सत्यमेव जयते

Ministry of Micro, Small and Medium Enterprises,
Government of India

MSME

MICRO, SMALL & MEDIUM ENTERPRISES
सूक्ष्म, लघु एवं मध्यम उद्यम

# MSME –TDC, Chennai

## CERTIFIED LEAN SIX SIGMA

## GREEN BELT TRAINING

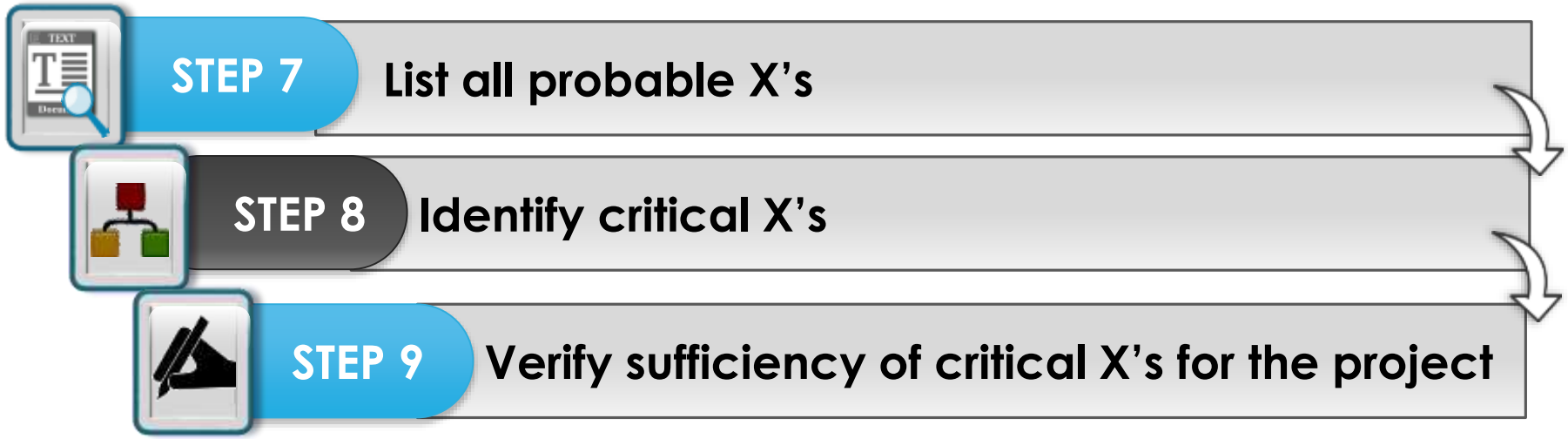
## DAY-3

## ANALYZE PHASE

## IDENTIFY CRITICAL 'X'


Dr.Gopal Sivakumar

# ANALYZE PHASE OVERVIEW



# ANALYZE PHASE DELIVERABLES

1. Factors responsible for Waste, Risks and Variation
2. Identification of Potential X's
3. Validated Root Cause
4. Sufficiency of Validated Factors

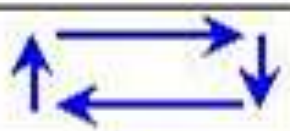
# STEP 7: List all probable X's

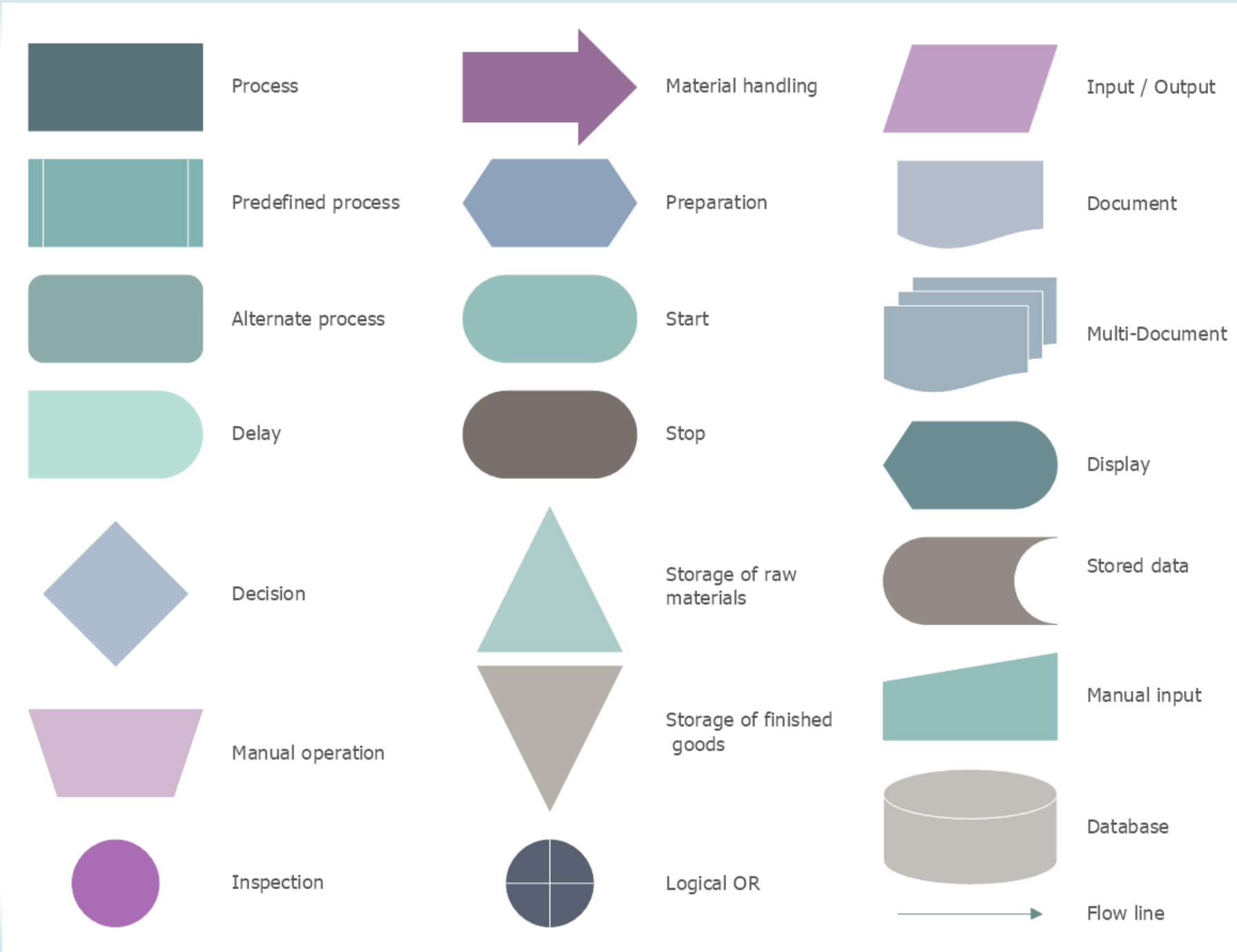
**The key objective of analyze phase is to identify factors responsible for the gap in performance.**

Sources of gap in performance

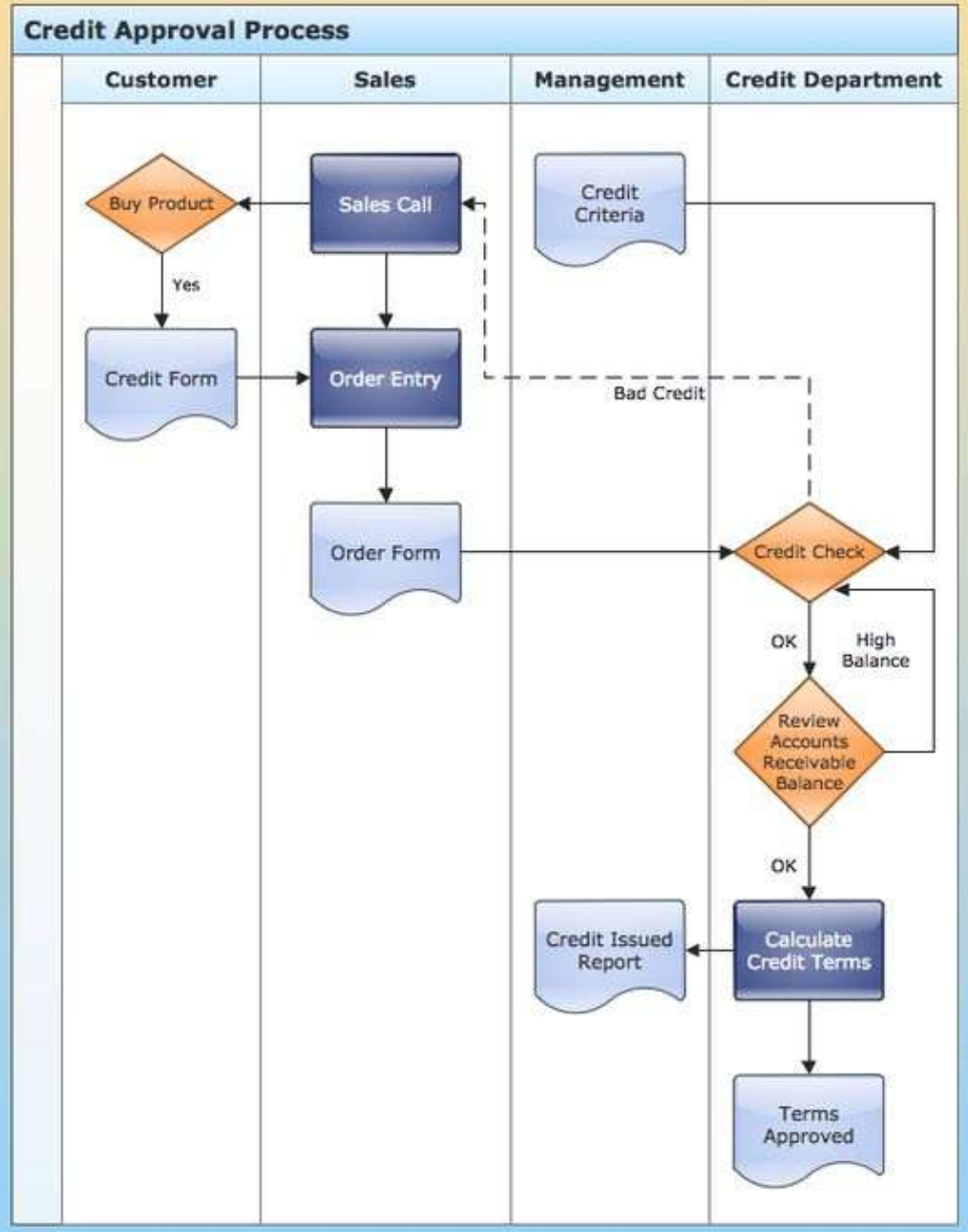
- **Sources of waste** – Value add and Non-value add analysis
- **Sources of Risk** – Failure Mode and Effect Analysis
- **Sources of Variation** - Quality Screening using a set of tools and by engaging a cross functional team to identify and prioritize factors responsible for variation

# Typical symbols used in Process Maps

| | | |
|---|---|---|
|  | **Start & End Points** | Identify the boundaries of the process. |
|  | **Activity** | What is being done. Indicates necessary and unnecessary activities performed in the process. |
|  | **Decision** | Illustrates decision points and where loops occur in the process. Also used to accept, reject, approve, etc. |
|  | **Arrow** | Represents a process path/flow. |
|  | **Input or Output** | Shows important inputs or outputs without describing in detail. |
|  | **Process Connectors** | Connect flow to another page or process. |
| A# | **Activity Number** | Shows the activity in the sequence performed. |
| D# | **Decision Number** | Shows the decision points in the sequence performed. |


Process
Predefined process
Alternate process
Delay
Decision
Manual operation
Inspection
Material handling
Preparation
Start
Stop
Storage of raw materials
Storage of finished goods
Logical OR
Input / Output
Document
Multi-Document
Display
Stored data
Manual input
Database
Flow line

# Cross-Functional Process



**Value add / Non-value add analysis**

- Reducing cycle time
- Preventing rework & Duplication of efforts
- Identifying and segregating value-add and non-value added tasks

WHEN FMEA

## PROCESS FMEA

- Whenever changes are made targeting some improvement goals

- When analyzing failures

## DESIGN FMEA

- During design or redesign, after **QFD**

# SOURCE OF VARIATION: Qualitative Screening

- Brainstorming
  - Group discussion to identify potential factors
  - Voluntary generation of a large volume of creative and new idea by the participants
- Five Why's Analysis
  - By repeatedly asking the question "Why", GB/BB can peel away the layers of symptoms which can lead to the root cause of a problem.

# Fishbone / C&E / Ishikawa Diagram

- C-E diagram (Cause and Effect diagram) is an effective way to summarize and list various causes and root causes.
- In C-E diagram, the most important thing is to show correlation between cause-effect, and all possible causality needs to be considered.
- Two ways of developing Fishbone diagram
  - Put first level causes in main bones
  - Or use 5M+1E on main bones

| | | |
|---|---|---|
| - Men | - Materials | - Methods |
| - Machines | - Measurements | - Environment |

# Pareto Diagram

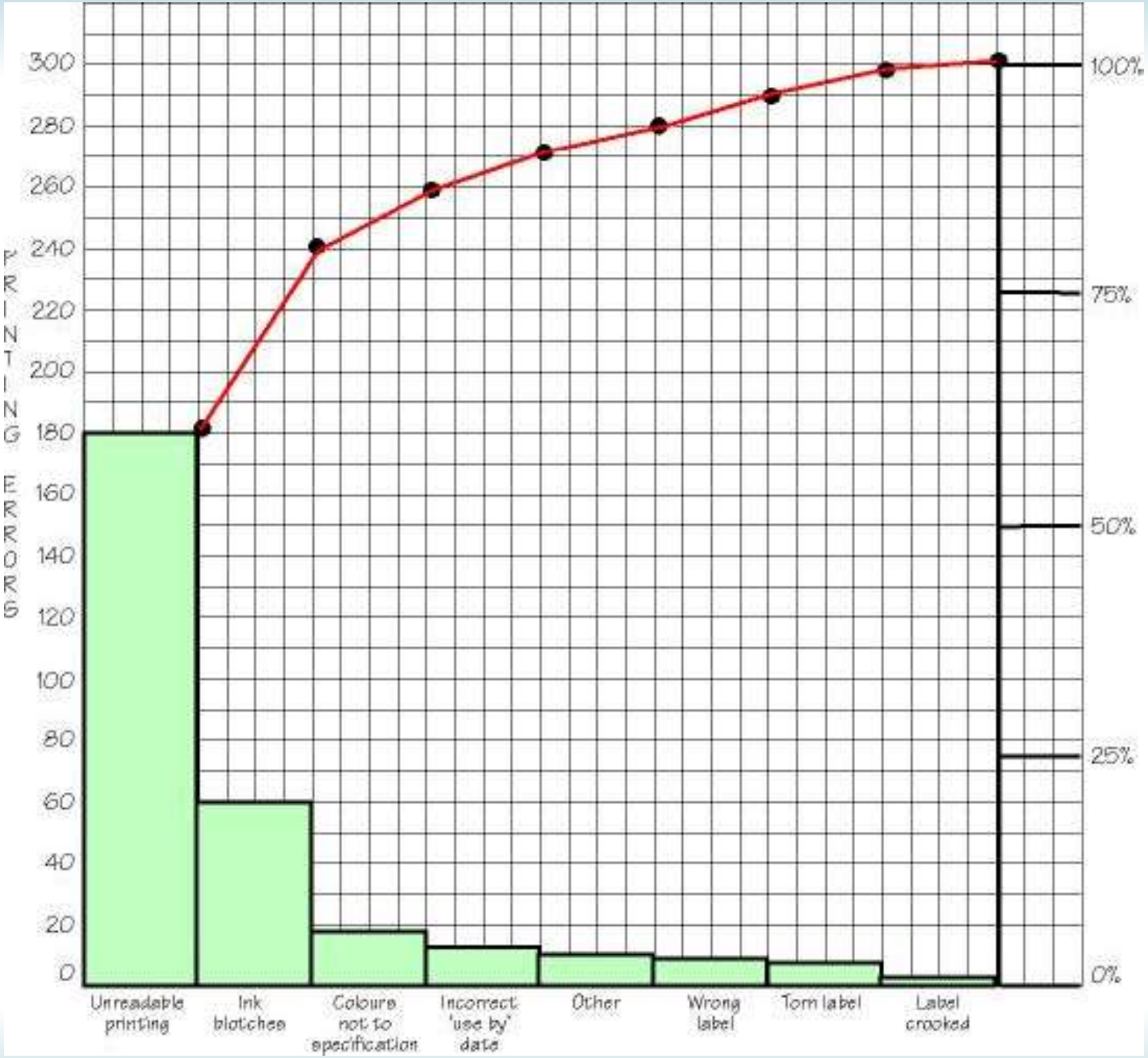
- The Pareto chart is named after Vilfredo Pareto, an Italian engineer, sociologist, economist, political scientist and philosopher.

**Pareto is a special type of bar chart where the plotted values are arranged from largest to smallest. A Pareto chart is one of the basic quality control tools used to highlight the most frequently occurring defects.**

# 80-20 Rule

- 20% of the people contain 80% of the wealth;
- 20% of the product line may generate 80% of the waste;
- 20% of the customers may generate 80% of the complaints,
- 80% of the warehouse space is taken up by 20% of the part numbers etc.

| Category | Frequency | Cumulative frequency |
|---|---|---|
| Unreadable printing | 180 | 180 |
| Ink blotches | 60 | 240 |
| Colours not to specification | 18 | 258 |
| Incorrect ‘use by’ date | 12 | 270 |
| Other | 10 | 280 |
| Wrong label | 9 | 289 |
| Torn label | 8 | 297 |
| Label on crooked | 3 | 300 |
| Total | 300 | |


PRINTING ERRORS
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
100%
75%
50%
25%
0%
Unreadable printing
Ink blotches
Colours not to specification
Incorrect 'use by' date
Other
Wrong label
Torn label
Label crooked

# Stratification

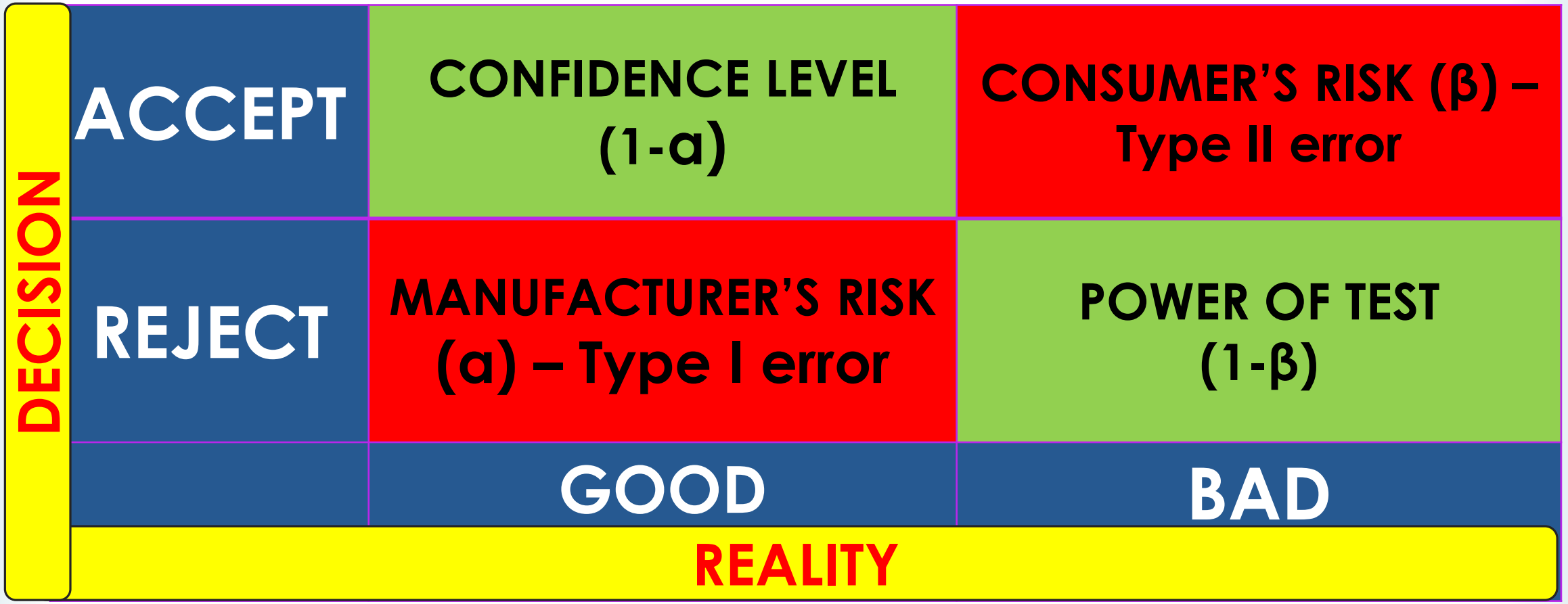
1. Subdivisions
2. Multi-perspective (weighted pareto) analysis
3. Repeat analysis

# STEP 8: Identify critical X's

## Sample Vs. Census

| Type of Study | Conditions Favoring the Use of Sample | Census |
|---|---|---|
| 1. Budget | Small | Large |
| 2. Time available | Short | Long |
| 3. Population size | Large | Small |
| 4. Variance in the characteristic | Small | Large |
| 5. Cost of sampling errors | Low | High |
| 6. Cost of nonsampling errors | High | Low |
| 7. Attention to individual cases | Yes | No |

# Understanding Sampling Risk & Errors



# HYPOTHESIS TESTING

- A procedure that evaluates two mutually exclusive statements about a population.
- A hypothesis test uses sample data to determine which statement is best supported by the data.
- These two statements are called the null hypothesis and the alternative hypotheses.

**Null Hypothesis:** $H_0$ States that a population parameter is equal to a desired value.

- Statement of Innocence / No Change / No difference
- Statement that has to be assumed, if you cannot prove otherwise

**Alternative Hypothesis:** $H_1$ or $H_A$ States that the population parameter is different than the desired value.

- Statement that will be valid if null hypothesis is rejected
- Just like a court case, we first assume that the accused (X) is innocent and then try to prove it otherwise based on evidence (Data).
  - If evidence does not show significant difference, we cannot reject the innocence (Ho)
  - But if Evidence is strong enough, we reject the Innocence (Ho) and pronounce the suspect Guilty (Ha).

# P-Value

**The probability of significance**

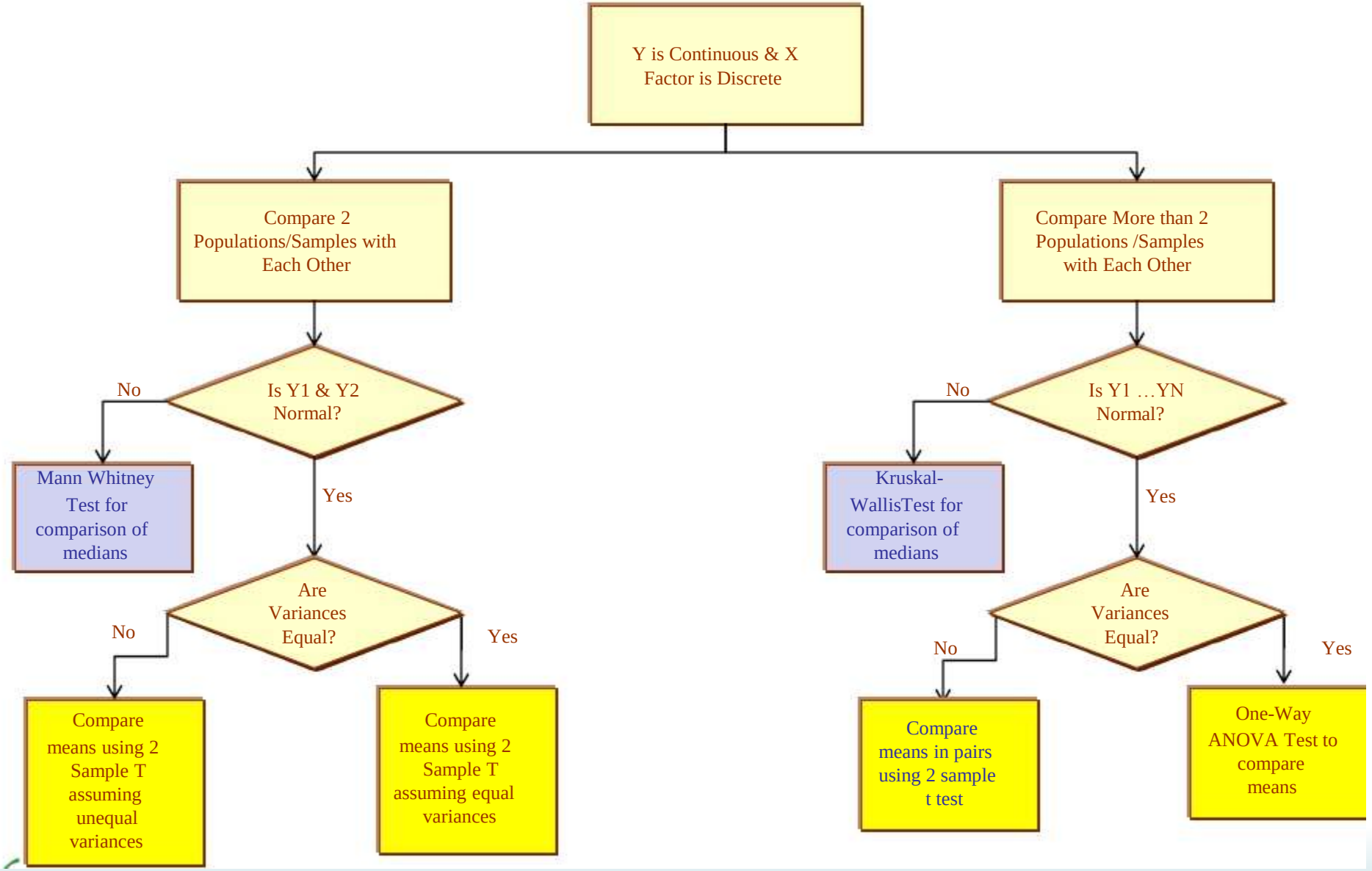
**If P value is less than 0.05, the X factor has an impact on the Y response**

**If P < 0.05; Reject Null Hypothesis**

**If P value is more than 0.05, the X factor has no impact on the Y response**

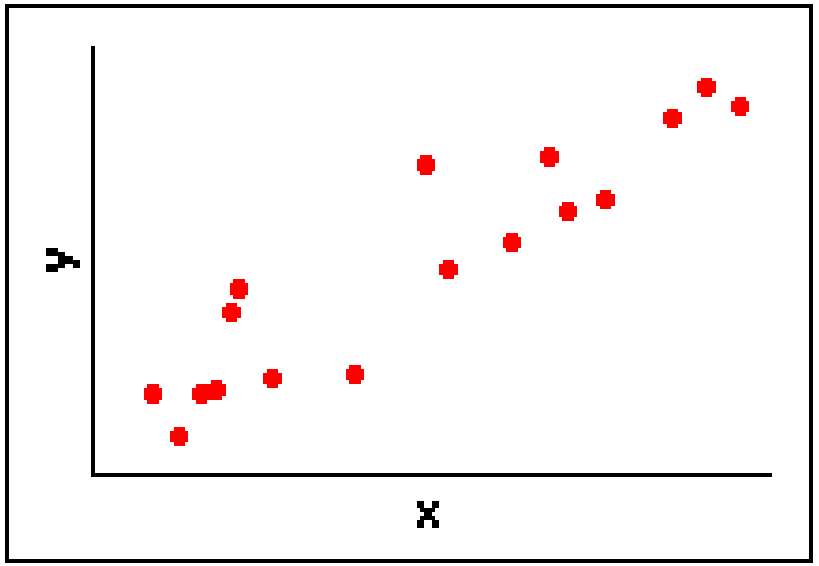
**If P > 0.05; Accept Null Hypothesis**

# Continuous Y and Discrete X

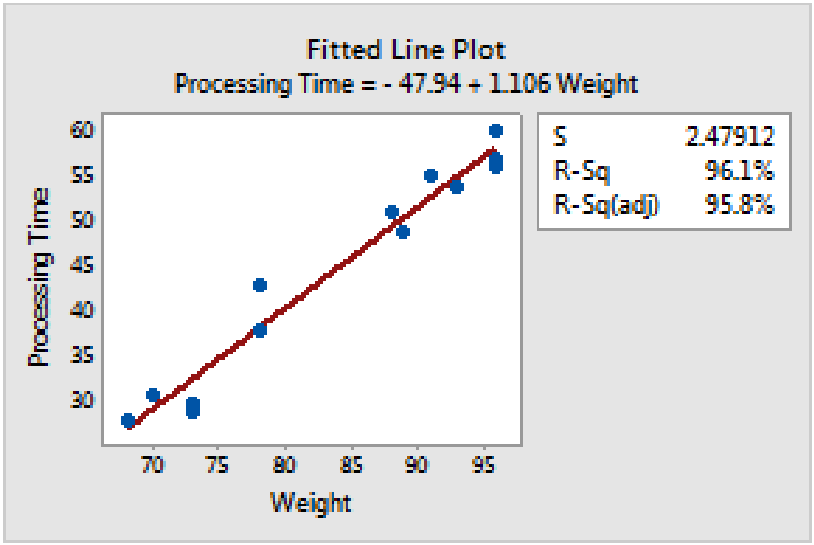


# SCATTER PLOT

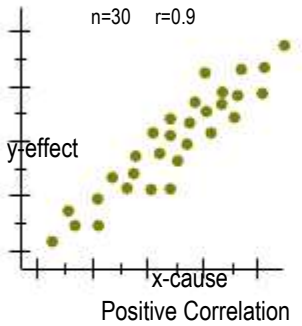
Scatterplots are used to explore the potential relationship between a pair of continuous variables.



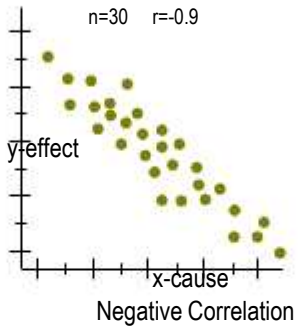

For example, you could examine the relationship between the fuel efficiency of a vehicle and its horsepower, or plant growth and soil PH.



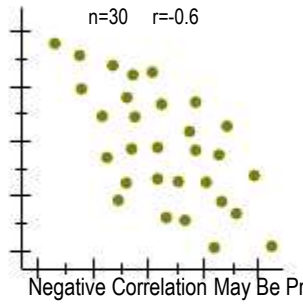
# Scatter Diagram Interpretation



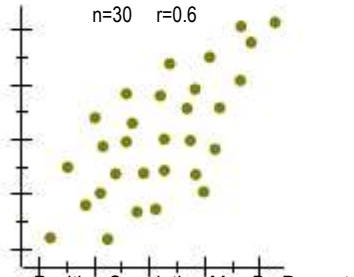
Positive Correlation



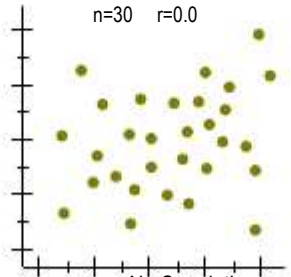
Negative Correlation



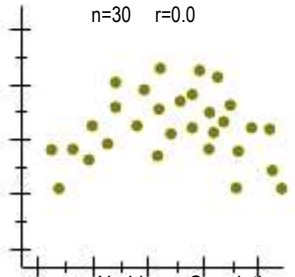
Negative Correlation May Be Present



Positive Correlation May Be Present



No Correlation



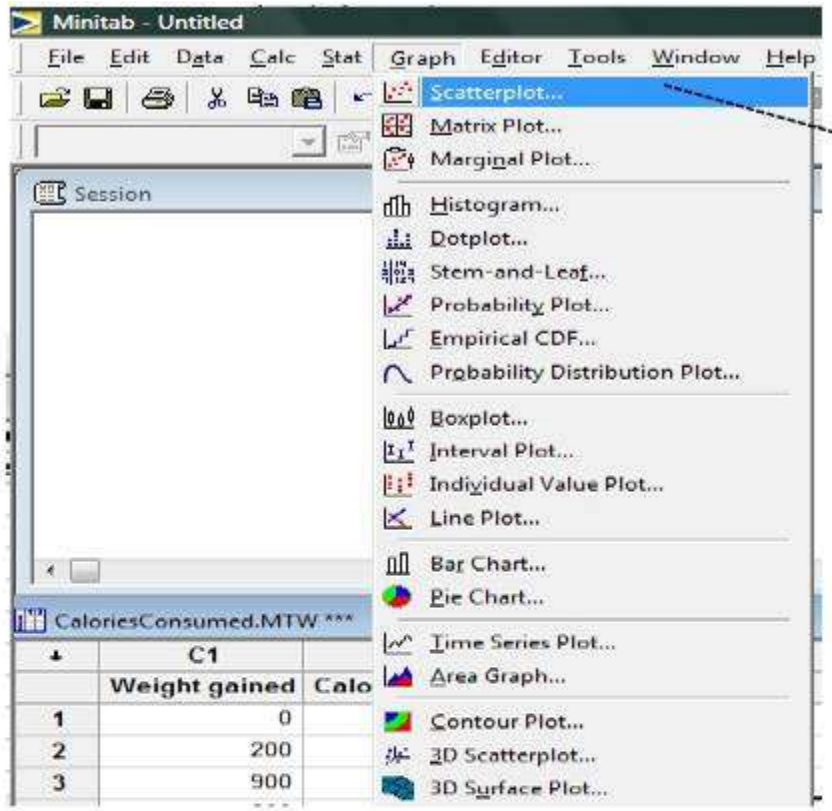
No Linear Correlation

# USES OF SCATTER DIAGRAM

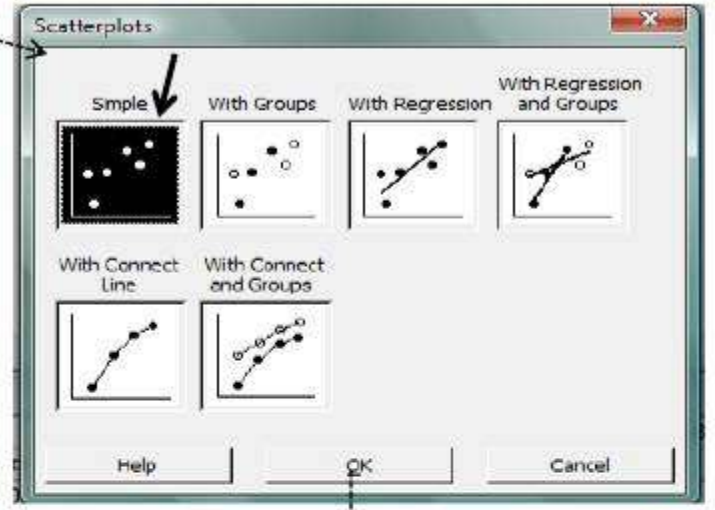
- If an increase in Y depends on increase in X, then, if X is controlled, Y will be naturally controlled.

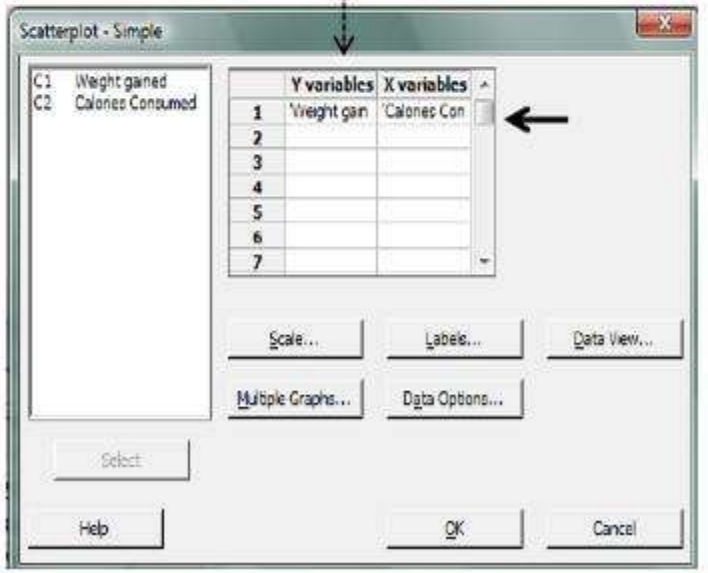
- If X is increased, Y will increase somewhat. Then Y seems to have causes other than X.

# Scatter Plot




- Graph>Scatterplot



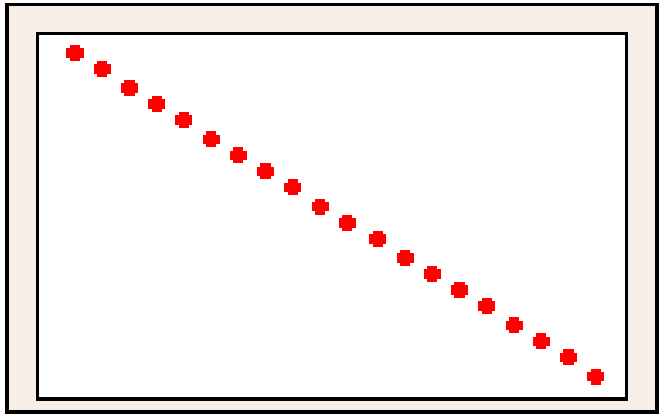




CaloriesConsumed.mtw

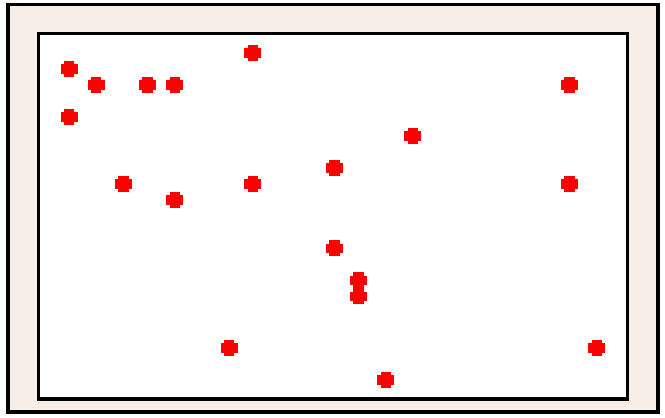
# CORRELATION

A measure of linear association between two variables.

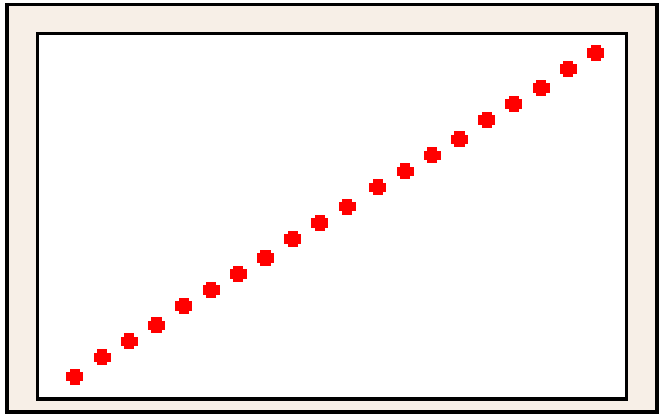
It quantifies correlation with a single number - the correlation coefficient- which describes both the strength and direction of the relationship. The correlation coefficient ranges from -1 to 1 where:



-1 describes a relationship where an increase in one variable is accompanied by a predictable and consistent decrease in the other.

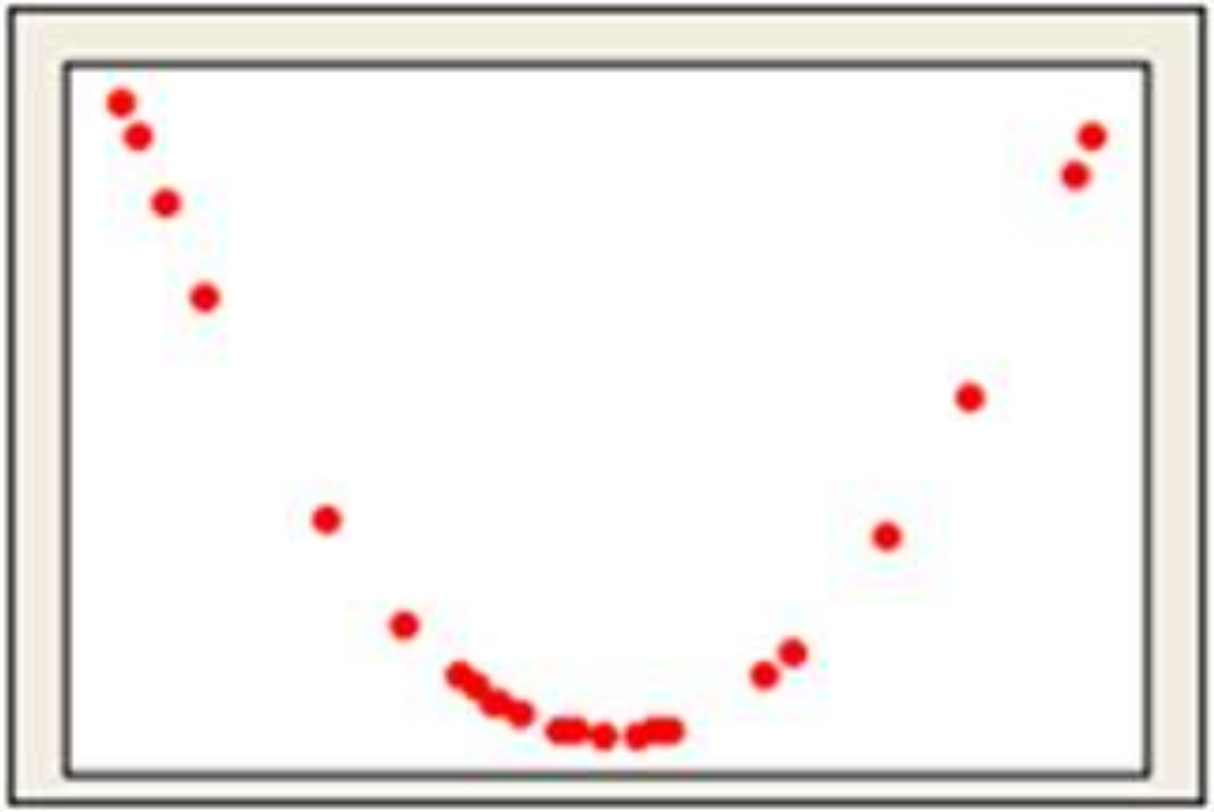


0 describes a random or non-existent relationship.



1 describes a relationship where an increase in one variable is accompanied by a predictable and consistent increase in the other.

# Low correlation does not mean no relationship exists



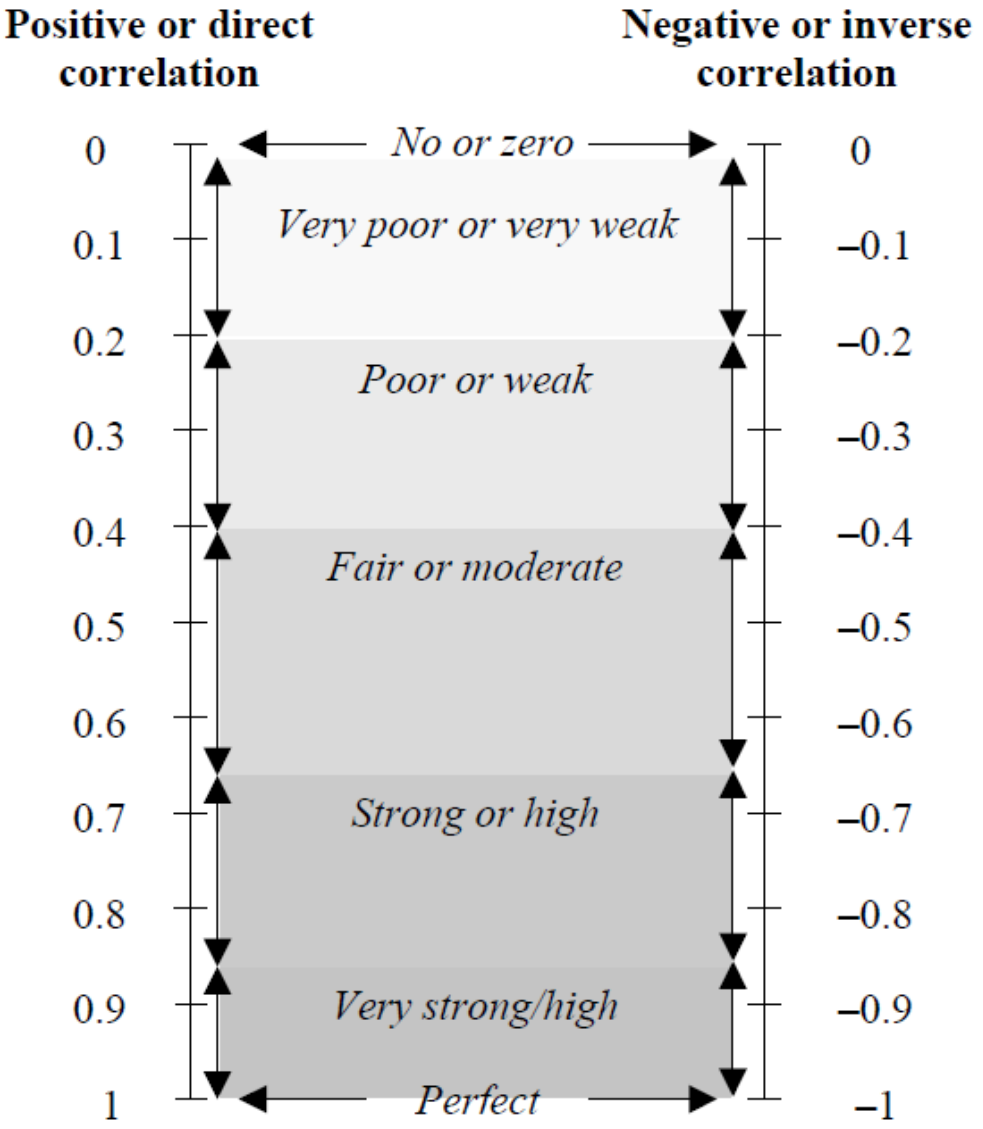
This graph illustrates a very strong relationship with a Pearson correlation coefficient of 0.

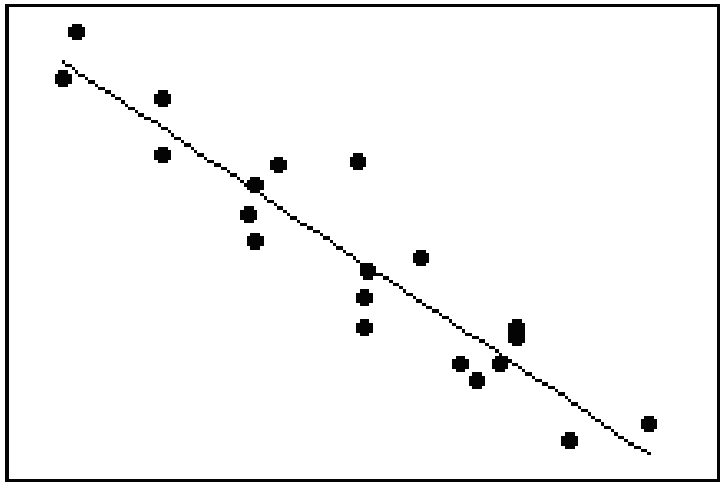
$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}}$$

Where:

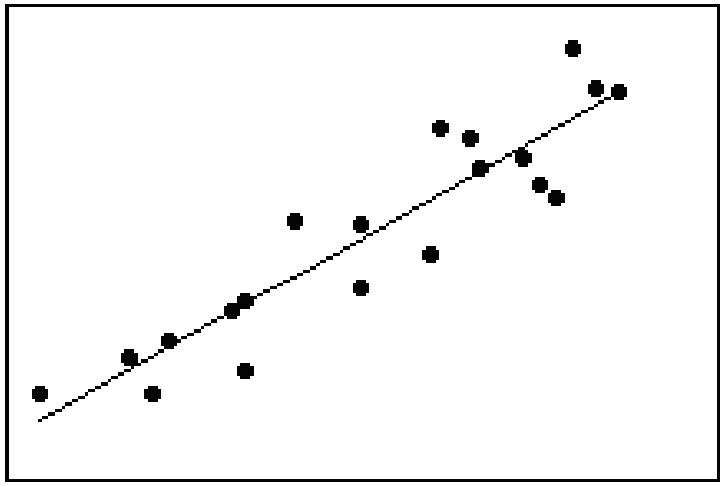
| | | |
|---|---|---|
| $N$ | = | number of pairs of scores |
| $\Sigma xy$ | = | sum of the products of paired scores |
| $\Sigma x$ | = | sum of x scores |
| $\Sigma y$ | = | sum of y scores |
| $\Sigma x^2$ | = | sum of squared x scores |
| $\Sigma y^2$ | = | sum of squared y scores |

**Pearson's correlation coefficient (r)**

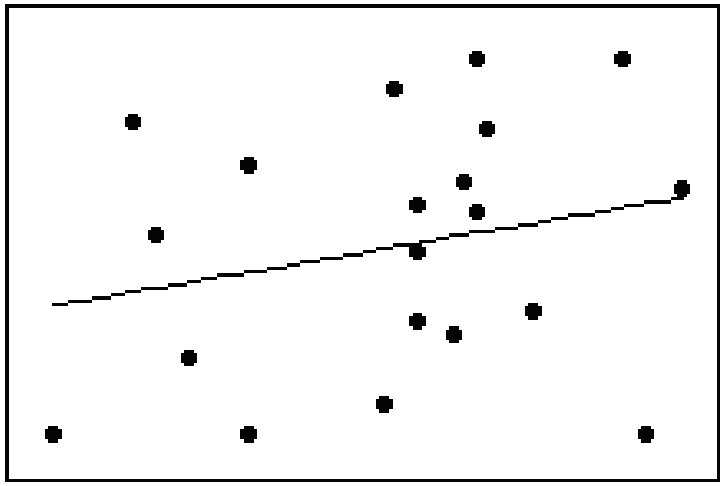


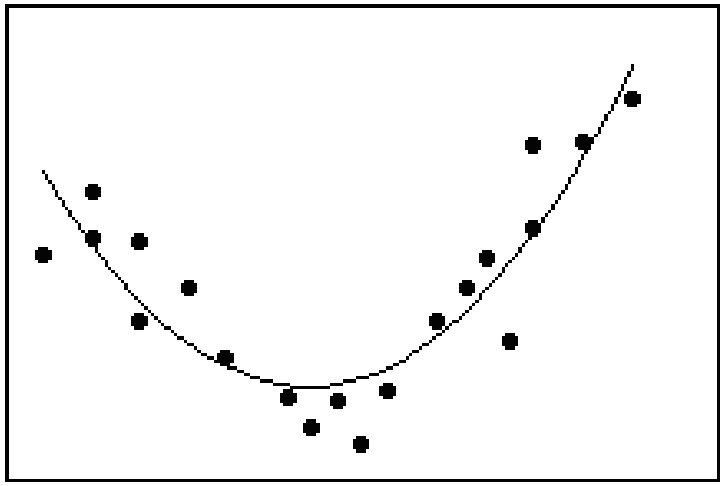
If one variable tends to increase as the other decreases, the coefficient is negative. The above correlation is -0.93.



Conversely, if the two variables tend to increase together the coefficient is positive. Here the correlation is +0.92.



At +0.23 the data points appear to fall randomly around the line. This model does not account for much of the variance.



Correlation coefficients only measure linear relationships. A meaningful nonlinear relationship can exist even if the correlation coefficient is 0. Look at a scatterplot to determine this.

# REGRESSION ANALYSIS

Generates an equation to describe the statistical relationship between one or more predictors and the response variable and to predict new observations.

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