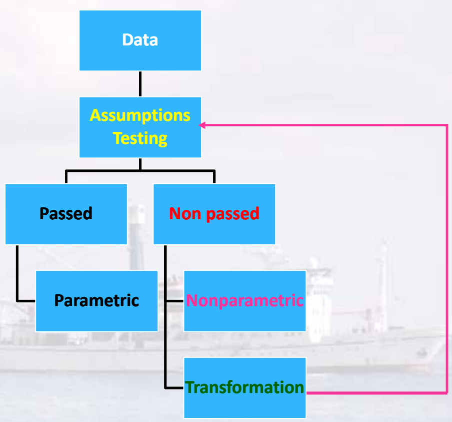
Inferential Statistics:

Testing Hypothesis



Types of Hypothesis

Research Hypothesis

Statistical Hypothesis

Null Hypothesis

- All variables are not relation
- null hypothesis always equal (=)
- No need to write with statistical symbols

Alternative Hypothesis

- Anything else that possible aside from null hypothesis
- Usually define as >, <, ≠

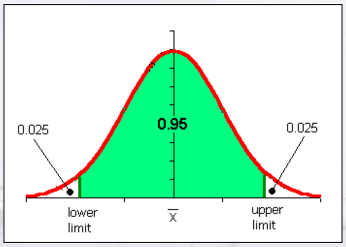
Why Null Hypothesis??

Steps of Testing Hypothesis

- From research to statistics
  - Null Hypothesis (H_0)
  - Alternative Hypothesis (H_a or H_i)
  - How many 'tail' (sided) you want?
- Define your 'alpha'
- Define your testing statistics

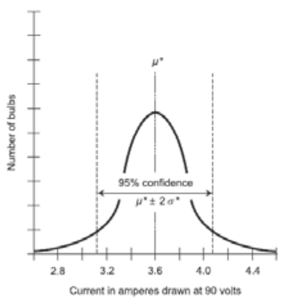
What is alpha?

- α : Level of Significance

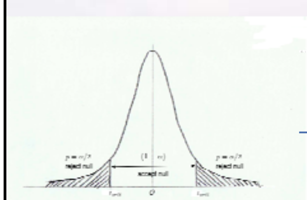


- α : is not confidence interval

Confidence Interval



One or Two-sided Test



Try to define the hypothesis

Steps of Testing Hypothesis

- Computed your data
- Compare your result with table value **OR**
- Use P-value
- Conclude your result as *'human words'*

What is p-value???

P-value = the probability of finding the observed or more extreme results when the *null hypothesis* is TRUE

What is p-value???

P-value $\leq$ α

P-value > α

Approach to conclude

- Ronald Fisher's Approach
- Neyman and Pearson's Approach
- Modern Statistics Approach***
  - "Failed to reject H_o or retained H_o"

Type I and Type II Error

	Actual Situation	
	H_0 TRUE	H_0 not TRUE
REJECT H_0	Type I error (α)	Correct Decision
FAILED TO REJECT H_0	Correct Decision	Type II error (β)

One population t-test

- Compare between population mean and constant

Two population t-test

- Compare between two population means
- Three cases to concern

One population t-test

* chi-square Goodness of Fit Test: Sex Ratio

male	female
1	0
13	14
111	245
317	461
601	862
891	828
977	483
697	248
306	138
123	159
43	227

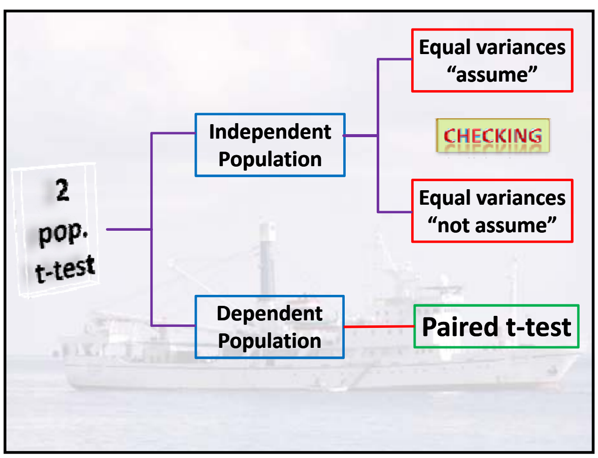
$$\chi^2 = \sum \frac{(observed - expected)^2}{expected}$$

* Proportion Test: Sex Ratio

One population t-test

* t-test
* t-test: Is average no. of male equal to 372?

$$t = \frac{\bar{x} - \mu}{s / \sqrt{n}}$$



Two population t-test

Equal variance

$$t \cong \frac{(\bar{x}_1 - \bar{x}_2)}{s_p\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

$$s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}$$

$$df = n_1 + n_2 - 2$$

Unequal variance

$$t \cong \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}}$$

$$df = \frac{\left(\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}\right)^2}{\frac{\left(s_1^2/n_1\right)^2}{(n_1-1)}+\frac{\left(s_2^2/n_2\right)^2}{(n_2-1)}}$$

Testing Equality of Population Variances

Statistical hypothesis

$$H_0 : \sigma_1^2 = \sigma_2^2$$

Test statistics $F = \frac{S_1^2}{S_2^2}; df = n_1 - 1, n_2 - 1$

Caution!!

- **Two-sided test**

$$F = \frac{Greater\ \ S^2}{Lesser\ \ S^2}$$

Two population t-test

Example 1 :

	Group 1	Group 2
mean	76.4	81.2
sd.	8.2	7.6
n	90	100

Example 2

```
> male=c(1,13,111,317,601,891,977,697,306,123,43)
> female=c(0,14,245,461,862,828,483,248,138,159,227)
```

Paired t-test

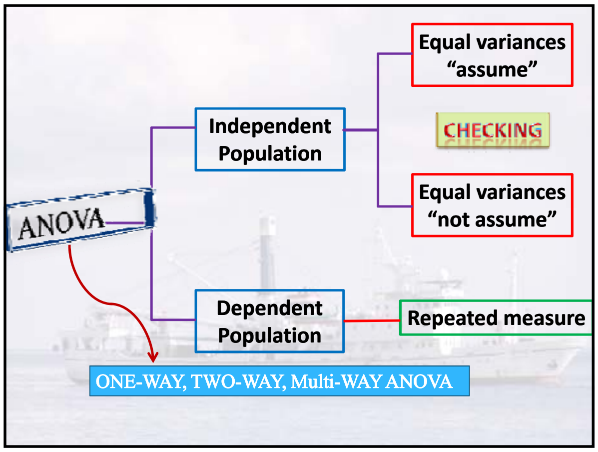
$$t = \frac{\overline{D} - \mu_D}{s_{\overline{D}}}$$

$$s_{\overline{D}} = \frac{S_D}{\sqrt{n}}$$

To be continued…

Inferential Statistics:

ANOVA



Basic ANOVA by Basic Designs

* CRD = Completely Randomized Design
* RCBD = Randomized Complete Block Design
* Factorial experiment in any basic design

ปัญหาที่พบบ่อย (Don't worry, it's my note)

* หน่วยทดลองที่นำมาใช้ มีความสม่ำเสมอกัน
* ไม่มีผลต่อการจัด treatment จึงใช้การสุ่มแบบ equal probability คือให้โอกาสต่อหน่วยทดลองในการได้รับ treatment ใด ๆ เท่า ๆกัน
* จึงเรียกว่า "สุ่มแบบสมบูรณ์ หรือ สุ่มตลอด"
* สามารถวิเคราะห์แบบ "ข้อมูลสูญหาย หรือจำนวนซ้ำไม่เท่ากัน" ได้
* เอะอะอะไร ก็ "สุ่มตลอด"....โดยไม่ได้สนใจจะตรวจสอบว่า หน่วยทดลองที่นำมาใช้น่ะ....สม่ำเสมอจริงไหม..แถมไม่เคยสนใจด้วยซ้ำว่า ต้อง "สุ่ม...ให้ตลอด..."
* ไม่สนใจเลยว่า ข้อกำหนด (assumption) ของแผนนี้ ว่าไว้ยังไงบ้าง..
* พี่เขาสอนมาให้ใช้แบบนี้ ไม่รู้หรอกว่าทำไม...ไม่สนด้วยว่าทำไม ถึงสงสัยก็ไม่คิดจะถาม กลัวต้องถูกสั่งให้วิเคราะห์อะไรที่ยุ่งยาก-ซับซ้อนกว่านี้ กลัว กลัว และกลัว ฯลฯ
* คำนวณง่ายดี อะไร ๆ ก็...CRD
* แล้วแปลผลได้ถูกต้องหรือเปล่า...น่าสงสัย

Mathematical Model

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}; i = 1,2,..., t$$
$$j = 1,2,..., r$$

ANOVA table

Source	df	SS	MS	F
Treatment	t-1	SST	MST = SST/df	MST/MSE
Error	t(r-1)	SSE	MSE = SSE/df	
Total	tr-1	SS total		

Randomized Complete Block Design (RCBD)

ปัญหาที่พบบ่อย (Don’t worry, it’s my note)

* จะเอาอะไรเป็น block? (อย่าลืม..ภายในต้องไม่แตกต่าง ระหว่างต้องแตกต่าง)
* จัดกี่ block ดี?
* หาหน่วยทดลองลงใน block ได้พอไหม (อย่าลืมอีกนะ...มี “ซ้ำแฝง” ด้วย)
* จัด treatment ลงได้ครบไหม?
  * ถ้าครบ-รอดตัวไป เพราะเป็น RCBD วิเคราะห์ง่ายหน่อย
  * ถ้าไม่ครบ- ยากขึ้น เพราะต้องวิเคราะห์แบบ RIBD

Mathematical Model (RCBD)

$$Y_{ij} = \mu + \rho_i + \tau_j + \varepsilon_{ij}; i = 1,2,\ldots,r$$
$$j = 1,2,\ldots,t$$

ANOVA table

Source	df	SS	MS	F
Block	r-1	SSB	MSB = SSB/df	
Treatment	t-1	SST	MST = SST/df	MST/MSE
Error	(r-1)(t-1)	SSE	MSE = SSE/df	
Total	rt-1	SS total		

What will be happened if the result is significant?

Multi-factor Experiment : Factorial

- Studying many factors in the same time
- Easiest way, doing single factor for every factors
- If can not, 'Multi-factor' was available
- Factorial 'experiment' was just a kind of multi-factor experiment

Factorial Experiment

- Don't use experimental design
- This is a kind of "Experiment" which setting the level of, at least, 2 factors an experimental as treatment
- The treatment combination, can analyzing co – effect between each factor

Factorial Experiment

- Still have to use based experimental design such as
  - Factorial experiment in CRD
  - Factorial experiment in RCBD / RIBD
  - Factorial experiment in LSD

Factorial Experiment

- Basic knowledge
- Factor and Level
- Treatment Combination
- Main effect and Co effect
- Assigned effect and Random effect
- The different formulas
- The EMS

Problems

- Which one can be factor?, how many optimize number or levels or factors can be used?
- Do not forget
  - Calculation will as complicated as more number of factors
  - Which basic design can be used?
  - If too many blocks, can it be another factor?

Problems

- Don't forget
  - Are we get the number of experimental units enough for the treatment combination (Do not forget the "hiding sample")
  - Formulas depends on kind of effect
- For co – effect analysis, the large number of factors doesn't mean to the good result

Treatment Comparisons

Types of Treatment Comparisons

- Multiple Comparisons (*post hoc* comparisons)
- Orthogonal (planned comparison)
- Trend Comparisons

Multiple Comparisons

- Many methods, but same based, to calculating the 'critical value' to comparing the different mean "in each pair" of treatment
- So

$$\left|\overline{Y}_i - \overline{Y}_j\right| \geq crit.value$$

Assume that treatment i and j are different

Multiple Comparisons

- Size of critical value
  - Some methods have small critical value, the different between mean of treatment was not so much (sensitive test)
  - Some methods have large critical value, the treatment's mean have to very different to be able to see the different (conservative test)
- Number of critical value
  - Some methods using only one critical value to compare every single pair of treatment
  - Some methods have many different critical values according to range of treatment that used

Multiple Comparisons

- Fisher's least significant different (LSD)
- Bonferroni's test (developed from LSD)
- Duncan's new multiple range test (DMRT)
- Tukey's *w* procedure or Honestly significant difference,HSD)
- Student-Newman-Keul's test (SNK)
- Scheffe's test
- Dunnett's test

Orthogonal Comparison

- Treatments were grouped
- Getting completely summary
- Grouping according to the experimental objective
  = Planned comparisons
- High efficiency method and giving the significant level as same as we sets
- Not so familiar

Trend Comparisons

- Comparing trend of the responding result of treatment of experimental units
- Using only in case of quantitative experimental treatment
- Example: Response Surface Method

Can see more details of Treatment's mean comparisons from ordinary statistical books
(which about experimantal design)

Choosing of Treatment's Mean Comparison Methods

- Every methods are the same, not the best one
- How to choose
  - Error rates : Which one can better control an error?
  - Power of the test : Which one have higher power of test?
  - Conservativeness : Which one have more conservativeness?

Choosing of Treatment's Mean Comparison Methods

* How to choose
  * Optimality : Narrowest C.I. of the different between means
  * Convenience : Easy to calculate
  * Robustness : Usable even if breaking some assumptions
* SPSS, SAS can help you!!!

To be continued...

Inferential Statistics:

Regression Analysis

Meaning of Correlation Coefficients

Correlation coefficients	Level of coefficients
0.81 – 1.00	Highly correlated
0.51 – 0.80	Moderately correlated
0.21 – 0.50	Low correlated
0.00 – 0.20	Very low correlated

Regression Analysis

Variable	Number	Measurement
Independent Var.	Not less than 1	Number and Grouping
Dependent Var.	1	Metric Variable

Why Regression?

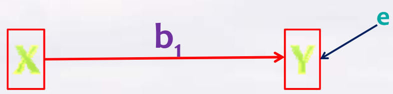
- Analyze the relationship among variables
- Causal relationship

Objectives

1. Study the pattern of relationship between variables
2. Estimates or Forecast

Regression Scatter Plot

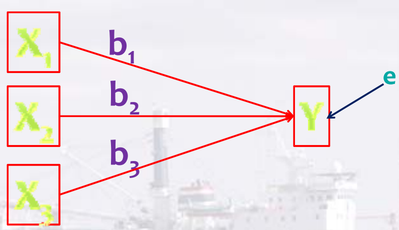
Simple Regression



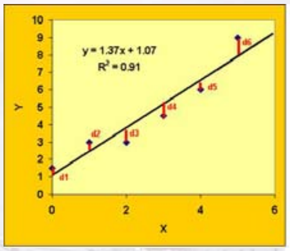
$$y = b_0 + b_1 x + e$$

- **b_0= Y intercept, when X=0**
- **b_1= Estimator of Regression Coefficient (Changed value of Y when X changed one unit)**

Multiple Regression



Predicted by Regression Line



- Residual or error
- Time series data

Predicted by Regression Line

Estimated a and b by

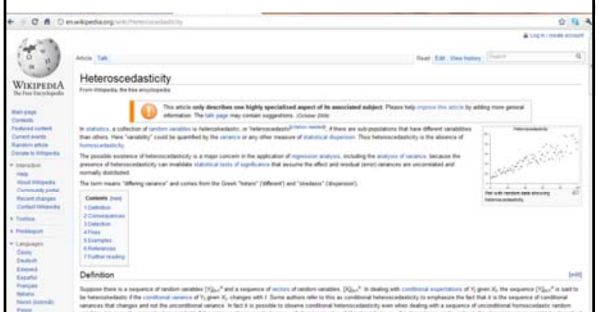
- Ordinary Least Square Analysis (OLSA)
- Maximum Likelihood Estimator (MLE)

Simple Regression Analysis

- Conditions or Assumptions
  - error ~ normal $(0, \sigma^2)$
  - $V(e) = \sigma^2$ is constant
  - e_t, e_{t+1} are independent
- Error term or Residual term
- Testing Hypothesis about α and β
- The coefficient of determination (R^2)
- The correlation coefficient (r)

Examining Condition

- e is normal
  - Chi-square test
  - Kolmogorov-Smirnov Test (any sample size: n)
  - Shapiro-Wilk Test ($n \leq 50$)
- V(e) is constant (if it is not constant, Heteroscedastic Problem)
  - Plot graph between e and $\hat{Y}$ or X and examined by eye
- e_t, e_{t+1} are independent
  - Durbin-Watson Test



Checking condition: e_t, e_{t+1} are independent

Durbin-Watson Test

$$DW = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_i^2}$$

0<DW<4

1. $DW \approx 2 \Rightarrow$ e_t, e_{t+1} are independent
2. $DW < 2 \Rightarrow$ e_t, e_{t+1} are positive relationship
3. $DW > 2 \Rightarrow$ e_t, e_{t+1} are negative relationship


THE END