Work Sampling

Sections:

1. How Work Sampling Works
2. Statistical Basis of Work Sampling
3. Application Issues in Work Sampling

Work Sampling Defined

Statistical technique for determining the proportions of time spent by subjects in various defined categories of activity

- Subjects = workers, machines
- Categories of activity = setting up a machine, producing parts, idle, etc.
- For statistical accuracy
  - Observations must be taken at random times
  - Period of the study must be representative of the types of activities performed by the subjects

Work Sampling Applications

- Machine utilization - how much time is spent by machines in various categories of activity
  - Previous example
- Worker utilization - how workers spend their time
- Allowances for time standards - assessment of delay components in PFD allowance factor
- Average unit time - determining the average time on each work unit
- Time standards - limited statistical accuracy when standards set by work sampling

When is Work Sampling Appropriate?

- Sufficient time is available to perform the study
  - Several weeks usually required for a work sampling study
- Multiple subjects
  - Work sampling suited to studies involving more than one subject
- Long cycle times for the jobs covered by the study
- Nonrepetitive work cycles
  - Jobs consist of various tasks rather than a single repetitive task

Example: How Work Sampling Works

- A total of 500 observations taken at random times during a one-week period (40 hours) on 10 machines with results shown below.

Category	No. of observations
(1) Being set up	75
(2) Running production	300
(3) Machine idle	125
	500

- How many hours per week did an average machine spend in each category?

Example: Solution

- Proportions of time determined as number of observations in each category divided by 500
- Time in each category determined by multiplying proportion by total hours (40 hr)

Category	Proportion	Hrs per category
(1) Being set up	75/500 = 0.15	0.15 x 40 = 6
(2) Running production	300/500 = 0.60	0.60 x 40 = 24
(3) Machine idle	125/500 = 0.25	0.25 x 40 = 10
	1.00	40

Statistical Basis of Work Sampling

- Binomial distribution, in which parameter p = true proportion of time spent in a given category of activity
- There are usually multiple activity categories, so we have $p_1, p_2, \ldots, p_k, \ldots, p_K$ proportions for K different activity categories
- The binomial distribution can be approximated by the normal distribution, where

$$\mu = np$$

$$\sigma = \sqrt{np(1-p)}$$

Alternative Parameters

- The parameters μ and σ can be converted back to proportions by dividing by the number of observations *n*

$$p = \frac{\mu}{n} = \frac{np}{n}$$

$$\sigma_p = \sqrt{\frac{p(1-p)}{n}}$$

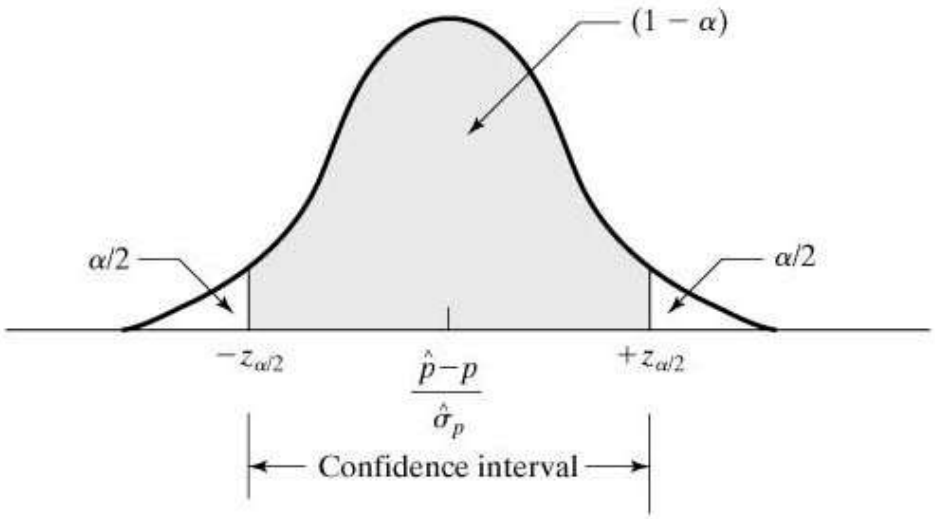
Estimating the Proportion *p*

- In a sampling study, we let $\hat{p}$ = the proportion of the total number of observations devoted to an activity category of interest
- The proportion $\hat{p}$ is our estimate of the true value of the population proportion *p*

Confidence Intervals

- The general statement of a confidence interval for $\hat{p}$ relative to p can be expressed as follows

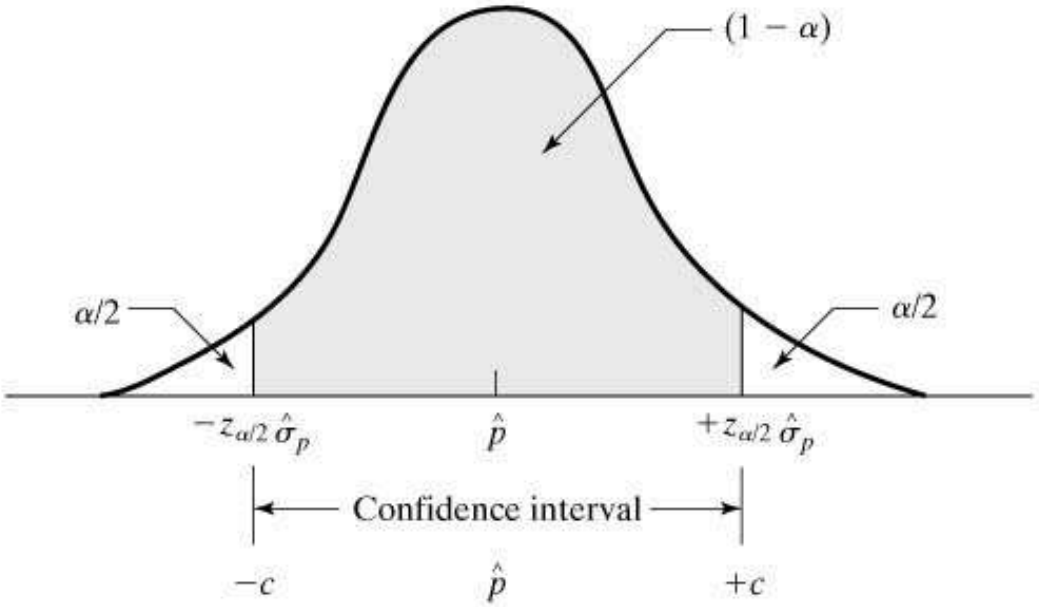
$$\Pr\left(-z_{\alpha/2} < \frac{\hat{p}-p}{\hat{\sigma}_p} < +z_{\alpha/2}\right) = 1 - \alpha$$



Confidence Intervals

- This can be rearranged to the following

$$\Pr\left(\hat{p} - z_{\alpha/2}\hat{\sigma}_p < p < \hat{p} + z_{\alpha/2}\hat{\sigma}_p\right) = 1 - \alpha$$



Number of Observations Required

- How many observations are required to achieve a given confidence interval about the estimate of p?
- We need to decide two parameters:
  1. Confidence level 1 - α
     - This allows us to find the corresponding value of $z_{\alpha/2}$
  2. The half-width c of the confidence interval, defined as the desired acceptable deviation from p
     - Thus, we have $p \pm c$

Number of Observations Required

- Given $z_{\alpha/2}$ and c, the number of observations required to achieve the specified confidence level is given by the following

$$n = \frac{(z_{\alpha/2})^2 \hat{p}(1-\hat{p})}{c^2}$$

Determining Average Task Times

- Average task time for a given work category is determined by computing the total time associated with the category and then dividing by the total count of work units produced by that category

$$T_{ci} = \frac{p_i(TT)}{Q_i}$$

where T_{ci} = average task time, p_i = proportion of observations associated with category i, TT = total time, Q_i = total quantity associated with category i

Determining Standard Times

- Similar to determining average task time, except performance rating must be factored in
- First determine normal time for activity *i*

$$T_{ni} = \frac{p_i(TT)\left(\overline{PR_i}\right)}{Q_i}$$

- Then determine standard time

$$T_{stdi} = T_{ni}(1 + A_{pfd})$$

Defining the Activity Categories

Some guidelines:

- Must be defined to be consistent with objectives of study
- Must be immediately recognizable by observer
- If output measures are included, then activity categories must correlate with those measures
- If more than one output measure, then an activity category must be defined for each
- Helpful to limit the number of categories to ten or fewer

Work Sampling Observation Form

Date	**Work Sampling Data Collection Form**										Page of	
Period of Study							Activity Category (AC)					
Observer							1. Keypunch			5. Walking		
Department							2. Writing			6. Conversation		
Notes:							3. Filing			7. Personal		
							4. Telephone			8. Away		
	Subjects											
Observation Date and Time	Smith		Jones		Wang		Schneider		Kim		Kowalski	
	AC	PR	AC	PR	AC	PR	AC	PR	AC	PR	AC	PR

Key: AC = activity category, PR = performance rating.

Advantages of Work Sampling

- Can be used to measure activities that are impractical to measure by direct observation
- Multiple subjects can be included
- Requires less time and lower cost than continuous direct observation
- Training requirements less than DTS or PMTS
- Less tiresome and tedious on observer than continuous observation
- Being a subject in work sampling is less demanding than being watched continuously for a long time

Disadvantages and Limitations

- Not as accurate for setting time standards as other work measurement techniques
- Usually not practical to study a single subject
- Work sampling provides less detailed information about work elements than DTS or PMTS
- Since work sampling deals with multiple subjects, individual differences will be missed
- Workers may be suspicious because they do not understand the statistical basis of work sampling
- Behavior of subjects may be influenced by the act of observing them