of variation in the response data

Sampling Error (cont)

- In order to determine what the sampling error (or standard error) is for an estimate, we first need to calculate the variance of the estimate
- The standard error is then simply the square root of the variance

$$SE(Y) = \sqrt{Var(Y)}$$

Sample Error for a Simple Random Sample

$$Var(\hat{Y}) = \frac{N^2}{n}(1 - n/N)s_y^2$$

$$s_y^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n - 1}$$

Sampling error

* The formula for the variance of a two-stage survey design involving PPS sampling at the first stage and a fixed cluster size of households at the second stage is:

$$\text{Var}(Y) = \frac{M^2}{m}\overline{N}\sigma_b^2 + \frac{N}{n}\sum_{i=1}^{M} N_i\left(1 - \frac{\overline{n}}{N_i}\right)S_i^2$$

Link between Estimate, Sampling Error and Relative Sampling Error

$$SE(\hat{Y}) = SQRT\ (Var(\hat{Y}))$$

$$RSE(\hat{Y}) = \frac{SE(\hat{Y})}{Est(\hat{Y})}\ x\ 100$$

Interpreting a RSE

* A user will often want to know how to interpret the accuracy of an estimate, with respect to the RSE
* If RSE < 5% It's a reliable estimate
* If 5% < RSE < 10% It's still good
* If 10% < RSE 20% It's usable
* If RSE > 20% Not overly reliable

Bias

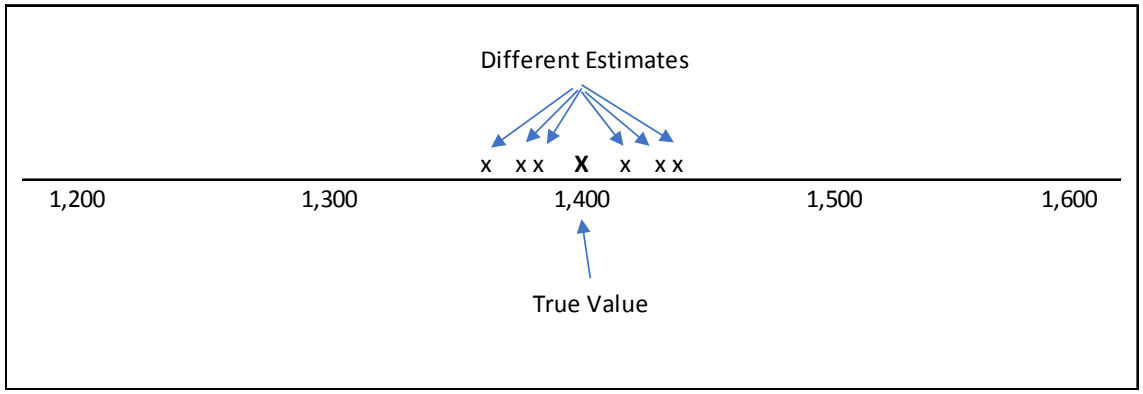
Definition

* Bias is occuring if you produce numerous values of the same estimate, and you repeatedly come up with something higher (or lower) than the true value

* Two main things often contribute to a bias being generated in a survey
  * Poor sample selection
  * Non-response

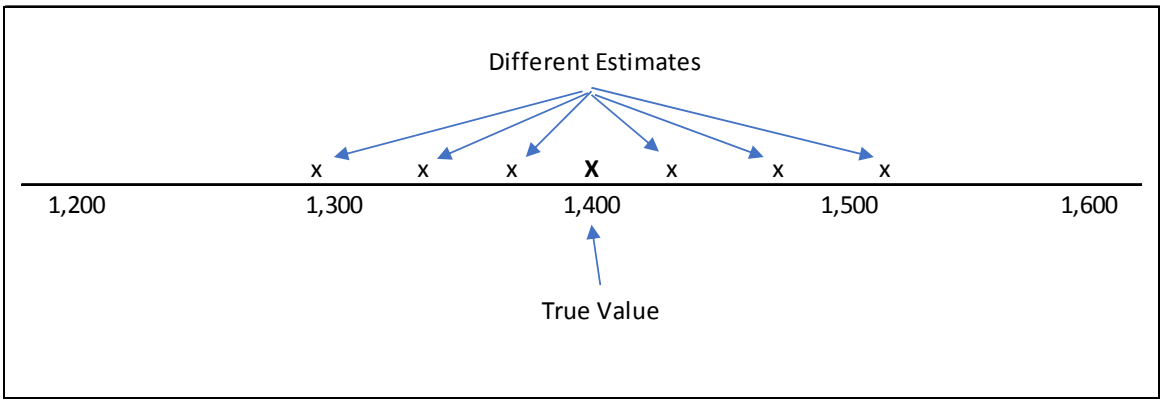
What happens to the estimates?

Scenario 1: Small sample error & small bias



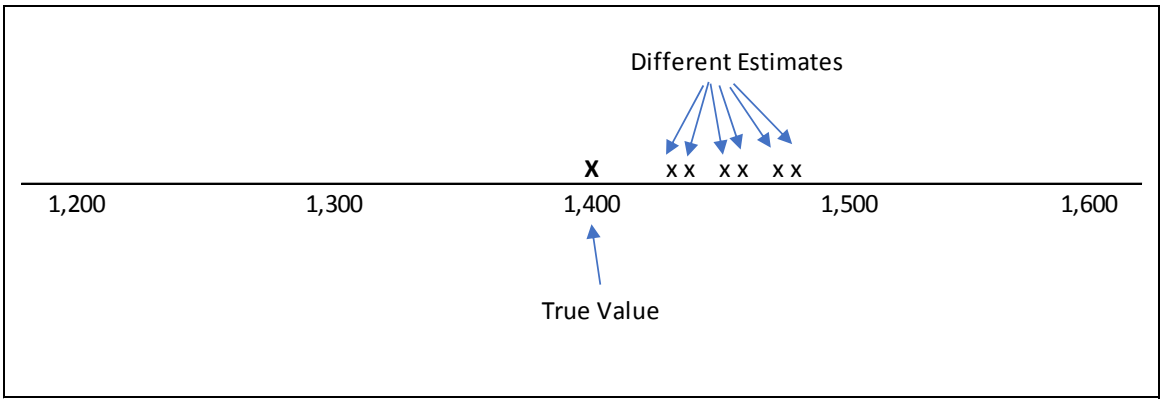
What happens to the estimates?

Scenario 2: Large sample error & small bias



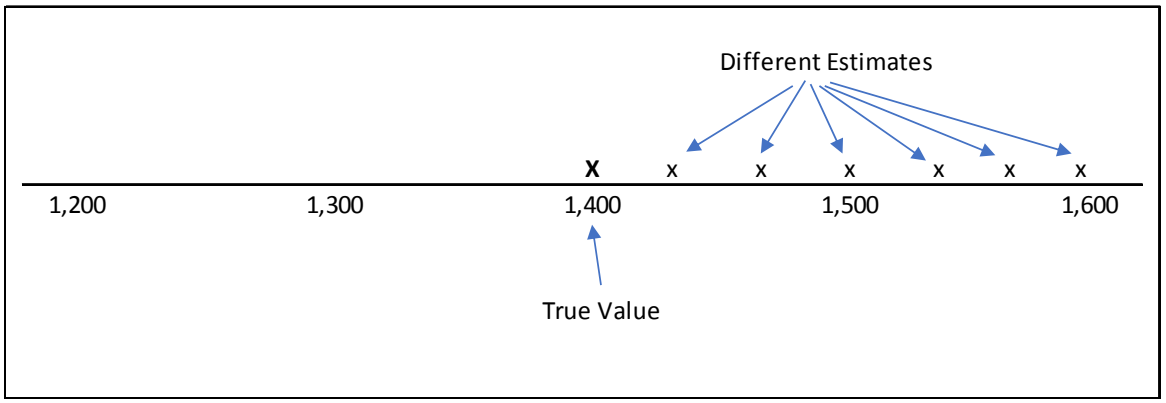
What happens to the estimates?

Scenario 3: Small sample error & large bias



What happens to the estimates?

Scenario 4: Large sample error & Large bias



An example of selection bias

* Suppose the Department of Fisheries want to run a household survey to determine fish catches by non-commercial fisherman in Samoa
  * The question they ask relates to the fish catches over the last week
* Also suppose that Samoa is made up of:
  * 150 coastal villages
  * 150 inland villages

An example of selection bias (cont)

* The Department of Fisheries decide to select only coastal villages because they believe they make-up most of the non-commercial fishing activity

* Let us assume the following:
  * Average fish catches by households living in coastal villages for the last week was: *70kg*
  * Average fish catches by households living in inland villages for the last week was: *30kg*

An example of selection bias (cont)

* The population and sample counts for the two regions are:

Coastal villages
* Population: 10,000 households
* Sample: 1,000 households

Inland villages
* Population: 10,000 households
* Sample: 0 households

An example of selection bias (cont)

The true value of Fish catch

True Value (Fish catch) = (10,000 x 70) + (10,000 x 30)
= 700,000 + 300,000
= 1,000,000

The estimation procedure would be

If the DoF weighted up to the total population

Est(Fish catch) = N/n x fish catch in sample
= 20,000/1,000 * (70 x 1,000)
= 1,400,000