TECH 646 Analysis of Research in Industry & Technology

Lecture 2-1

An Overview of Statistics and Applications in Solving Industry/Business Problems

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Lecture note based on the text books:

Book1: Cooper, D.R., & Schindler, P.S., *Business Research Methods* (12th edition), McGraw-Hill/Irwin

Book 2: Montgomerry, D. C., and Runger, G. C., *Applied Statistics and Probability for Engineers* (6th Edition), Wiley

TECH 646
Lecture 1 – Part 2

Book 2 used in IT 507 Measurement and Evaluation in Industry & Technology: *Applied Statistics and Probability for Engineers*, 6th Edition, by D.C. Montgomery and G. C. Runger, from Wiley

- **Chapter 1: The Roles of Statistics**
  - Engineering/Scientific Method
  - Reasoning Methods
  - An Example: Engineering Design with Comparison Experiments
- **Beginning Statistics**
- **Chapter 9. Tests of Hypothesis for a Single Sample**
- **Minitab 17 & 18 Related**

The Roles of Statistics

- Industry Technology research
- Business research
- Engineering
- Quality Control, Statistical Process Control: Manufacturing and Production
- Other Fields: Medical, Healthcare, etc.,

Discussion on a WSJ Article, "Technology Can't Save Us from Math Mishaps," WSJ, Aug. 20-21, 2011, https://www.wsj.com/articles/SB100014240531119035969045765182515236321 10

Statistics Supports

- The field of **statistics** deals with the collection, presentation, analysis, and use of data to:
    - Make decisions
    - Solve problems
    - Design products and processes
- It is the **science of data**.

Variability

- Statistical techniques are useful to describe and understand variability.
- By variability, we mean successive observations of a system or phenomenon do not produce exactly the same result.
- Random variable $X = \mu + \varepsilon$, where μ is a constant and ε is a random disturbance.
- Statistics gives us a framework for describing this variability and for learning about potential sources of variability.

Industry and Business Problems

- **Transportation System Planning** (regional highway problem)
  - **Data Gathering**:
    - Number of persons per household
    - Number of vehicles per household
    - Number of nonwork
    - Homebased trip
    - etc
  - Trip Generation Model - **Regression analysis**

Industry and Business Problems

- **Hospital Emergency Department** (LWOT problem)
  - Types of services, ED capacity, Staff
  - Consequences: Patient Leave Without Treatment (LWOT)
  - Want to know: What proportion of patient LWOT from ED
  - Probability modeling

Basic Methods of Collecting Data (Engineering/Technology)

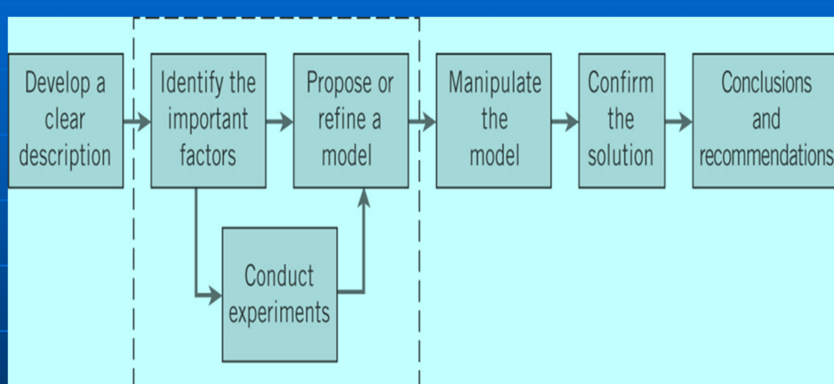
Three basic methods

- Retrospective Study
  - Using historical data
  - Data collected in the past for other purposes
- Observational Study
  - Data, presently collected, by a passive observer
- Design Experiment
  - Data collected in response to process input changes

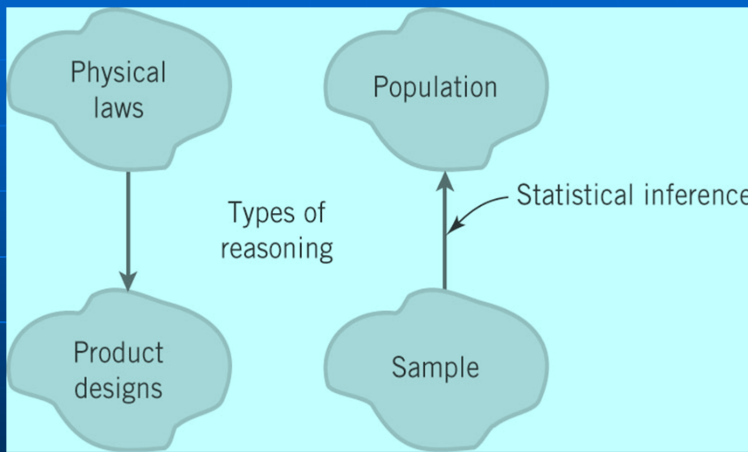
Engineering and Scientific Methods

1. Develop a clear and concise description of the problem
2. Identify important factors
3. Propose a model, State any limitations or assumptions
4. Conduct experiments, Collect data to test or validate the tentative model
5. Refine the model based on the observed data
6. Manipulate/Refine the model
7. Conduct an appropriate experiment to confirm the proposed solution: Effective & Efficient
8. Draw Conclusions and/or Make Recommendation

Engineering and Scientific Methods (cont.)



Reasoning Methods



An Example: Engineering Design with a Comparison Experiment (Design Experiment)

Problem Statement

- A **Nylon connector**, with minimum a pull-force of 12.75 pounds, to be housed in an automotive engine application is in the design phase. The design engineer asks for a design with a wall thickness of 2/32 inch and 8 prototypes for experiment. The pull-force measurement, in lb, is as follows: 12.6, 12.9, 13.4, 12.3, 13.6, 13.5, 12.6, 13.1.

An Example: Engineering Design with a Comparison Experiment

Problem Statement

- Wanting to know if the **mean pull-off force** of this 2/32-inch design exceeds the required maximum load of 12.75 lb to be encountered in it's expected application.

7 Step Process for Hypothesis Testing (Reference - Chapter 9)

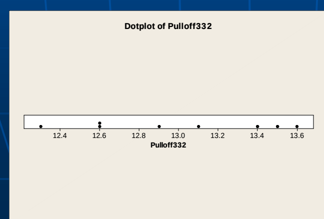
1) **Parameter of interest: pull-off force**
2) **Null-hypothesis: H0: μ = 12.75 pounds**
3) **Alternative Hypothesis: H1: μ > 12.75 pounds; we want to reject H0 if the mean pull-off force exceeds 12.75 pounds**
4) **Test statistics (t-statistics)**
5) **Reject H0: if the P-value is less than α = 0.05**

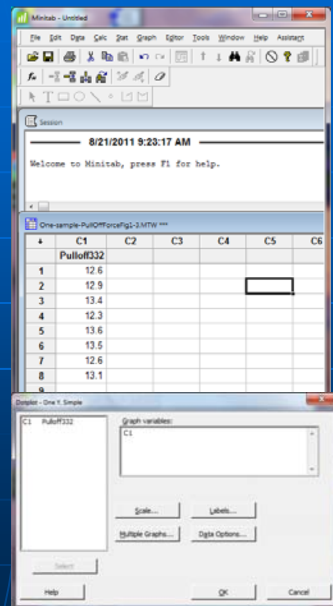
- ** P-value is the smallest level of significance that would lead to rejection of the null hypothesis H0 with the given data.

7 Step Process for Hypothesis Testing

6) Minitab 17/18: Enter 8 measured pull-force data

- Display Dot Plot diagram
  - Graph => Dotplot =>select One Y (Simple)
  - Click OK button to see the next dialog box
  - Enter C1 into the Graph Variable text box
  - Then click OK button to see the Dot Plot





7 Step Process for Hypothesis Testing

6) Display Descriptive Statistics

Stat => Basic Statistics => Display Descriptive Statistics

- Mean $\bar{X}$ = 13.000, Standard Deviation σ or s = 0.478. μ0 = 12.75, n =8

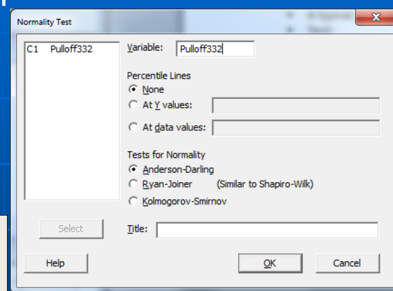
Descriptive Statistics: Pulloff

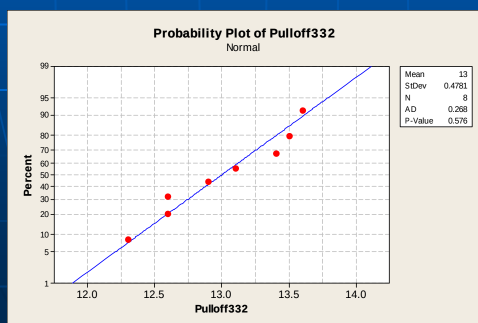
Variable	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Pulloff332	8	13.000	0.478	12.300	12.600	13.000	13.475	13.600

7 Step Process for Hypothesis Testing

6) Testing the Assumption of Normality (Minitab 17/18)

- Stat => Basic Statistics => Normality Test
- Enter the following setting, as shown, then click OK





7 Step Process for Hypothesis Testing (Reference - Chapter 9)

6) Computation: (Minitab 18, 1-Sample t)

Hypothesis Test on the Mean

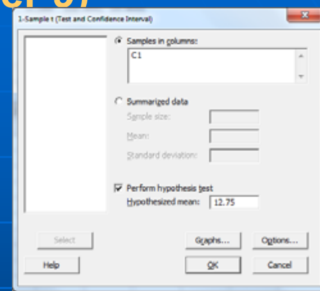
- Sample mean $\bar{X}$ = 13.000
- Sample standard deviation s = 0.478
- μ0 = 12.75
- n =8

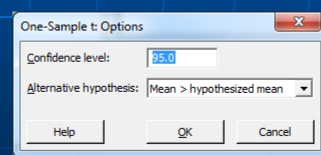
- $t_0 = \frac{\bar{X}-\mu_0}{s/\sqrt{n}} = 1.48$ **(T-value)**

7 Step Process for Hypothesis Testing (Reference - Chapter 9)

6) Computation: (Minitab 17/18, 1-Sample t)

- Stat => Basic Statistics => 1 Sample t
- Enter C1 into the Sample in Column dialog box
- CHECK the Perform hypothesis test and enter 12.75 as Hypothesized mean, then click OK
- Options:
  - Confidence Level 95.0
  - Alternative hypothesis: Mean > hypothesized mean





7 Step Process for Hypothesis Testing (Reference - Chapter 9)

6) Computation: (Minitab 17/18, 1-Sample t)

Descriptive Statistics

N	Mean	StDev	SE Mean	95% Lower Bound for μ
8	13.000	0.478	0.169	12.680

μ: mean of C1

Test

Null hypothesis	H_0: μ = 12.75
Alternative hypothesis	H_1: μ > 12.75

T-Value	P-Value
1.48	0.091

One-Sample T: Pulloff

Test of μ (mu) = 12.75 VS. μ > 12.75

Variable	N	Mean	StDev	SE Mean	95% Lower Bound	T	P
Pulloff332	8	13.000	0.478	0.169	12.680	1.48	0.091

7 Step Process for Hypothesis Testing

7) Conclusion

- From Appendix A Table V (page 711, for a t-distribution with 7 degrees of freedom (n -1=8-1), that t0 = 1.48 falls between two values, 1.415 for which α = 0.1, and 1.895, for which α = 0.05.
- Because this is a one-tailed test, we know that the Probability value or P-value (0.091) is between those two values, that is, $0.05 < P < 0.1$.
- Since $P = 0.091 < 0.1$, we do not have sufficient evidence to reject H0 and conclude that the mean pull-off force does not exceed 12.75 pounds

An Example: Engineering Design with a Comparison Experiment (Design Experiment)

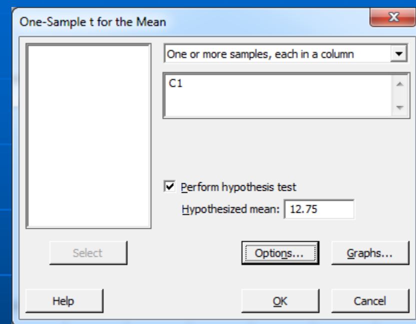
2nd Experiment

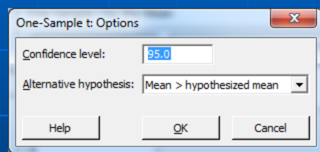
- The second of set of A **Nylon connector** was produced.
- The pull-force measurement, in lb, is as follows: 12.9, 13.7, 12.8, 13.9, 14.2, 13.2, 13.5, and 13.1.

An Example: Engineering Design with a Comparison Experiment (Design Experiment)

2nd Experiment

- One-Sample T: C1





Descriptive Statistics

N	Mean	StDev	SE Mean	95% Lower Bound for μ
8	13.413	0.497	0.176	13.080

μ: mean of C1

Test

Null hypothesis H₀: μ = 12.75 → $H_0: \mu = 12.75$
Alternative hypothesis $H_1: \mu > 12.75$

T-Value	P-Value
3.77	0.003

Hypothesis Testing

Conclusion

- From **Appendix A Table V** (page 711, for a t-distribution with 7 degrees of freedom (n -1=8-1), that t0 = 3.77 falls between two values: 3.499 for which α = 0.005, and 4.029, for which α = 0.0025.
- Because this is a one-tailed test, we know that the Probability value or P-value (0.003) is between those two values, that is, 0.005 < P < 0.0025.
- Since P = 0.003 < 0.005, we can reject H0 and conclude that the mean pull-off force does exceed 12.75 pounds