# Measures of Dispersion

**Data Science for Quality Management: Describing Data Numerically**

with **Wendy Martin**

**Learning objectives:**

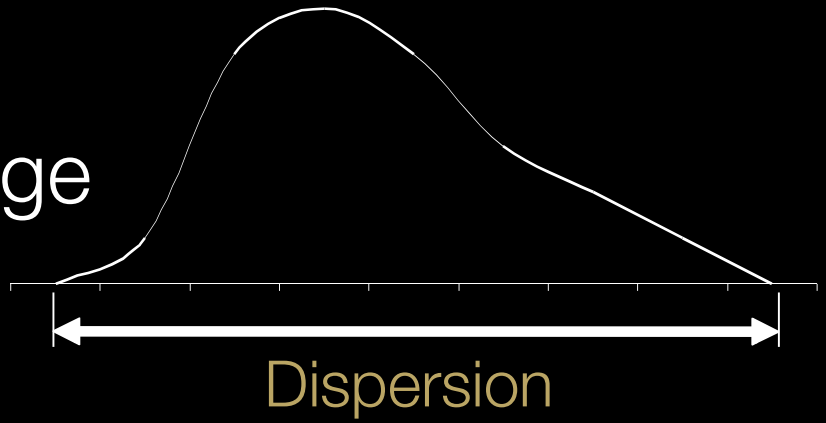
Calculate the sample range
Calculate the interquartile range
Calculate the sample standard deviation
Calculate the sample variance

# Measures of Dispersion

Measures of dispersion reflect the variation or spread in a data set or distribution. Some of the common measures of dispersion are:

# Measures of Dispersion

- Range
- Interquartile Range
- Semi-Interquartile Range
- Standard Deviation
- Variance



# The Range

- The range is the difference between the highest and lowest value in a data set
- Symbols:
  Population (generally does not exist)
  Sample (R)

# The Range

- Calculations: $R = X_H - X_L$
- Example:
- For our sample data set, the low is 36 and the high is 67
- The range is: $R = 67 - 36 = 31$

# The Range

Advantages

- Depends on only two values - Maximum minus minimum
- Easy to understand

Disadvantages

- Extremely sensitive to “outliers”

# How to Calculate in RStudio

- In R Studio:

```
> range(preform$weight)
> rng<-range(preform$weight)
> rng[2]-rng[1]
```

# The Interquartile Range

- The Interquartile Range is the range of the middle 50% of the data or distribution
- Symbols:
  Population or sample, IQR or IQ range
- Calculations:
  IQR = Q3 - Q1

# Interquartile Range: Example

- For our preform data set, Q1 is 37.25 and Q3 is 57.75, the interquartile range is:

- IQR = 57.75 – 37.25 = 20.5

# How to Calculate in RStudio

- In R Studio:

```
> IQR(preform$weight)
```

# The Standard Deviation

- The standard deviation is a measure of variation that includes all data values in its calculation
- The standard deviation is the square-root of the average squared distance values fall from the mean

# Standard Deviation: Calculations

- For a sample

$$s = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$$

# Standard Deviation: Example

- For our sample data set, with a mean of 48.6

$$s = \sqrt{\frac{\sum(X - \bar{X})^2}{n-1}} = \sqrt{\frac{\sum(X - 48.6)^2}{9}} = \sqrt{\frac{1442.40}{9}} = 12.66$$

# Standard Deviation: Example 2

65 67 36 37 36 57 53 39 38 58

1. Calculate the mean: 48.6
2. Calculate deviations from the mean for each value

   16.4 18.4 -12.6 -11.6 -12.6 8.4 4.4 -9.6 -10.6 9.4

# Standard Deviation: Example 2

3. Square each deviation

| | | | |
|---|---|---|---|
| 269.96 | 338.56 | 158.76 | 134.56 |
| 158.76 | 70.56 | 19.36 | 92.16 |
| 112.36 | 88.36 | | |

4. Sum the squared deviations: 1442.40

# Standard Deviation: Example 2

5. Divide the sum of the squared deviations by (n – 1) and then take the square root of this value

   s = 12.66

# How to Calculate in RStudio

- In R Studio:

```
> sd(preform$weight)
```

# The Variance

- The variance is the square of the standard deviation
- The variance is the average squared distance values fall from the mean
- Symbols: Population ($\sigma^2$) and Sample ($s^2$)

# Variance: Calculations

- For a sample

$$s^2 = \frac{\sum (X - \bar{X})^2}{n - 1}$$

# Variance: Calculations

- For our sample preform data set, in which the standard deviation is 12.6596 (using four decimal places), the variance is:
- $s^2 = (12.6596)^2 = 160.27$

# How to Calculate in RStudio

- In R Studio:

> var(preform$weight)

# 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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