Assessing Capability with Non-Normal Data - Transformation

Data Science for Quality Management: Process Capability

with **Wendy Martin**

Learning objective:

Assess capability / performance from a non normal distribution with lognormal transformed data

Assess Potential Capability Due to Spread - Cp

```
# Cp Only
cap.ln[1,1:4] = 0.7595473
```

$$C_p = \frac{USL - LSL}{\sim NT} = \frac{12}{15.8} = 0.7595$$

For C_{pk}, we don't want to use the normal formulas on the transformed data…

Reasons why:

1. Capability indices are indicators of risk
2. We use these indices to make decisions with respect to risk
3. Using the normal formulas could give us either less risk, or more risk, depending on the true underlying distribution

Assess Capability to Produce Within Specification – Cpk

1. Fit a distribution to the original data, and determine predicted % out of specification (lower and upper spec)

2. Use that % OOS to calculate a Z-score, and divide the lowest number (either upper % OOS or lower % OOS) by 3 to obtain a C_{pk} (est)

Assess Capability to Produce Within Specification – Cpk

Determine % OOS using LogNormal curve:

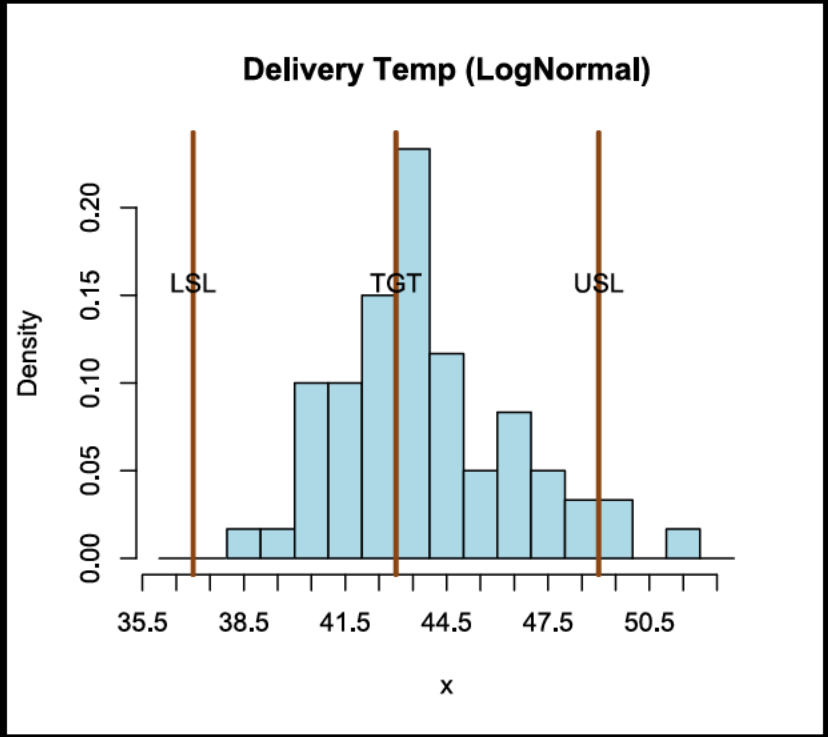
```
l.out<-plnorm(q = LSL,
meanlog = mean(log(data)),
sdlog = sd(log(data)), lower.tail = T) = 0.004736549


u.out<-plnorm(q = USL,
meanlog = mean(log(data)),
sdlog = sd(log(data)), lower.tail = F) = 0.02024086
```

Make a Visualization

```
hist.grouped(Delivery$Temp
             ,stat.lsl = LSL
             ,stat.usl = USL
             ,stat.target = Target
             ,main = “Delivery Temp
            (LogNormal)"
             ,freq = F)

plot(function(x)dlnorm(x = x,
meanlog = mean(log(data)),
sdlog = sd(log(data))),35,55, add=TRUE)
```



Assess Capability to Produce Within Specification – Cpk

Use the % OOS to calculate a Z Score and divide by 3 to get Cpk (eq)

```
Zu<-qnorm(0.02024086,lower.tail=F)
= 2.0488
Cpk.upper<-Zu/3 = 0.6829332
```

Assess Capability to Produce Within Specification- Cpk

```
# Cpk Only
cap.ln[2,1:4] = 0.6829332
```

$$C_{pk} = \frac{Z_{EQ}}{3}$$

What Should I do for Cpm when my data are non-normal?

- Answer: It depends on what type of non-normal
  - Skewness
  - Kurtosis
  - Both

Assess Capability to Conform to Nominal – Cpm

$$C_{pm} = \frac{USL - LSL}{6\sqrt{\left(\frac{NT}{6}\right)^2 + (\text{Median} - \text{Nominal})^2}}$$

Assess Capability to Conform to Nominal – Cpm

Using the Log Normal Distribution

$$C_{pm} = \frac{49 - 37}{6\sqrt{\left(\frac{(15.8}{6}\right)^2 + (43 - 43)^2}}$$

$$C_{pm} = 0.7595$$

Sources

The material used in the PowerPoint presentations associated with this course was drawn from a number of sources. Specifically, much of the content included was adopted or adapted from the following previously-published material:

- Luftig, J. An Introduction to Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1982
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- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005