Statistics 2
Chapter 11

Nonparametric Methods
Chi Square Applications

Chapter 11

Nonparametric Methods: Chi-Square Applications

GOALS

When you have completed this chapter, you will be able to:

ONE

Discuss the role of quality control in production and service operations.

TWO

Define several terms used in quality control, such as: chance causes, assignable causes, in control and out of control, attribute, variable, mean and range charts, p charts, and c bar charts.

THREE

Construct and interpret a Pareto chart.

FOUR

Construct and interpret a Fishbone diagram.

Chapter 11 *continued*

Nonparametric Methods: Chi-Square Applications

GOALS

When you have completed this chapter, you will be able to:

FIVE

Construct and interpret two charts for variables, namely a mean chart and a range chart.

SIX

Construct and interpret two charts for attributes - a percent defective chart and a chart for the number of defects per unit.

SEVEN

Discuss what is meant by acceptance sampling.

EIGHT

Construct an operating characteristic curve for various sampling plans.

Control Charts

- Statistical Quality Control emphasizes in-process control with the objective of controlling the quality of a manufacturing process or service operation using sampling techniques.
- Statistical sampling techniques are used to aid in the manufacturing of a product to specifications rather than attempt to inspect quality into the product after it is manufactured.
- Control Charts are useful for monitoring a process.

Causes of Variation

- There is variation in all parts produced by a manufacturing process. There are two sources of variation:
  - Chance Variation is random in nature and cannot be entirely eliminated.
  - Assignable Variation is nonrandom in nature and can be reduced or eliminated.
- *Note:* Variation can and will change the shape, dispersion, and central tendency of the distribution of the product characteristic being measured.

Purpose of Quality Control Charts

- The purpose of quality-control charts is to determine and portray graphically just when an assignable cause enters the production system so that it can be identified and corrected. This is accomplished by periodically selecting a small random sample from the current production.

Types of Quality Control Charts-Variables

- The mean or the x-bar chart is designed to control variables such as weight, length, etc. The upper control limit (UCL) and the lower control limit (LCL) are obtained from the equation:

$$UCL = \overline{\overline{X}} + A_2\overline{R} \text{ and } LCL = \overline{\overline{X}} - A_2\overline{R}$$

- where $\overline{\overline{X}}$ is the mean of the sample means and $\overline{R}$ is the mean of the sample ranges

Types of Quality Control Charts-Variables

- The range chart is designed to show whether the overall range of measurements is in or out of control. The upper control limit (UCL) and the lower control limit (LCL) are obtained from the equation:

$$UCL = D_4\overline{R} \; and \; LCL = D_3\overline{R}$$

EXAMPLE 1

- A manufacturer of chair wheels wishes to determine whether the manufacturing process is out of control. Every 15 minutes for a five hour period a wheel was selected and the diameter measured. The diameters (in mm.) of the wheels are:

Hour	#mm.	#mm.	#mm.	#mm
1	23	24	26	28
2	26	24	30	27
3	24	32	26	27
4	24	28	31	26
5	25	24	25	27

EXAMPLE 1 *continued*

- The table below shows the means and ranges:

Hour	X	R
1	25.25	5
2	26.75	6
3	27.25	8
4	27.25	7
5	25.25	3

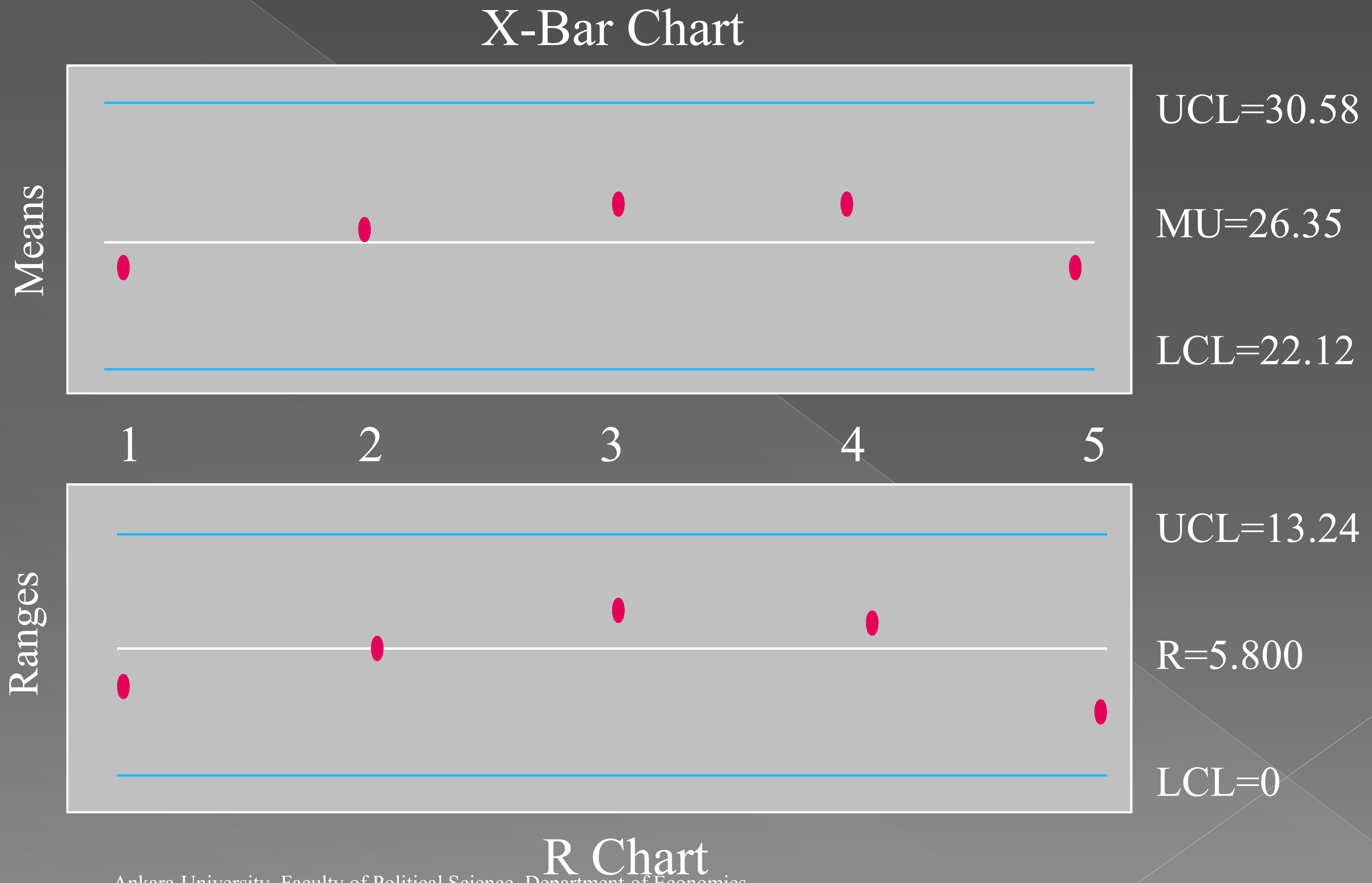
EXAMPLE 1 *continued*

- Compute the grand mean (X double bar) and the average range.
  - Grand mean = (25.25+26.75+...+25.25)/5 = 26.35
  - Average range = (5+6+...+3)/5=5.8
- Determine the UCL and LCL for the average diameter
  - UCL=26.35+.729(5.8)=30.58
  - LCL=26.35-.729(5.8)=22.12

EXAMPLE 1 *continued*

- Determine the UCL and LCL for the range diameter.
  - UCL=2.282(5.8) = 13.24
  - LCL=2.282(0) = 0.
- Is the process out of control?
  - Observe from the next slide that the process is in control. No points are outside the control limits.

EXAMPLE 1 *continued*



Types of Quality Control Charts-Attributes

- The percent defective chart is also called a p-chart or the p-bar chart. It graphically shows the proportion of the production that is not acceptable. The proportion of defectives is found by

$$\bar{p} = \frac{Sum\ of\ the\ percent\ defectives}{Number\ of\ samples}$$

Types of Quality Control Charts-Attributes

- The UCL and LCL are computed as the mean percent defective plus or minus 3 times the standard error of the percents:

$$UCL\ and\ LCL = \bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

EXAMPLE 2

- A manufacturer of running shoes wants to establish control limits for the percent defective. Ten samples of 400 shoes revealed the mean percent defective was 8.0% Where should the manufacturer set the control limits?

$$.08 \pm 3\sqrt{\frac{.08(1-.08)}{400}}$$

$$= .08 \pm .041$$

Types of Quality Control Charts-Attributes

- The c-chart or the c-bar chart is designed to control the number of defects per unit. The UCL and LCL are found by:

$$UCL\ and\ LCL = \bar{c} \pm 3\sqrt{\bar{c}}$$

EXAMPLE 3

- A manufacturer of computer circuit boards tested 10 after they were manufactured. The number of defects obtained per circuit board were: 5,3,4,0,2,2,1,4,3, and 2. Construct the appropriate control limits.

$$\bar{c} = 26/10 = 2.6$$

$$UCL \ and \ LCL = 2.6 \pm 3\sqrt{2.6}$$

$$= 2.6 \pm 4.84$$

Acceptance Sampling

- Acceptance sampling is a method of determining whether an incoming lot of a product meets specified standards.
  - It is based on random sampling techniques.
  - A random sample of *n* units is obtained from the entire lot.
  - c is the maximum number of defective units that may be found in the sample for the lot to still be considered acceptable

Operating Characteristic Curve

- An OC curve, or operating characteristic curve, is developed using the binomial probability distribution in order to determine the probabilities of accepting lots of various quality level

EXAMPLE 4

- Suppose a manufacturer and a supplier agree on a sampling plan with n=10 and acceptance number of 1. What is the probability of accepting a lot with 5% defective? A lot with 10% defective?

$$p(r \leq 1, n = 10, p = .05) = .599 + .315 = .914$$

$$p(r \leq 1, n = 10, p = .1) = .349 + .387 = .736$$