Individuals and Moving Range Charts – Data Transformation

Data Science for Quality Management: X and Moving Range Charts for Non-Normally Distributed Data

with **Wendy Martin**

Learning objective:

Transform non-normal distributions using the Log Normal transformation

X and MR Charts

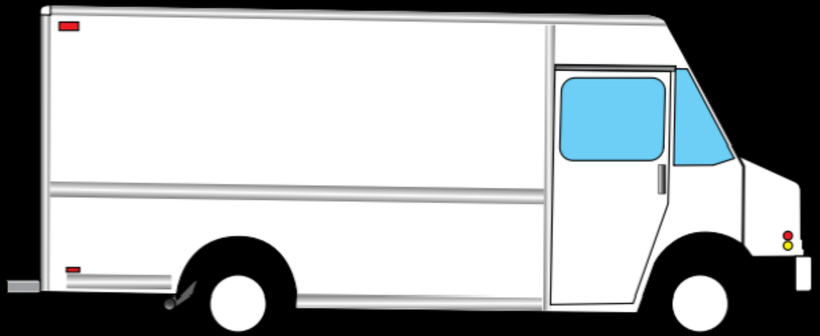
Lognormal Transformation

The Food Distributor Delivery Problem:

- Currently, for the food category in question, the temperature of the refrigeration unit upon delivery is supposed to be between 37 and 49 degrees, and ideally (Nominal) at 43 degrees.

X and MR Charts
Lognormal Transformation

- Each time a truck arrives with a temperature outside of these limits, the truck is rejected; the food is declared to be “spoilage”, and a claim filed against the Distributor.



X and MR Charts

Lognormal Transformation

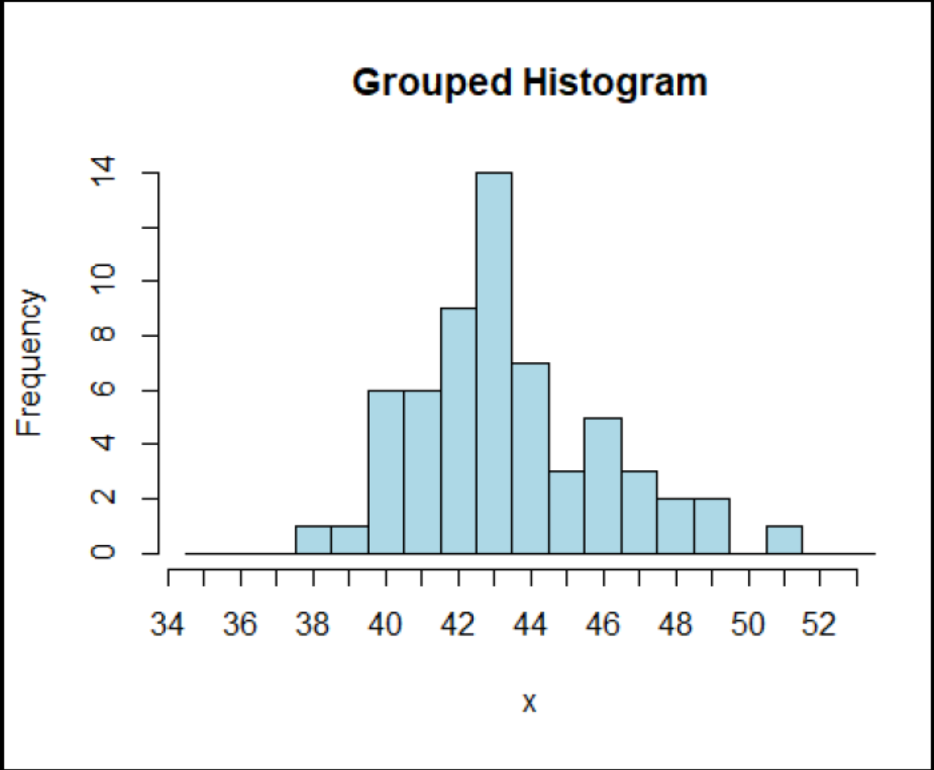
- For each truck that is rejected at the customer’s dock, it costs the Distributor approximately $550.00 in total losses.
- This could be a problem, in that the Distributor makes an average of 1000 deliveries per day for this type of food.

X and MR Charts

Lognormal Transformation

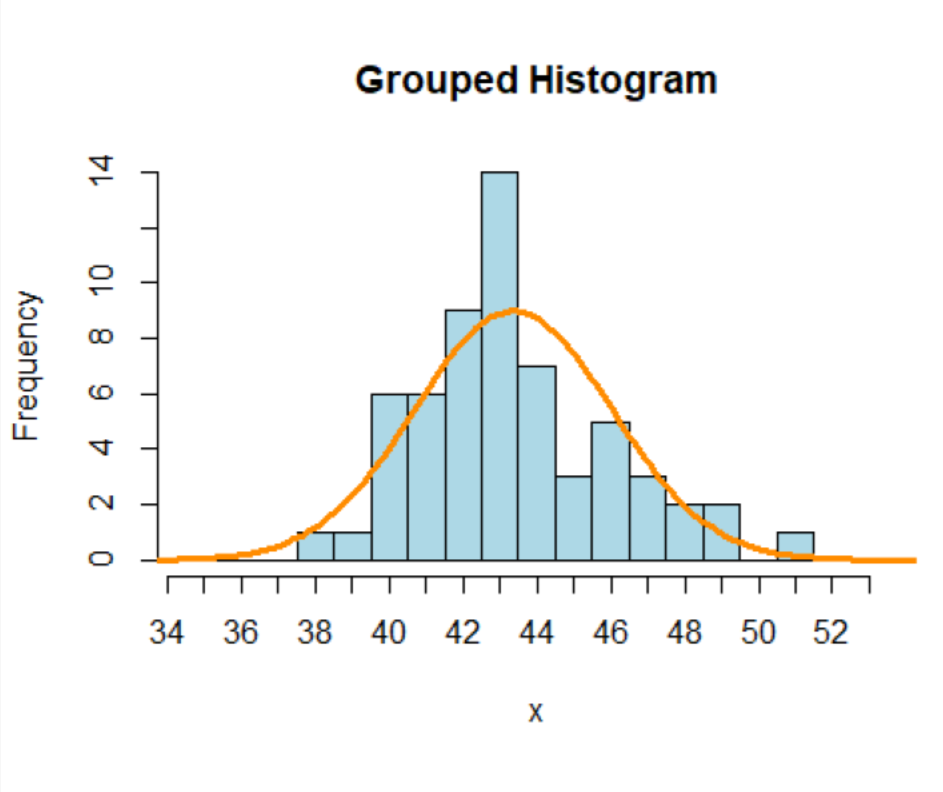
- A random sample of truck delivery records have been selected for review from the last few months of delivery data (Delivery.dat).
- When evaluating the data, we find that the Temperature data are non-normal, and that we are sampling from a moderately skewed, mesokurtic distribution:

Transforming Non-Normal Distributions




```
nqtr(summary.continuous(Delivery$Temp)
, 5)
n            60
mean         43.36667
var          7.08362
g3.skewness  0.63363
g3test.p     0.04312
g4.kurtosis  0.31915
g4test.p     0.47427
```

Transforming Non-Normal Distributions



This condition renders the use of s and $\hat{s}$ values questionable for the generation of control limits.

Transforming Non-Normal Distributions

- In many instances, these type of non-normal distributions may be transformed with mathematical functions to achieve a state of normality; specifically, the Natural-Log Transformation.

Transforming Non-Normal Distributions

- This transformation requires us to calculate the ln(X) values, re-test them for normality, and if we accept normality, generate the required control limits from these transformed values.
- All these operations may be executed within Rstudio.

Transforming Non-Normal Distributions

Filter

	Temperature
1	44
2	40
3	46
4	40
5	50
6	43
7	40
8	42
9	48
10	42
11	46

The raw data as it was gathered.

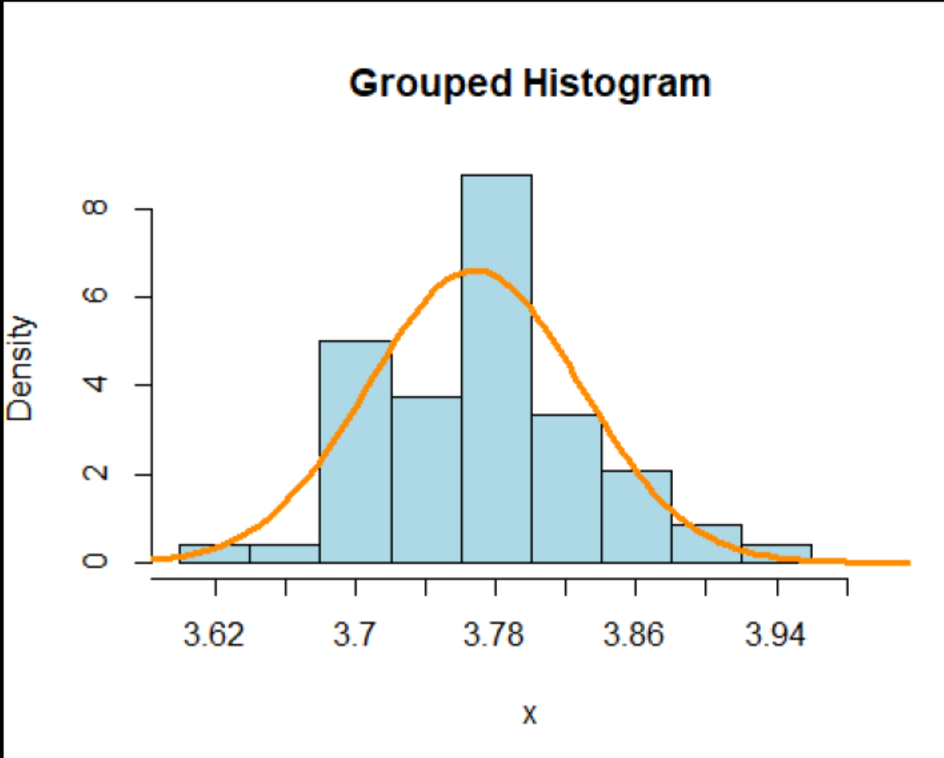
Transforming Non-Normal Distributions

```
> Delivery$lntemp<-log(Delivery$Temp)
```

Transforming Non-Normal Distributions

- Testing the transformed data for normality, we can now see that the log X values are normally distributed, so that the use of s (the standard deviation) is now justified.

Transforming Non-Normal Distributions




```
nqtr(summary.continuous(Delivery$lntemp)
,5)
n             60
mean          3.76788
var           0.00366
g3.skewness   0.46738
g3test.p      0.12596
g4.kurtosis   0.11273
g4test.p      0.68757
```

Transforming Non-Normal Distributions

When using the Lognormal Transformation, there are two considerations:

- If the data are all positive (no negative values) the log transformation can simply be applied to the original data values.

Transforming Non-Normal Distributions

- If there are negative values in the data set (which can occur with Interval scale data or when data are taken from a reference point), a constant must be added to each data value prior to performing the log transformation.

Transforming Non-Normal Distributions

- In this case, we will add 2 times the absolute value of the minimum value to each value prior to the lognormal transformation

Transforming Non-Normal Distributions

- This transformation helps to avoid taking the log of a negative number, which would result in a ‘NaN’ (not a number) in R.

Transforming Non-Normal Distributions

```
> Delivery$Temp2<-2*abs(min(Delivery$Temp))
+ Delivery$Temp


> Delivery$lntemp2<-log(Delivery$Temp2)
```

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
- Luftig, J. Advanced Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1984.
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- Luftig, J. Guidelines for Reporting the Capability of Critical Product Characteristics. Anheuser-Busch Companies, St. Louis, MO. 1994
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- Littlejohn, R., Ouellette, S., & Petrovich, M. Black Belt Business Improvement Specialist Training, Luftig & Warren International, 2000
- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005