LEANOhio

Transforming the Public Sector

Green Belt

Introduction to Hypothesis Testing

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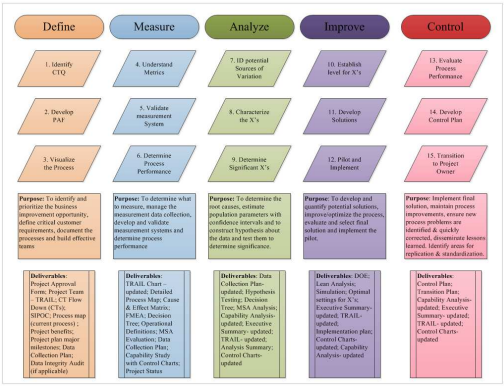
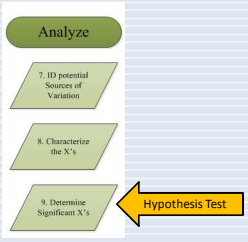


DMAIC Flow

Analyze:
- ID Potential Sources of Variation
- Characterize the X's
- Determine Significant X's

Analyze Purpose: To determine the root causes, estimate population parameters with confidence intervals and to **construct hypothesis about the data and test them to determine significance**.



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Objectives

- Introduce the basic concepts of hypothesis testing
- Understand how to determine whether enough statistical evidence exists to conclude that your hypothesis is reasonable
- Understand the risk of accepting or rejecting your hypothesis
- Understand that wherever a p-value shows up in Excel or Minitab - you have performed a hypothesis test!
- Link hypothesis testing to the next steps of your Analyze Phase

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Hypothesis Tests

- It is human nature to conduct informal hypothesis tests.
  - I bet if I take 71 to work today it will be faster
  - That restaurant looks good
  - Large dogs are better at catching tennis balls than small dogs
  - I bet if we move everyone's desk – it will increase communication!
  - I bet of we change everyone's title – it will make everyone HAPPY!

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Hypothesis: Gas Station Food Is Good

- Make my Hypothesis
  - Gas Station food is good
  - Collect data
  - Analyze Data
  - Decide
- Gas Station food is Good?

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Why Hypothesis Test?

- In any series of data, there is some kind of central tendency
  - Mean
  - Median
  - Mode
- Hypothesis testing can help determine whether or not a given number is statistically different from the central tendency of the data set

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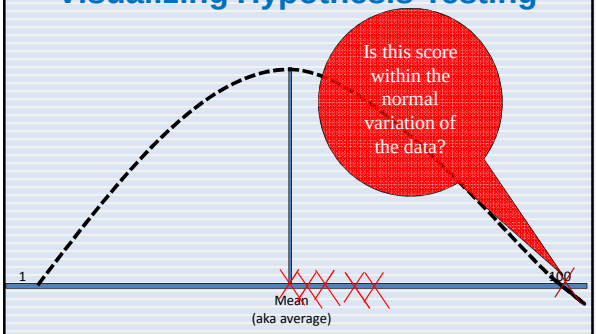
Visualizing Hypothesis Testing



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Hypothesis Testing

- Helps handle uncertainty
- Minimizes subjectivity
- Prevents the omission of important information
- Manages the risk of decision errors

Hypothesis testing assumes a condition exists in a population and a sample is taken to confirm or deny the assumption.

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A hypothesis test involves 2 statements.

2 Outcomes:
1.Reject the null
2. Fail to reject the null

- Statement 1 (Ho - null) – There is no difference between data point **A** and data point **B**
- Statement 2 (Ha) – There is a difference between data point **A** and data point **B**

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Hypothesis Fundamentals

The most common use of a hypothesis test is to determine whether or not a treated sample population (n) has a score which is statistically different from the non-treated sample or from a larger population (N).

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Hypothesis Test

- Write your Hypothesis: In Hypothesis testing we first establish the null hypothesis (Ho), the assumption, and an alternative hypothesis (Ha).
- We assume the null hypothesis is true

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Hypothesis Testing Steps

1: Write your Hypothesis: (Ho and Ha)

↓

2: Collect Data (a sample of reality)

↓

3: DECIDE:
What does the evidence suggest?
Reject H_o? or Don't Reject H_o?

Hypothesis Scenario

- A group relies on a form to process applications. A group Poka Yoke's the form used to process the application.

Step One: Write the Hypothesis

- A group relies on a form to process applications. A group Poka Yoke's the form used to process the application.
- HO: Time to process original form = Time to process Poka Yoke'd form
- HA: Time to process original form ≠ Time to process Poka Yoke'd form

Step Two: Collect Data

What data do you need?

- Baseline to process form: Average of 6 minutes per form
- Average time to process Poka Yoke'd Form: 4 minutes per form

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Step Three: Decide

- What does the evidence suggest.
- HO: Time to process original form (6 mi[illegible] to process Poka Yoke'd form (6 mi
- HA: Time to process original form (6 min) ≠ Time to process Poka Yoke'd form (4 min)

Fail to Reject the Null: There is a statistical difference

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Examples of Hypothesis Testing

- Defendants are presumed to be "Not Guilty"
- The null hypothesis is that the defendant is:
  - "Not Guilty"
- The prosecuting attorney must provide evidence beyond a reasonable doubt
- If the jury accepts the alternate hypothesis, they find the defendant:
  - "Guilty"

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Examples of Hypothesis Testing

- We would like to get out of class early today
- The null hypothesis is:
  - We will get out early
- If we accept the alternative hypothesis, we conclude:
  - We will not be leaving early today ☹

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DOP A&A Section: Hypothesis Testing Practice

Write a Hypothesis Test for the Scenarios:

- The DOP section receives two types of Slow Forms: Renewal and Initials
- HO: Time to Process Renewal Forms= Time to Process Initial Forms
- HA: Time to Process Renewal Forms ≠ Time to Process Initial Forms

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DOP A&A Section: Hypothesis Testing Practice

Write a Hypothesis Test for the Scenarios:

- The DOP section receives forms online and by paper.
- HO: Time to Process Paper Forms= Time to Process Online Forms
- HA: Time to Process Paper Forms ≠ Time to Online Forms

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DOP A&A Section: Hypothesis Testing Practice

Write a Hypothesis Test for the Scenarios:

The DOP section is divided into four regions: North, South, East, and West.

- HO: Time to Process Forms in North = South = East = West
- HA: Time to Process Forms in North ≠ South ≠ East ≠ West

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Levels of Risk

- There is always a level of risk and confidence when accepting or rejecting a hypothesis.
- We specify the level of decision risk and test sensitivity which is acceptable
- This is alpha, or the p-value
  - We determine how close to perfect our results need to be for us to be confident in our decision.

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P Value

- Specific statistical tests will give you a p-value which will indicate whether the null hypothesis should be accepted or rejected.
- Based on the p-value, you will determine if your risk is too great to accept the null hypothesis

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More on P values

Consider the following

- If p-value = 10% (α= .10) there is less than a 10% chance that these observations could have occurred randomly - *pretty good*
- If p-value = 5% (α = .05) there is less than a 5% chance that these observations could have occurred randomly - *even better*
- If p-value = 1% (α = .01) one percent chance that these observations could have occurred randomly - *terrific odds*

More on P values

- The alpha should depend on practical considerations: financial, safety, or risk to the customer.
- The alpha is also known as: confidence, our degree of certainty that the alternative hypothesis is true.
- In government the typical alpha is set at .05.
- This means we are willing to accept a 5% risk that we will make the incorrect conclusion.
- We are 95% confident!

In government the typical alpha is set at .05.

Key Concepts

- **Alpha risk (α)**: The rejection of the null hypothesis when it is true.
  - Example - when the jury determines the defendant is guilty when they are really innocent
- **Beta risk (β):** The acceptance of the null hypothesis when it is false.
  - Example - when the jury determines the defendant is innocent when they really committed the crime

Alpha Risk (α) and Beta Risk- (β)

- Alpha risk is associated with a Type I error--the chance of being wrong if we reject the null hypothesis in favor of the alternative.
  - Alpha risk is given in Excel/Minitab as a **p-value**
- Beta risk (β) is associated with a Type II error--the chance of being wrong if we accept the null hypothesis.
  - Often, when we make a Type II error, we have missed a factor affecting the process, and possibly an opportunity for improvement.
  - It could mean that we took no action when we probably should have - this should be seriously considered

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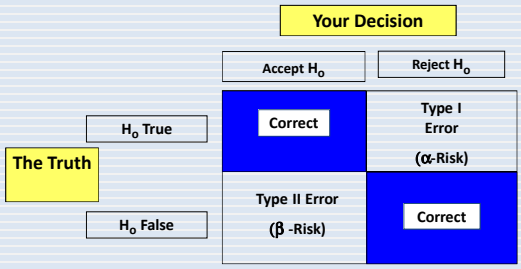
Decision Errors



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Alpha and Beta Errors

- When you incorrectly reject the null hypothesis, and therefore accept the alternate hypothesis, you have made a Type I error - Alpha
- When you incorrectly accept the null hypothesis you have made a Type II error - Beta

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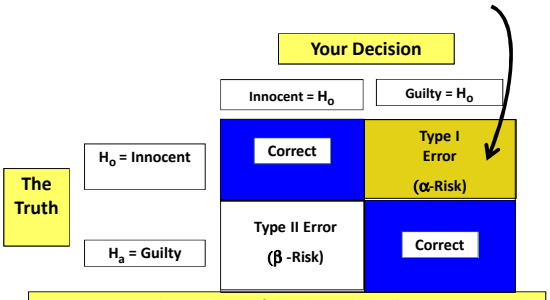
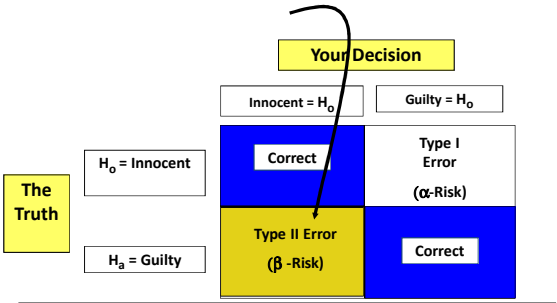
Alpha Risk - Type I Error ("p-value")



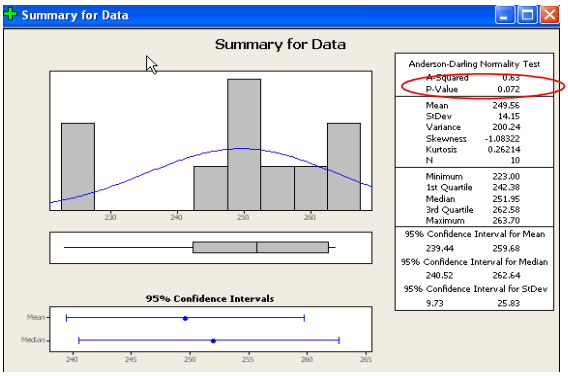
Beta Risk - Type II Error



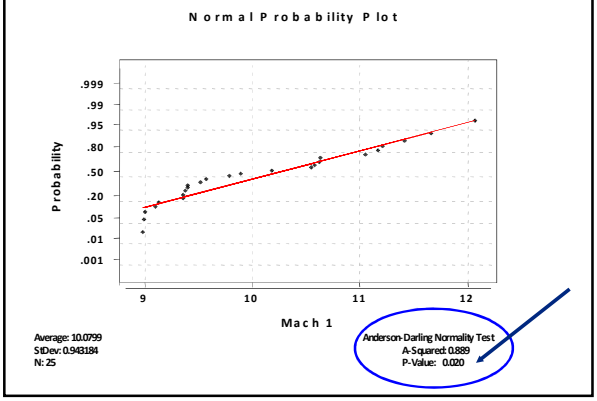
Hypothesis Testing: How It Works

- The p-value is the probability that such error could occur when Ho is true
- The p-value is based on an assumed or actual reference distribution in tests such as:
  - Normality tests
  - Chi-Square
  - Descriptive Statistics
  - t-distribution
  - F-distribution
- Every test of significance is a test of a null hypothesis

P-Values Are Everywhere !



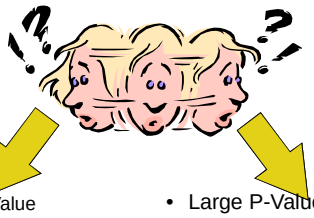
P-Values Are Everywhere !



P- Values are everywhere, even in Excel!

t-Test: Paired Two Sample for Means		
	Variable 1	Variable 2
Mean	169.583333	75.33333333
Variance	18970.44697	852.969697
Observations	12	12
Pearson Correlation	0.1014423	
Hypothesized Mean Difference	0	
df	11	
t Stat	2.368164241	
P(T<=t) one-tail	0.018636275	
t Critical one-tail	1.795884819	
P(T<=t) two-tail	0.037272551	
t Critical two-tail	2.20098516	

What are P-values Used For?



- Small P-Value
- Ample Evidence
- H_o is Rejected
- Support alternate

- Large P-Value
- Little evidence
- H_o is Not Rejected

How Low Must P be?

- P-value is the probability that the null hypothesis is true.

A NEW MANTRA

"If p is low the H_o must go"

- 1 - p measures our confidence in the alternative hypothesis

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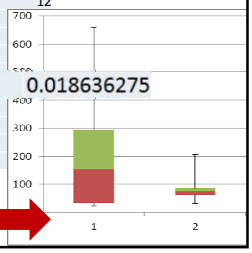
What would we Conclude?

t-Test: Paired Two Sample for Means

	Variable 1	Variable 2
Mean	169.583333	75.33333333
Variance	18970.44697	852.969697
Observations	12	12
Pearson Correlation	0.1014423	
Hypothesized Mean Difference	0	
df	11	
P(T<=t) one-tail		0.018636275
t Critical one-tail	1.795884819	
P(T<=t) two-tail	0.037272551	
t Critical two-tail	2.20098516	

The p is low, So….
The Ho must go!



Does the conclusion seem logical given the visual representation of the two groups?

Hypothesis Testing Steps

Write your Hypothesis: (Ho and Ha) Assume the null Hypothesis is true

↓

Collect Data (a sample of reality)

↓

DECIDE: p value
What does the evidence suggest?
Reject H_o? or Don't Reject H_o?

Fundamentals of Hypothesis Testing

- Generally, the hypothesis takes the form of: Y=f(x1,x2...xn)
- We devise a test to prove the hypothesis true or false by testing the effect of the X's on Y
- Again, we assume that the null hypothesis is true
- We then look for compelling evidence to support or reject that null hypothesis
- If we reject the null hypothesis, then we accept the alternative hypothesis
- A hypothesis will be proposed for each statistical test performed

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Hypothesis Form

Hypothesis Testing Form			
What is the Y?		What Type of Data?	
What is the X?		What Type of Data	
How many "levels" does X have?			
Is my data Stable?			
What type of tool would you use?			
Is my data Normal? (Outliers?)			
Comparing Median or Means?			
Ho: (=)			
Ha:			
P value: (0.05)			
Interpret results:			

Questions?

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