Chapter 11

Fundamentals of Hypothesis Testing: One-Sample Tests

Hypothesis testing for 1-sample tests:

HYPOTHESIS: A statement about the value of a population parameter, developed for the purpose of testing.
H_0 and H_1 are mutually exclusive and collectively exhaustive.

H_0 → null hypothesis   example: $H_0: \mu = 368$
H_a → alternative hypothesis   example: $H_a: \mu \neq 368$

The null hypothesis is written in terms of the populations and NOT a sample.

So H_0 and H_a can only represent the following: μ, π, σ

H_0 : always involves equality (eg. "=", "≤ ", and "≥ ")
H_a: always involves the rest (eg. "≠", "<", and "> ")

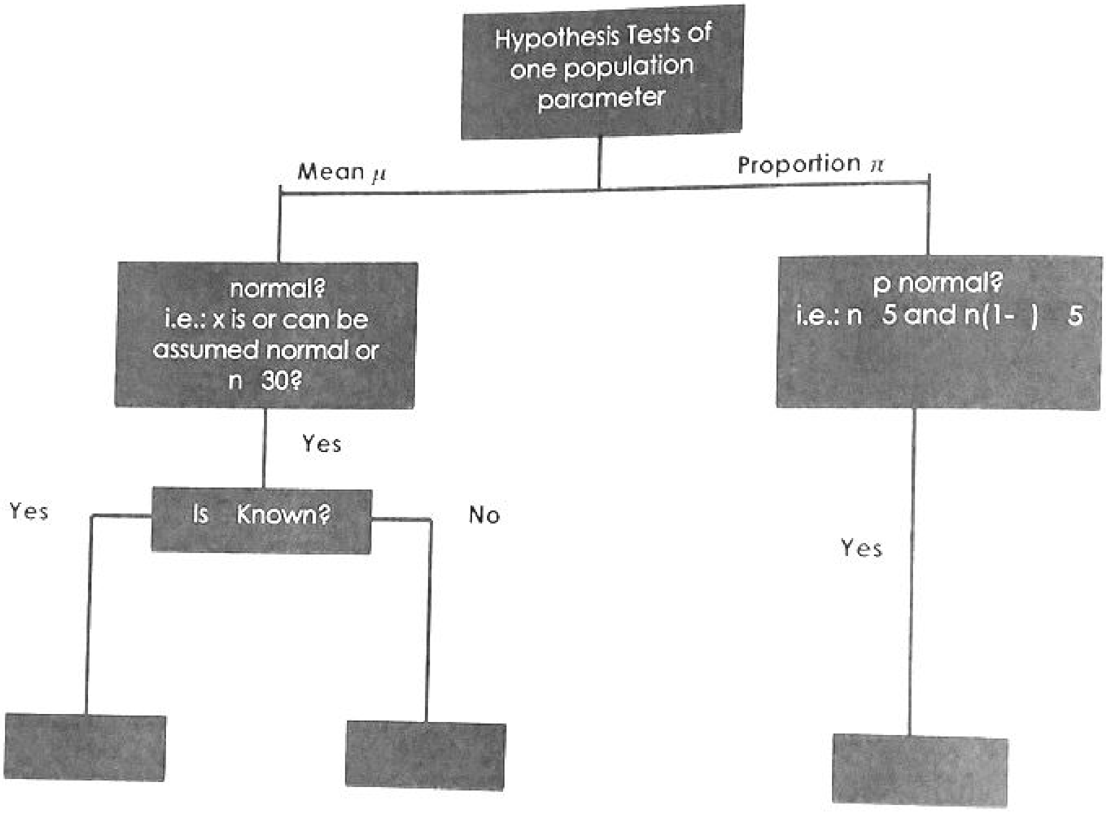
**The alternative hypothesis is the opposite of the null hypothesis

**If you reject the null hypothesis, you have proof that the alternative hypothesis is correct

**If you don't reject the null hypothesis, you have failed to prove the alternative hypothesis

****The greater the sample size is, the narrower the normal distribution becomes.**

The Hypothesis Testing Process



α = level of significance

Question 1

A company that makes batteries needs to make sure that the voltage is not too high or too low. The ideal voltage for the battery is 5.60 volts. It is known that the standard deviation of the process is 0.18 volts and the voltages will fit a normal distribution.

The process has been set up to produce 1 million batteries. Before too many are produced, the batteries need to be checked to see if the average voltage is close to 5.60 volts. A sample of 25 batteries is tested and the average voltage was 5.65 volts.

Should the process be allowed to continue production or should it be adjusted? Use a 5% level of significance.

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

Ho:
Ha:

c) What is the test statistic and P-value?

d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

Question 2

A bank manager wants to test the hypothesis that less that 60% of all the bank's customers use the ATM to pay their bills. A random sample of 80 customers has been selected and it was found that 43 of them use the ATM to pay bills. Use the 10% significance level.

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

Ho:

Ha:

c) What is the test statistic and P-value?

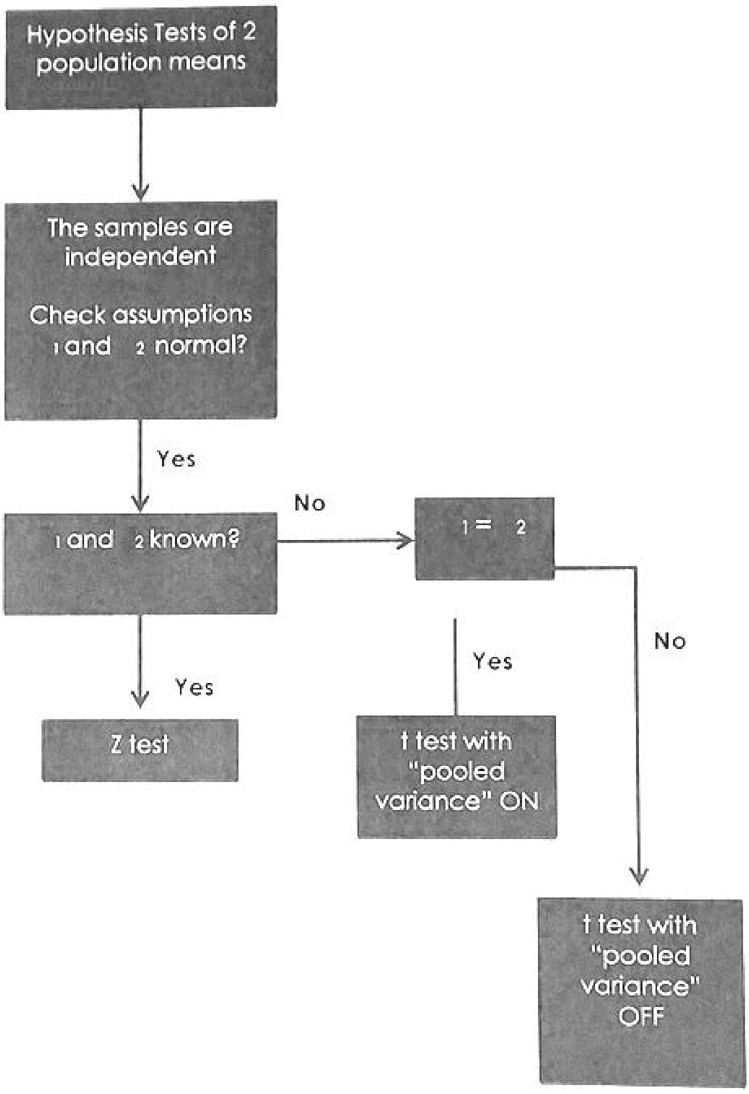
d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

Chapter 12

Hypothesis Testing: Two-Sample Tests



Question 1

A company makes bolts that are used on an automotive component uses two machines to make these bolts. It has been determined that the standard deviation of the bolt diameters made by machine 1 is 0.025mm, and the standard deviation of the bolt diameters for machine 2 is 0.022mm. The manufacturer decided to take samples from both machines to test whether the mean diameter of the bolts from machine 2 was significantly larger than the mean diameter from machine 1. The sample of 100 bolts from machine 1 has a mean diameter of 5.02mm and a sample of 100 bolts from machine 2 had a mean diameter of 5.09mm when the dial on both machines was set at 5.00mm. At the 5% level of significance what is the conclusion?

g) What type of parameter is being tested here?

$\propto, \mu, \pi, \sigma$

h) State the Null and Alternative Hypothesis

i) What is the test statistic and P-value?

j) What is the critical value(s)?

k) Comparing p-value to level of significance, what is the conclusion?

l) Comparing the critical value(s) to the test statistic, what is the conclusion?

Question 2

We wish to determine if there's a difference in the braking distance for 2 types of tires. Use the 5% significance level and assume that the braking distances for each type of tire are normally distributed with the same variance.
Based on the data for the samples of tires shown, at the 5% significance, should we conclude that there's a difference in the mean braking distance?

Tire A	Tire B
83	75
79	84
82	76
84	83
80	85
81	78
	83

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

c) What is the test statistic and P-value?

d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

Question 3

A real estate agency wants to compare the appraised values of single-family homes in two Counties. A sample of 60 listings in Farmingdale and 99 listings in Levittown yields the following results:

	Farmingdale	Levittown
$\bar{X}$	191.33	172.34
S	32.60	16.92
n	60	99

At the 0.05 level of significance, is there evidence of a difference in the average appraised values for single-family homes in the two communities? Assume both populations of appraised house values have equal variances.

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

c) What is the test statistic and P-value?

d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

F-Test (Difference Between 2 Variances)

- Helps determine whether two independent populations have the same amount of variability
- I.e. $\sigma1 = \sigma2$ or $\sigma1 \neq \sigma2$
- Helps determine whether to use "pooled" variance t-test or not

$F = \frac{S1^2}{S2^2}$ (S1→the larger sample variance, S2→ the smaller sample variance)

Question:

Given:

	Line A	Line B
$\bar{X}$	8.005	7.997
S	0.012	0.005
n	11	16

Q. At the 5% level of significance, is there evidence that the variance in line A is greater than the variance in line B?

The null & alternative hypothesis:

Ho: $\sigma^2 A \leq \sigma^2 B$
Ho: $\sigma^2 A > \sigma^2 B$

$F = \frac{0.012^2}{(0.005)^2} = 5.76$

Now, compare your Fcalc to your F critical value:

To find critical value (calc steps):

STAT→DIST→F→InvF
Area: 0.05
N:df: 10
D:df: 15
EXE

Since xInv= 2.54, and Fcalc = 5.76
5.76>2.54
We reject Ho
Meaning, we have evidence that the variance of line A is greater than the variance of line B

Critical Values For F-Test:

If two-tailed test (i.e. Ha has a ≠):

Dist> F >InvF

1st critical value "F Upper "
area: alpha/2 = 0.1/2= 0.05, n:df=12, d:df=14
xInv= 2.5342

2nd critical value "F Lower"
- area: 1-(alpha/2) = 1-(0.1/2)=0.95, n:df=12, d:df=14
xInv= 0.3792

** For a one-tail test: simply plug in alpha as the area

*****F-Test also known as "Test of Homogeneity of Variances" –"TEST THE ASSUMPTION OF EQUAL VARIANCES"**

*****F-statistic is also known as "Levene Statistic"**

Question 4

We wish to determine if there's a difference in the braking distance for 2 types of tires. Use the 5% significance level and assume that the braking distances for each type of tire are normally distributed with the same variance.

Tire A	Tire B
83	75
79	84
82	76
84	83
80	85
81	78
	83

Test to see if the assumption about equal variances seems reasonable at the 5% level.

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

c) What is the test statistic and P-value?

d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

Comparing the Means of 2 Related/Dependent Populations (Paired T-Test):

To determine whether populations are dependent:

1- Taken repeated measurements from the same set of items or individuals
2- Or, match items or individuals according to some characteristic

Null hypothesis for two related populations:

Ho: $\mu D = 0$ (where $\mu D = \mu 1 - \mu 2$)
Ha: $\mu D \neq 0$

Example:

A local pizza restaurant situated across the street from your college campus advertises that it delivers to the dorms faster than the local branch of a national pizza chain. In order to determine whether this is true or not, you and some friends have decided to order 10 pizzas from the local pizza restaurant and 10 pizzas from the national chain. Pizzas from both locations were ordered at the same time, thus you have matched samples.
At the 0.05 level of significance, is the mean delivery time for the local pizza restaurant less than the mean delivery time for the national pizza chain?

Time	Local	Chain	Difference
1	16.8	22.0	
2	11.7	15.2	
3	15.6	18.7	
4	16.7	15.6	
5	17.5	20.8	
6	18.1	19.5	
7	14.1	17.0	
8	21.8	19.5	
9	13.9	16.5	
10	20.8	24.0	

Solution:

Ho: $\mu D \geq 0$
Ha: $\mu D < 0$

Find difference list, input difference list into List1, test→t→(1-s)

Question 5

Below are lists of online book prices and bookstore prices for a selected sample of books, and those are listed below:

Book Title	Bookstore	Online
Business 10E	132.75	136.91
Business and society	201.50	178.58
Ethics for the information age	80.00	65.00
Foundations of Macroeconomics	153.50	120.43
Principles OF macroeconomics	153.50	217.99
Financial management	216.00	197.10
Organizational behavior	199.75	168.71
Understanding organizational behavior	147.00	178.63
Marketing	132.00	95.89
Abnormal psychology	182.25	145.49
Give me liberty	45.50	37.60
Mathematical interest	89.95	91.69
Advanced accounting	123.02	148.41
Talking about people	57.50	53.93
Information systems management	88.25	83.69
Macroeconomics 7E	189.25	133.32
Microeconomics 7E	179.25	151.48
Multinational financial management	210.25	147.30
American government	66.75	55.16

Is there evidence that the mean price is different between the two sellers of textbooks at the 5% level of significance?

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

Ho:

Ha:

c) What is the test statistic and P-value?

d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

Question 6

independant means treated as 2 different samples

1. If we are testing for the difference between means of two independent population presuming equal variances with samples of n1=20 and n2=20, the number of degrees of freedom is equal to:

a) 39
b) 38
c) 19
d) 18

*** Hint: (n1+n2)-2

2. In testing for differences between the means of two independent populations, the null hypothesis is:

a) Ho: $\mu 1 - \mu 2 = 2$
b) Ho: $\mu 1 - \mu 2 = 0$
c) Ho: $\mu 1 - \mu 2 > 0$
d) Ho: $\mu 1 - \mu 2 < 2$

3. If we are testing for the difference between means of two related populations presuming equal variances with samples of n1=20 and n2=20, the number of degrees of freedom is equal to:

a) 39
b) 38
c) 19
d) 18

4. In testing for differences between the means of two related populations, the null hypothesis is:

a) Ho: $\mu D = 2$
b) Ho: $\mu D = 0$
c) Ho: $\mu D > 0$
d) Ho: $\mu D < 2$

Difference Between 2 Proportions

Calc steps:

STAT→test→z→(2-P)

Example:

From 1,564 workaholics of whom 786 men and 778 women, 707 men and 638 women loved their jobs as it was challenging and stimulating. At the 0.05 level of significance, determine whether the proportion of workaholic men who love their job, is greater than the proportion of women.

Ho: $\pi 1 \leq \pi 2$
H1: $\pi 1 > \pi 2$

Critical Value:
STAT→DIST→NORM→InvN
Tail: Right
Area: 0.05
σ: 1
μ: 0
EXE

xInv: 1.645

To test:
STAT→test→Z→(2-P)
P1: >p2
X1: 707
n1: 786
x2: 638
n2: 778

Results:
p=0.000002997, which is < 0.05

z= 4.527, which is >1.645

We reject the Ho, in other words, there is evidence that the proportion of workaholic men who love their job is greater than the proportion of women.

Question 7

A political candidate thinks that his level of support differs among male & female voters. A random sample of 200 male voters and 100 female voters revealed that 85 of the men would vote and 35 of the women would vote for him. At 10% level of significance, what conclusion should the candidate make regarding the level of support?

a) What type of parameter is being tested here?

α, μ, π, σ

b) State the Null and Alternative Hypothesis

c) What is the test statistic and P-value?

d) What is the critical value(s)?

e) Comparing p-value to level of significance, what is the conclusion?

f) Comparing the critical value(s) to the test statistic, what is the conclusion?

Question 8

A human resources director decided to investigate employee perception of the fairness of two performance evaluation methods. To test for the differences between the two methods, 160 employees were randomly assigned to be evaluated by one of the methods: 78 were assigned to method 1, where individuals provide feedback to supervisory queries as part of the evaluation process. 82 were assigned to method 2, where individuals provided self-assessments of their work performances. Following the evaluation, employees were asked whether they considered the performance evaluation fair or unfair.

Employee Perception	*Evaluation Method* 1	2	Total
Fair	63	49	112
Unfair	15	33	48
Total	78	82	160

Using a 0.05 level of significance, is there evidence of a significant difference between the two methods in the proportion of fair ratings?

Chapter 13

One-Way ANOVA

Used for comparing 3 or more populations.

Assumptions:
- Randomness & independence
- Normality
- Homogeneity of variance (variance of the c groups are equal)

Imp table (crib it):

Source	Degrees of freedom	Sum of squares	Mean square (variance)	F
Among groups	c-1	SSA	MSA=$\frac{SSA}{c-1}$	F=$\frac{MSA}{MSW}$
Within groups	n-c	SSW	MSW=$\frac{SSW}{n-c}$	
Total	n-1	SST		

ANOVA is a right tail F test

c= number of groups
n= sample size

**ANOVA stands for analysis of variance & it extends the z and t tests to test more than 2 population means

Ho: $\mu 1 = \mu 2 = \mu 3 = \cdots \mu c$
*all population means are equal

Ha: $\textit{Not all of the populations are the same or are not equal}$
*At least one population mean is different

*does not necessarily mean that all population means are different (some pairs may be the same)