Module-5

Plant Location and Plant Layout:

Plant location –need - Factors – comparison – quantitative methods for evaluation

Plant layout: objectives-principles – factors influencing – tools and techniques including computer based layout design – CRAFT, ALDEP, CORELAP. (7 Hours)

Expected Outcome

CO5	Demonstrate the knowledge of selection of location for the new plant & optimizing the layout within the plant for smooth production.

http://tancem.com

Plant Location

Introduction

Plant Location- Introduction

- Three most important value of a property are

"**Location**,

Location and

Location"

Plant Location- Introduction

- **Service Organizations**

Hotel/ Restaurant

Hospital

Medical shop

Plant Location- Introduction

- **Service Organizations**

Bank

AT M

Focus on locating near their customers

Plant Location- Introduction

- Manufacturing Organizations

Cement Industry

Seek to be close to sources of transportation, suppliers, and labour

Plant Location- Introduction

- Selection of location is a **key-decision** due to large investment
- Change the location very often - not advisable
- Improper location of plant **Investments waste**
- Before selecting the location, **forecasts** should be made

Plant Location - Introduction

- The plant location based on
  - ✓ Company's **expansion plan** and **policy**
  - ✓ **Diversification plan** for the products
  - ✓ **Changing market** conditions
  - ✓ **Changing** sources of **raw materials** and
  - ✓ Many other factors that influence the choice of the location decision

Need for Selecting a Suitable Location

Need for Selecting a Suitable Location

- Situation-1: Starting a new organization

Need for Selecting a Suitable Location

- Situation-2: Expansion of existing organization

Need for Selecting a Suitable Location

- Situation-3: Global Location

Need for Selecting a Suitable Location

- **Starting a new organization**
- Expansion of existing organization
- Global Location

- Organizational objectives
- Long-term considerations
  - ✓ marketing
  - ✓ technology
  - ✓ strengths and weaknesses of organization
  - ✓ region specific resources & business environment
  - ✓ legal-governmental, social & geographical environments

Need for Selecting a Suitable Location

- **Starting a new organization**
- Expansion of existing organization
- Global Location

- Identity several alternate sites
- Do critical analysis best site selection
- Optimum location Reduction of operational and maintenance costs

Need for Selecting a Suitable Location

- Starting a new organization
- **Expansion of existing organization**
- Global Location

Demand for product increases

- Decisions
  - ✓ Expand the existing capacity & facilities
  - ✓ Look for new locations for additional facilities
  - ✓ Shutdown existing facilities to take advantage of some new locations - **drastic step** called as **"Uprooting and Transplanting"**

Need for Selecting a Suitable Location

- Starting a new organization
- Expansion of existing organization
- **Global Location**

- Scope for **virtual proximity** and **virtual factory**
- **Virtual Proximity**
  - ✓ Possible due to advancement in telecommunications technology
  - ✓ Logistics is an important factor in deciding on a location

Need for Selecting a Suitable Location

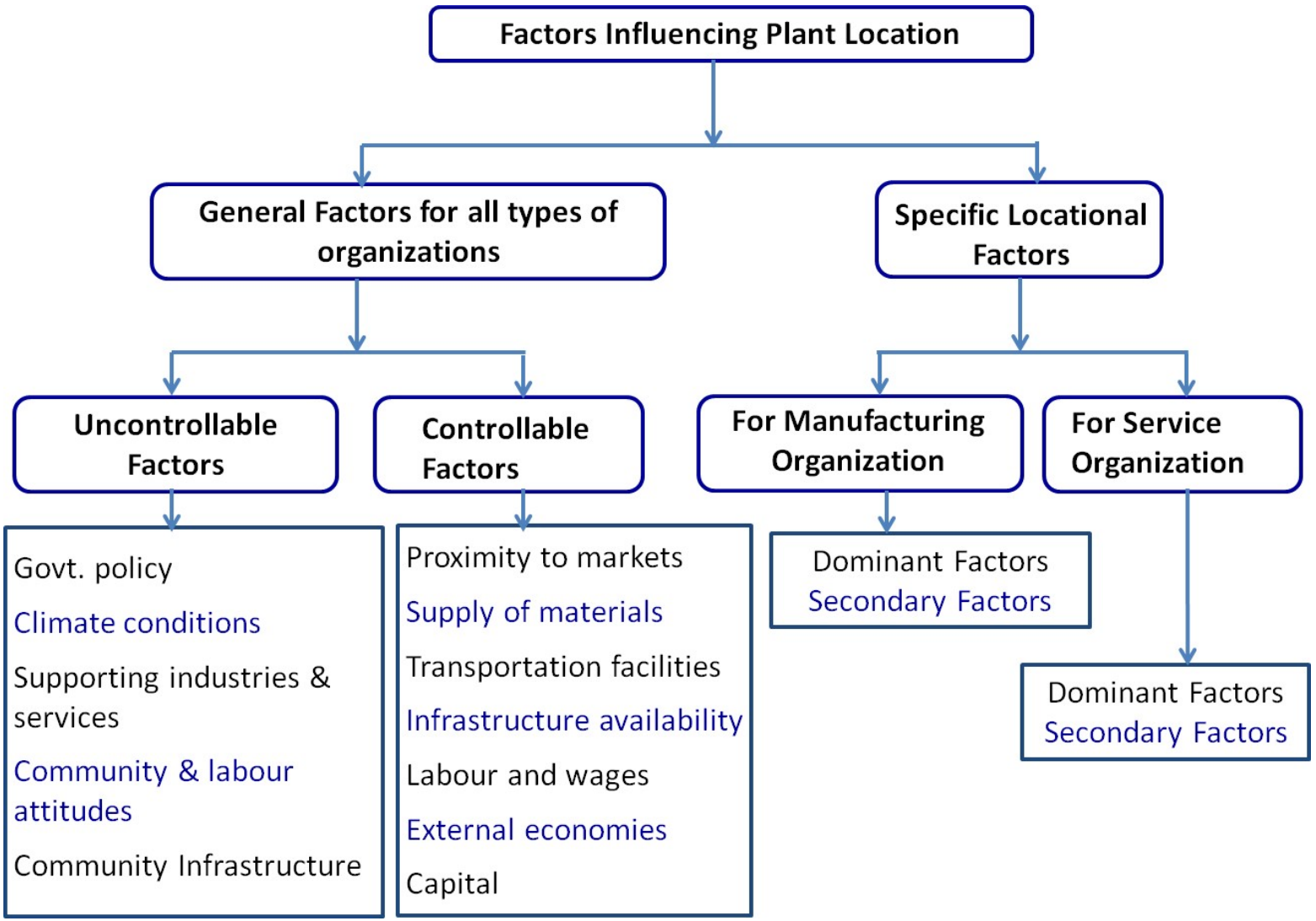
- Starting a new organization
- Expansion of existing organization
- **Global Location**

- Scope for **virtual proximity** and **virtual factory**
- **Virtual Factory**
  - ✓ Outsourcing the part of business

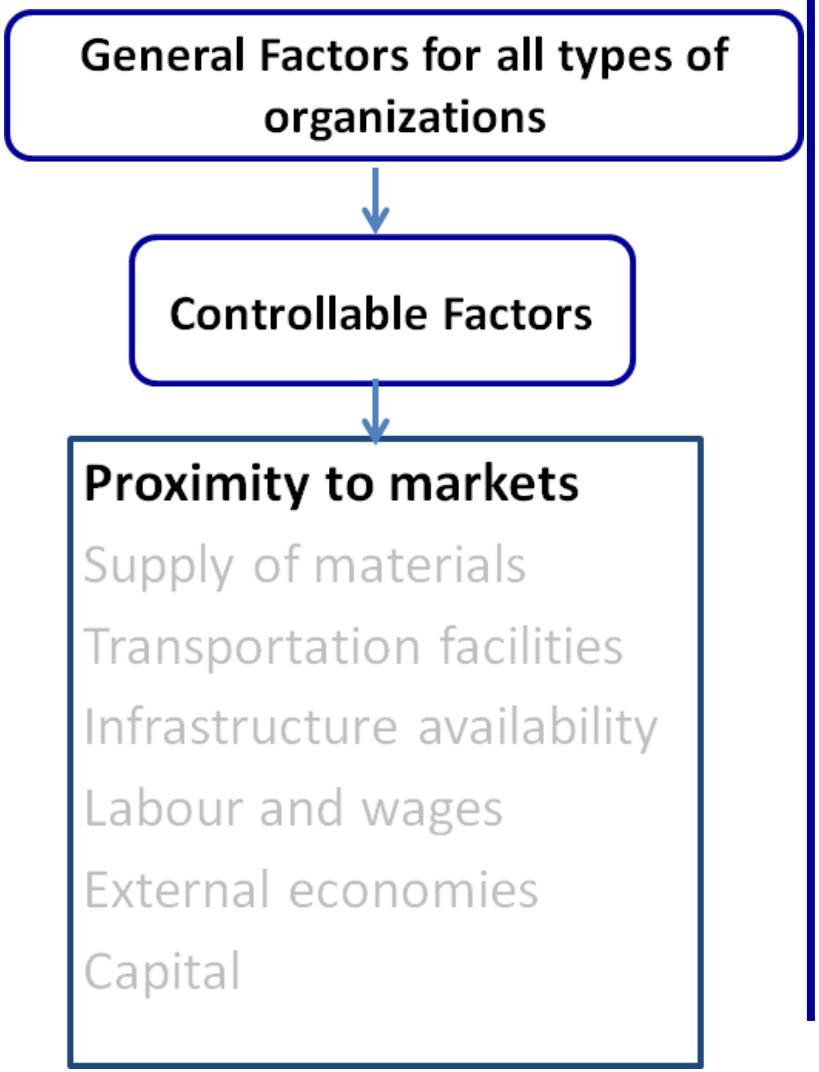
Factors influencing Plant/Factory Location

Factors Influencing Plant/ Factory Location

Facility location - Process of determining a geographic site for a firm's operations

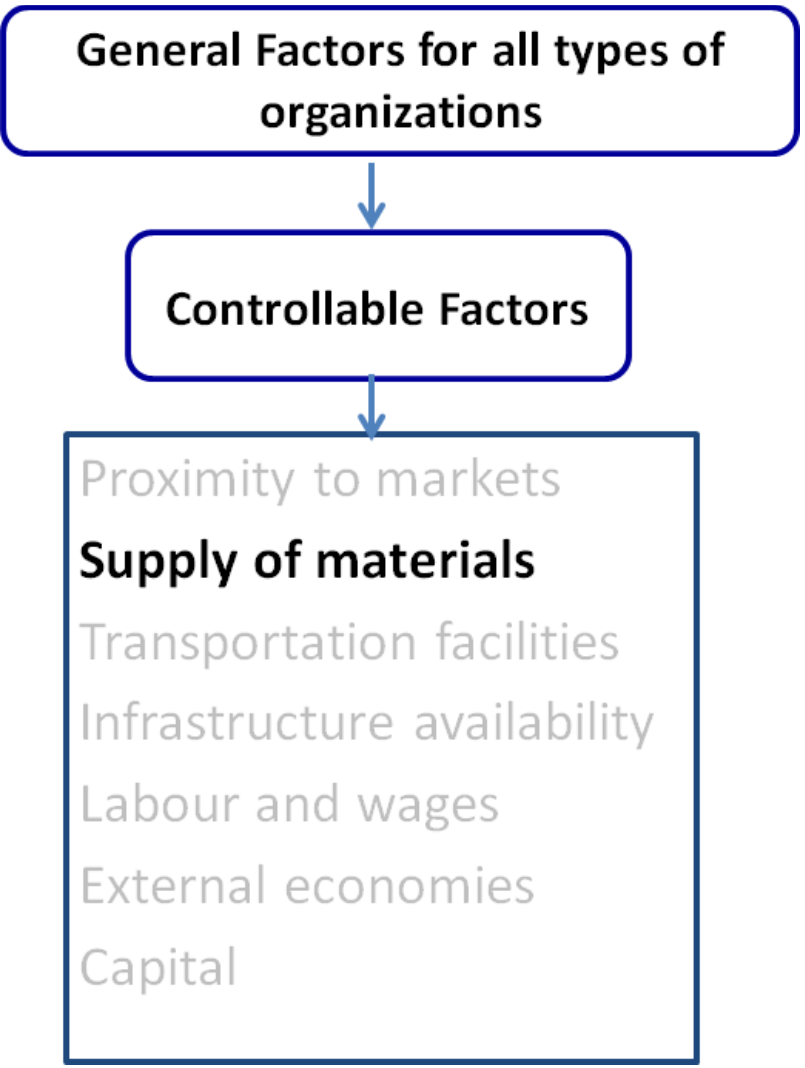


Factors Influencing Plant/ Factory Location



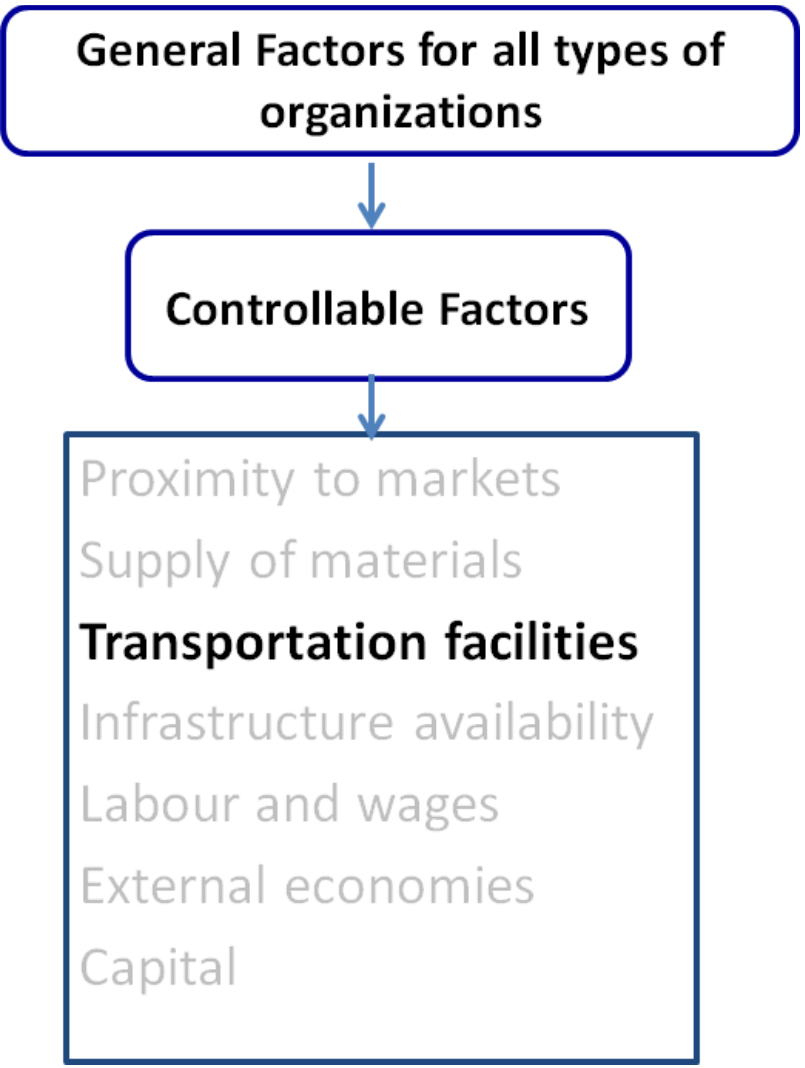
- Closeness to the market places
  -
  consistent supply of goods
- Locating nearer to the market is preferred if
  - ✓ Products are delicate & susceptible to spoilage
  - ✓ Frequent after sales services
  - ✓ High transportation cost
    increase the product cost
  - ✓ Low Shelf life of the

Factors Influencing Plant/ Factory Location



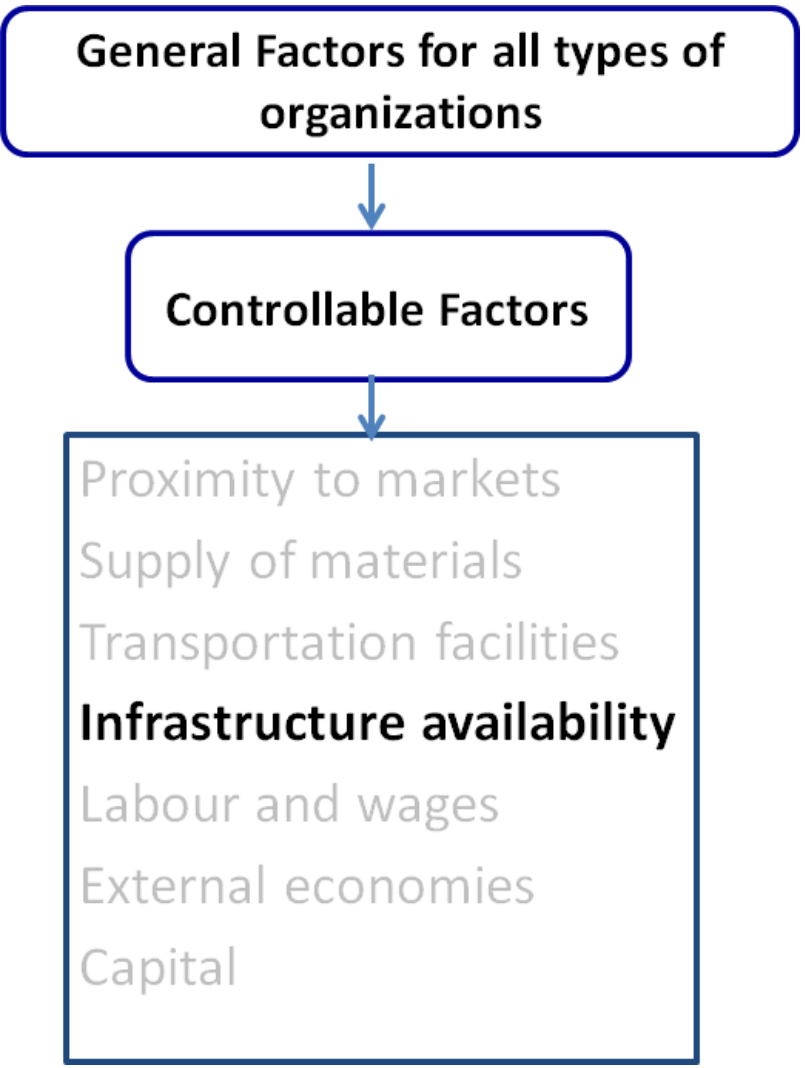
- Right qualities of raw material in time
- Plant location decided by
  - ✓ Raw material universally available
  - ✓ Raw materials processed from variety of locations
- Nearness to raw material is important in case of sugar, cement, jute and cotton textiles industries

Factors Influencing Plant/ Factory Location



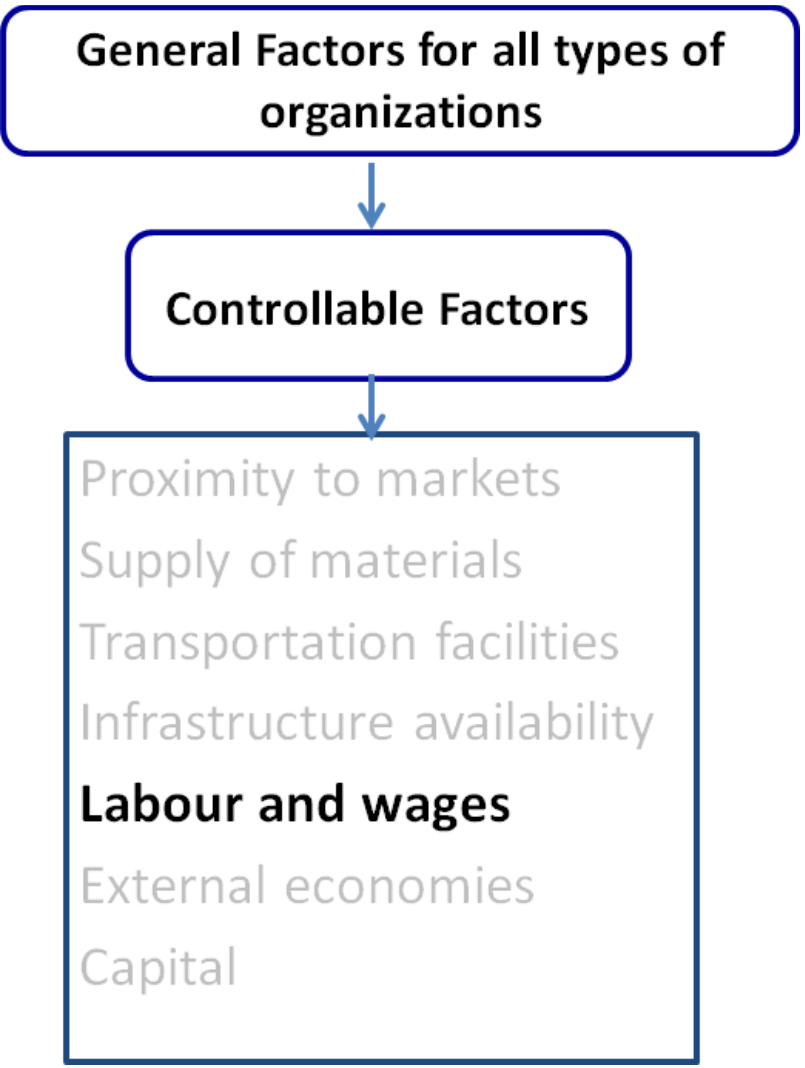
- Prerequisite for the location of the plant
- Speedy transport facilities
- Export goods demand a location near to the port or large airport
- Choice of transport method depends on relative costs, convenience, and suitability

Factors Influencing Plant/ Factory Location



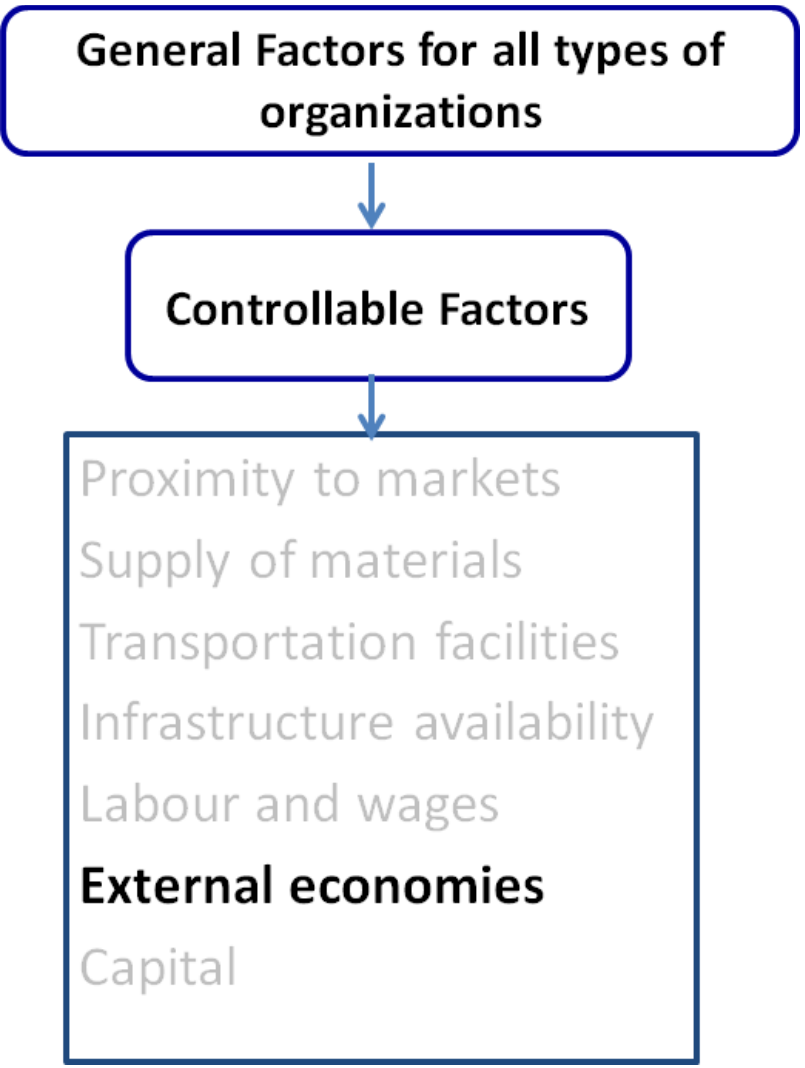
- Basic infrastructure facilities become the prominent factors in deciding the location
- Certain types of industries are **power hungry** e.g., aluminum and steel
- Process industries require **continuous supply of water** in large amount and good quality
- **Waste disposal** facility for process industries

Factors Influencing Plant/ Factory Location



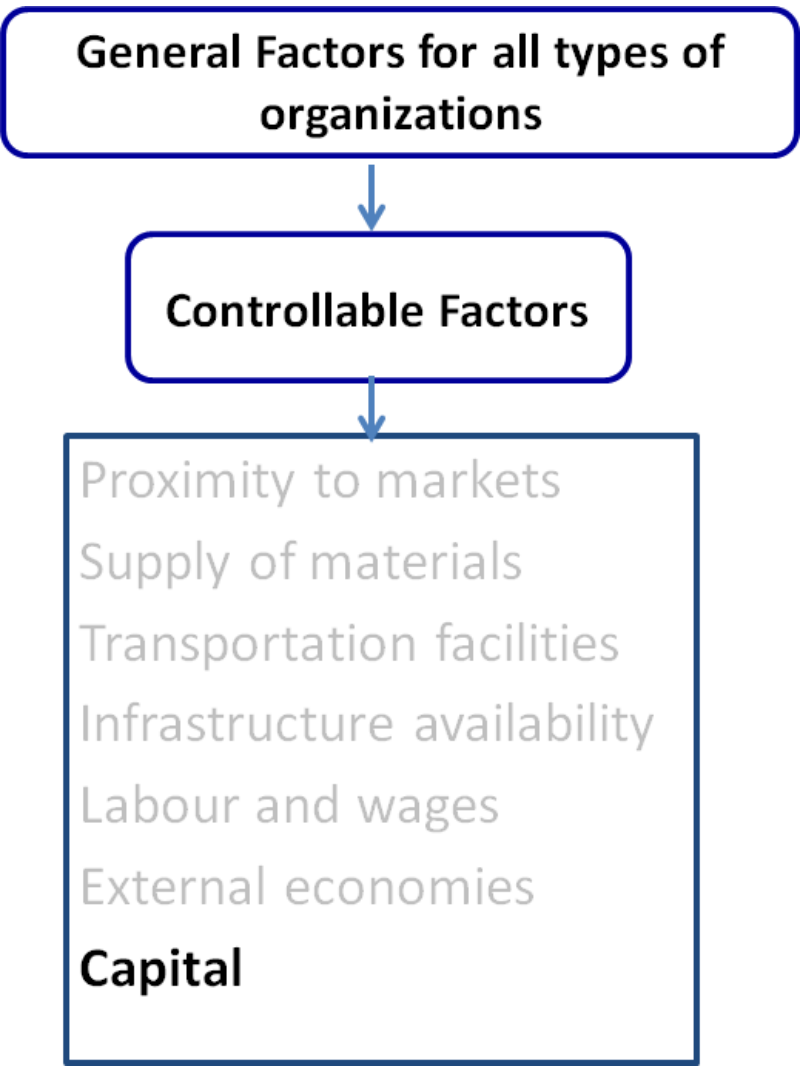
- Adequate number of labour
- Skills specific labour
- Importing labour is usually costly
- Productivity of labour
- Wage pattern
- Cost of living
- Bargaining power of the unions

Factors Influencing Plant/ Factory Location



- **Urbanization economies - Setting up** operations in a large city
- **Location economies - Settling down** among other companies of related Industries
- "**Just in Time**" production system (the so called Kanban System) to reduce inventory costs
- Just in time ensures to get spare parts from suppliers within just a few hours after ordering

Factors Influencing Plant/ Factory Location

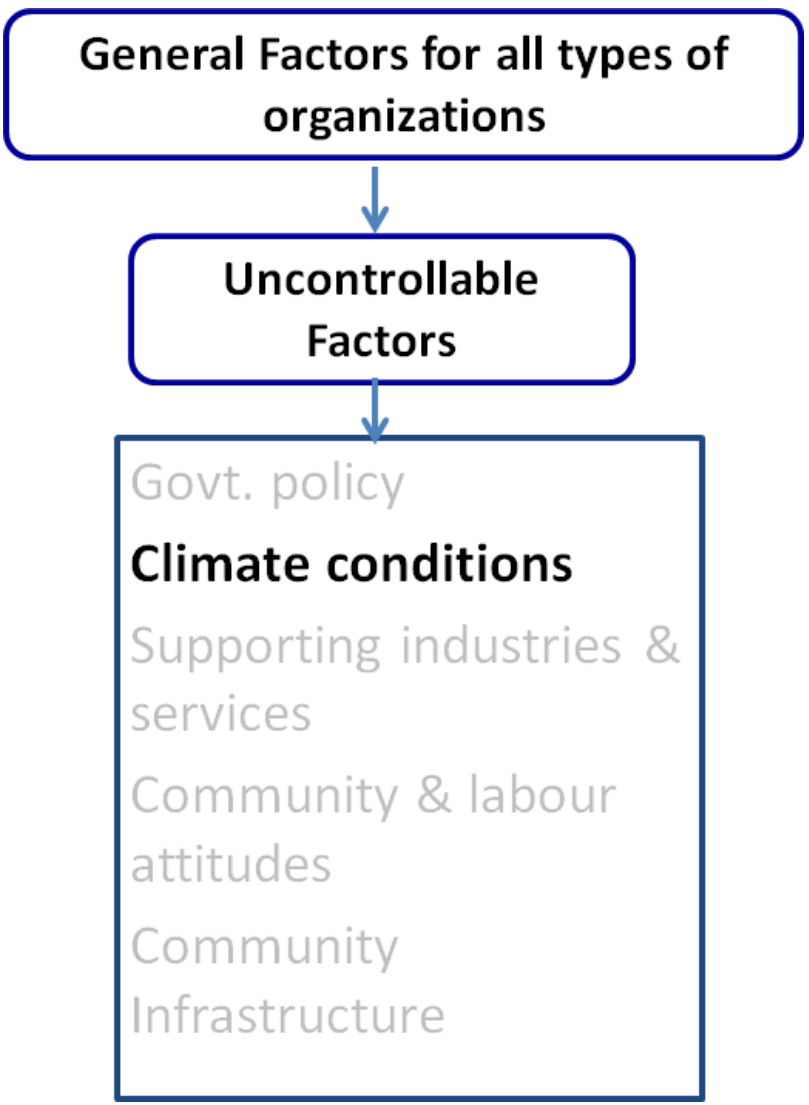


- Fixed capital costs as building and construction costs vary from region to region
- Financial capital is highly mobile and does not very much influence decisions
- **Example**: Large Multinational Corporations such as Coca Cola operate in many different countries and can raise capital where interest rates are lowest and conditions are most suitable

Factors Influencing Plant/ Factory Location

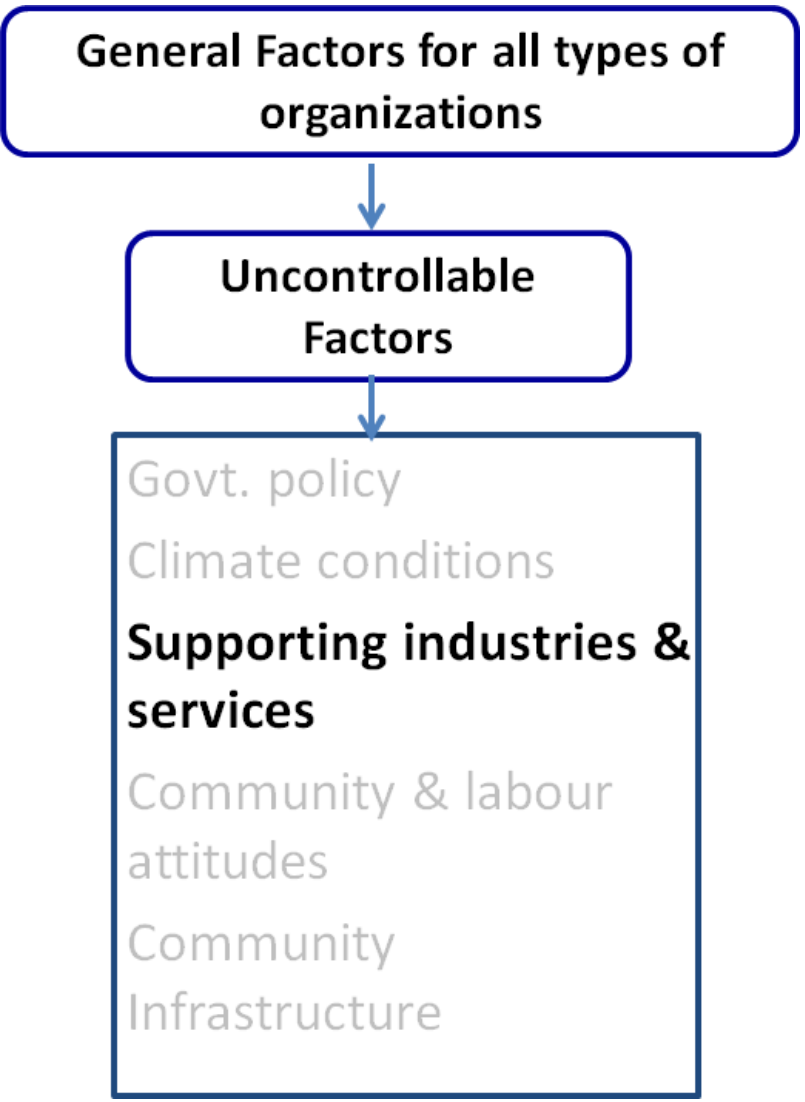
- Governments policies concerning labour laws, building codes, safety, etc., demand attention
- Offering package of incentives to entrepreneurs in particular locations
- **Examples:**
  - ✓ Sales tax exemption
  - ✓ Excise duties exemption
  - ✓ Bank Loan
  - ✓ Subsidy in electricity charges and investment subsidy

Factors Influencing Plant/ Factory Location



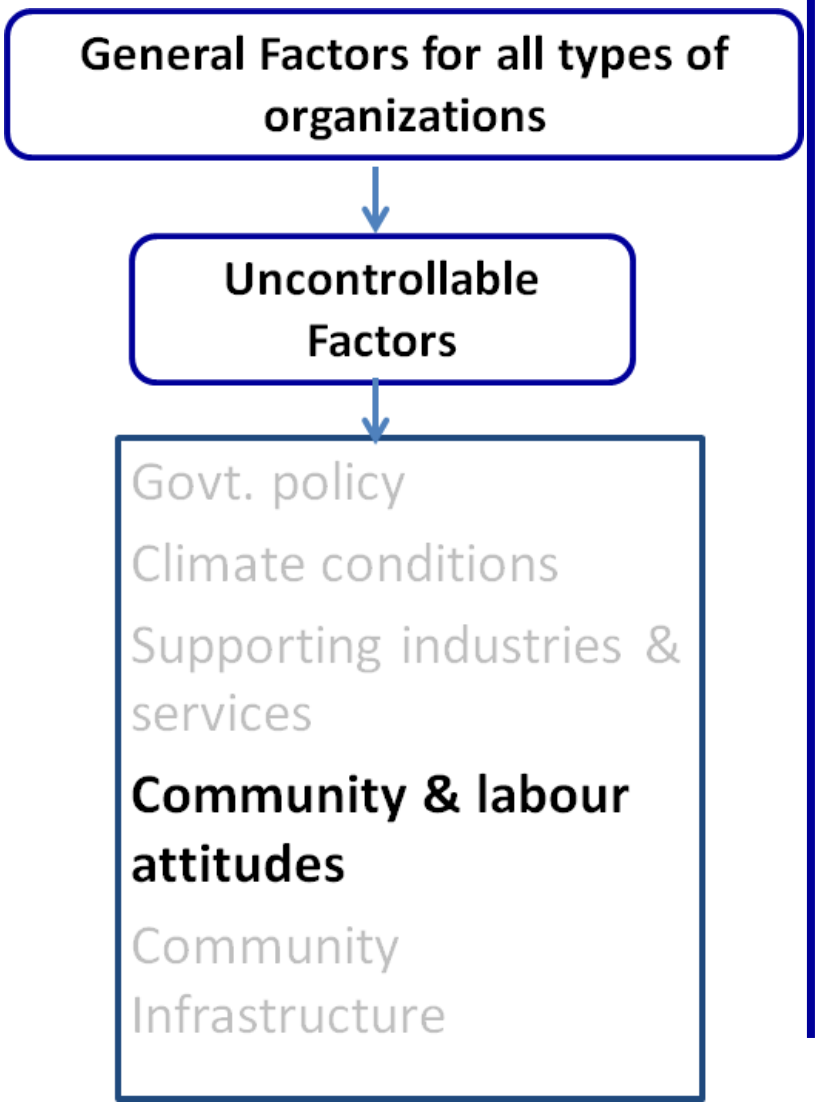
- Geology of the area needs to be considered
- Humidity and temperature plays a role
- Climates greatly influence human efficiency and behaviour
- Some industries require specific climatic conditions
- Example:
  - ✓ Textile mill require humidity

Factors Influencing Plant/ Factory Location



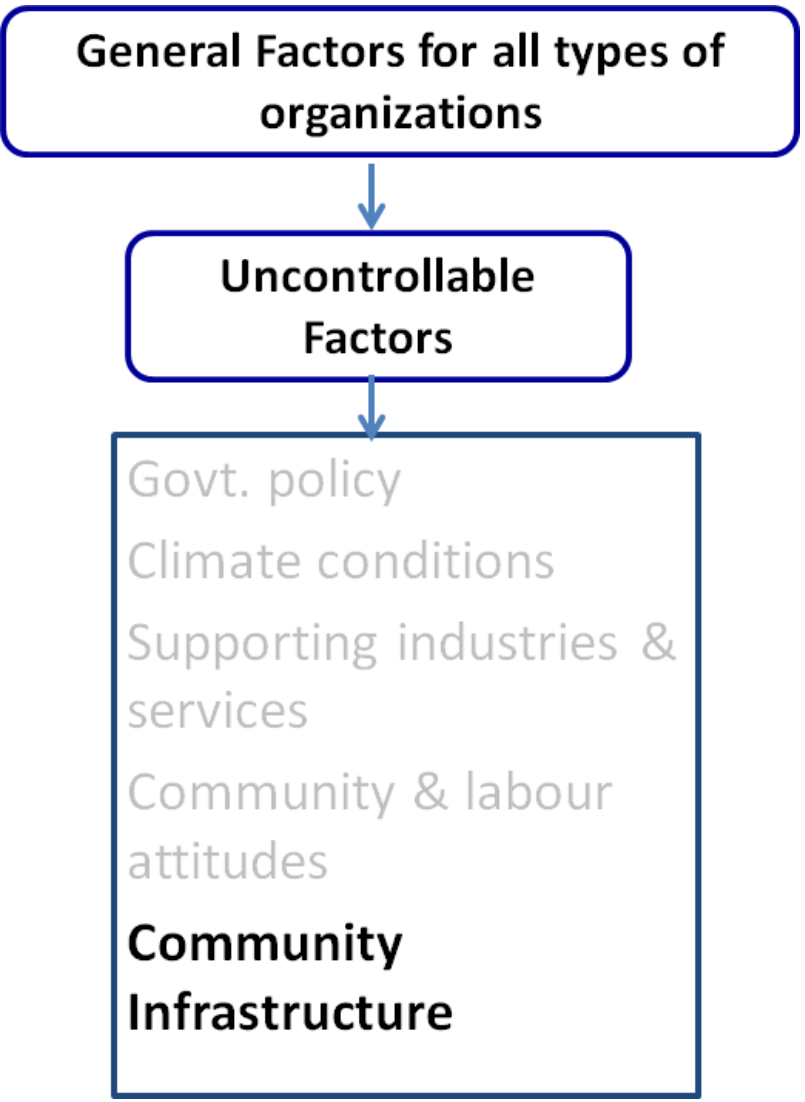
- OEM not making all the components by itself
- Subcontracts the work to vendors
- Source of supply of component is the key factor influences the location
- Service industries like
  - ✓ Communications
  - ✓ Banking
  - ✓ Professional consultancy
  - ✓ Other civil amenities services will play a vital role in selection of a location

Factors Influencing Plant/ Factory Location



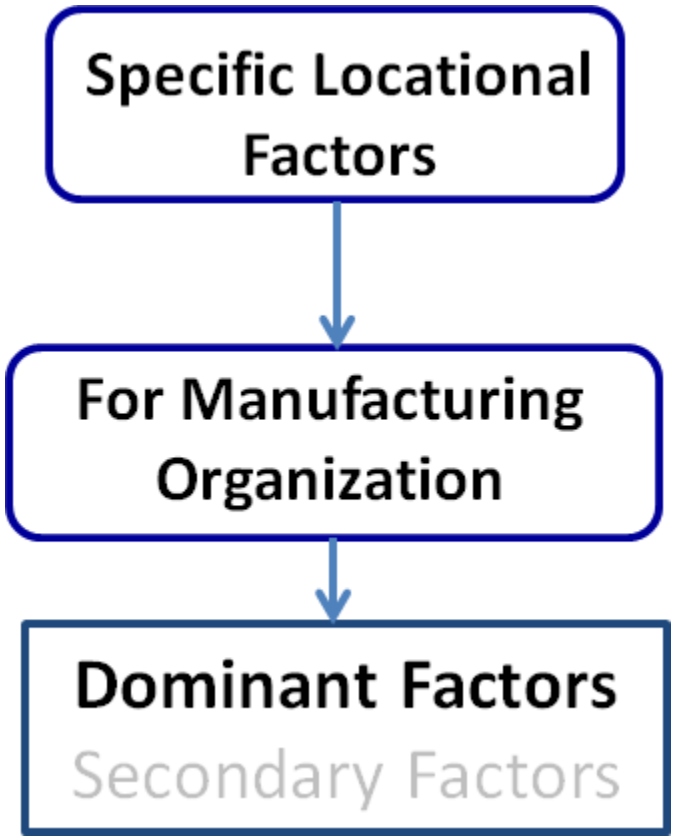
- Community attitude towards their work can make or mar the industry
- Community attitudes towards supporting trade union activities are important criteria
- Labour attitude towards management, which brings very often the strikes and lockouts - to be looked

Factors Influencing Plant/ Factory Location



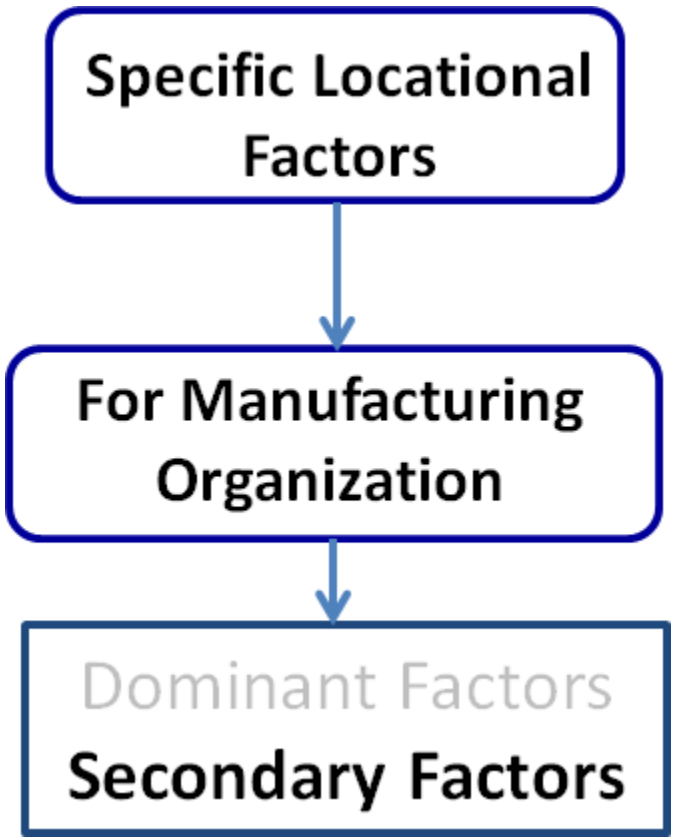
- All manufacturing activities require access to a community infrastructure, such as
  - ✓ Roads
  - ✓ Railways
  - ✓ Port facilities
  - ✓ Power lines
  - ✓ Service facilities and
  - ✓ Social overhead capital like schools, universities and hospitals

Factors Influencing Plant/ Factory Location



- Derived from competitive priorities (cost, quality, time, and flexibility) and have a particularly strong impact on sales or costs
- Factors dominating location decisions are
  - ✓ Favourable labour climate
  - ✓ Proximity to markets
  - ✓ Proximity to suppliers and resources
  - ✓ Utilities, taxes, and real estate costs
  - ✓ **Quality of life**

Factors Influencing Plant/ Factory Location



- Secondary Factors include
  - ✓ Room for expansion
  - ✓ Construction costs
  - ✓ Accessibility to multiple modes of transportation
  - ✓ Cost of shuffling people and materials between plants
  - ✓ Competition from other firms
- For global operations, are firms emphasizing local employee and education skills and the infrastructure.

local

Factors Influencing Plant/ Factory Location - Example

- Major Automobile Industries in Chennai

Automobile Hub

Detroit of Asia

Factors Influencing Plant/ Factory Location - Example

- Government policy
- Attractive incentive package
- Road, Rail & Port Connectivity
- Ease of doing business
- Skilled man power
- Communication
- Electricity
- Water availability
- Waste Disposal system
- Good Testing and Certification centre
- Strong auto-component base

Factors Influencing Plant/ Factory Location - Example

Supporting Industries & Services

Supporting industries:

- Force Motors
- VALEO
- Apollo Tyres
- CEAT
- Bridgestone
- JK Tyres
- SAINT GOBIN
- Brakes India
- India Pistons
- Rane
- Wheels India

Quantitative Methods for Evaluation

Location Model

- Various models are available which help to identify the ideal location
- Some of the popular models are

1. Break even analysis
2. Factor rating method
3. Weighted factor rating method
4. Load-distance method
5. Centre of gravity method

Location Model - Break Even Analysis

- Break even analysis implies that at some point in the operations,

Total revenue = Total cost

- Break even analysis is concerned with finding the point at which revenues and costs agree exactly
- **Break even point** is the volume of output at which neither a profit is made nor a loss is incurred
- Break even analysis can be used for location analysis especially when the costs of each location are known
- **Break even chart:** Graphical portrayal of revenue and costs as a function of output

Location Model - Break Even Analysis

- Example:
- A 3D printing manufacturing plant has to decide on the location of the production facility. Three locations namely A, B and C are considered. The fixed costs for these three locations are estimated to be Rs. 30,00,000, Rs. 25,00,000 and Rs. 50,00,000 respectively. The variable costs are Rs. 300, Rs. 200 and Rs. 350 respectively. Find out the following:

1. The range of annual sales/production volume for which each location is most suitable
2. Which one of the three is the best location at a production/sales volume of 5000 units.

Location Model - Break Even Analysis

Steps involved:

- **Step-1:** Determine variable cost and fixed cost of each location

Location	Fixed Cost (Rs)	Variable Cost (Rs)
A	30,00,000	300
B	50,00,000	200
C	25,00,000	350

Location Model - Break Even Analysis

- **Step-2**: Determine the total cost of each location

Location	Fixed Cost (Rs)	Variable Cost (Rs)	Total Cost (Rs)
A	30,00,000	300	?
B	50,00,000	200	?
C	25,00,000	350	?

Let us assume **Production Volume = X Units/Annum**

Total cost = Fixed cost + Variable Cost * Production Volume/Annum

Total cost for

A: 30,00,000 + 300 * X

B: 50,00,000 + 200 * X

We have to draw the graph, Total Cost Vs Production Volume/Annum, to find our the range for which each location is most suitable

Location Model - Break Even Analysis

- **Step-2**: Determine the total cost of each location

Location	Fixed Cost (Rs)	Variable Cost (Rs)	Total Cost (Rs)
A	30,00,000	300	?
B	50,00,000	200	?
C	25,00,000	350	?

Let us assume **Production Volume = X Units/Annum**

Total cost = Fixed cost + Variable Cost * Production Volume/Annum

Total cost for

A: 30,00,000 + 300 * X

B: 50,00,000 + 200 * X

To draw a graph, we need at least 2 points. Let us take X = 7000 Units and X = 21000 units

Location Model - Break Even Analysis

- **Step-2**: Determine the total cost of each location

Location	Fixed Cost (Rs in Lakhs)	Variable Cost (Rs)	Total Cost (Rs in Lakhs)	
			X =7000	X = 21000
A	30	300	51	93
B	50	200	64	92
C	25	350	49.5	98.5

Let us assume **Production Volume = X Units/Annum**

Total cost = Fixed cost + Variable Cost * Production Volume/Annum

Total cost for

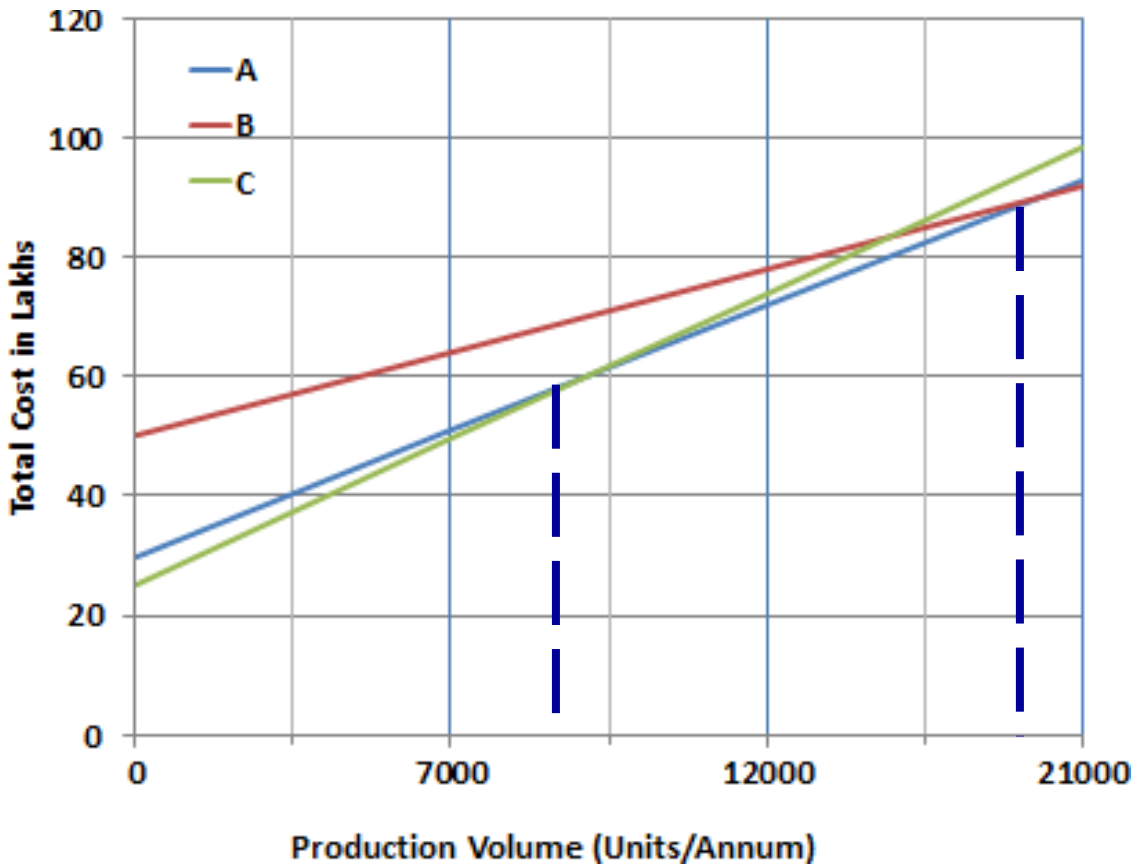
A: 30,00,000 + 300 * X

B: 50,00,000 + 200 * X

To draw a graph, we need at least 2 points. Let us take X = 7000 Units and X = 21000 units

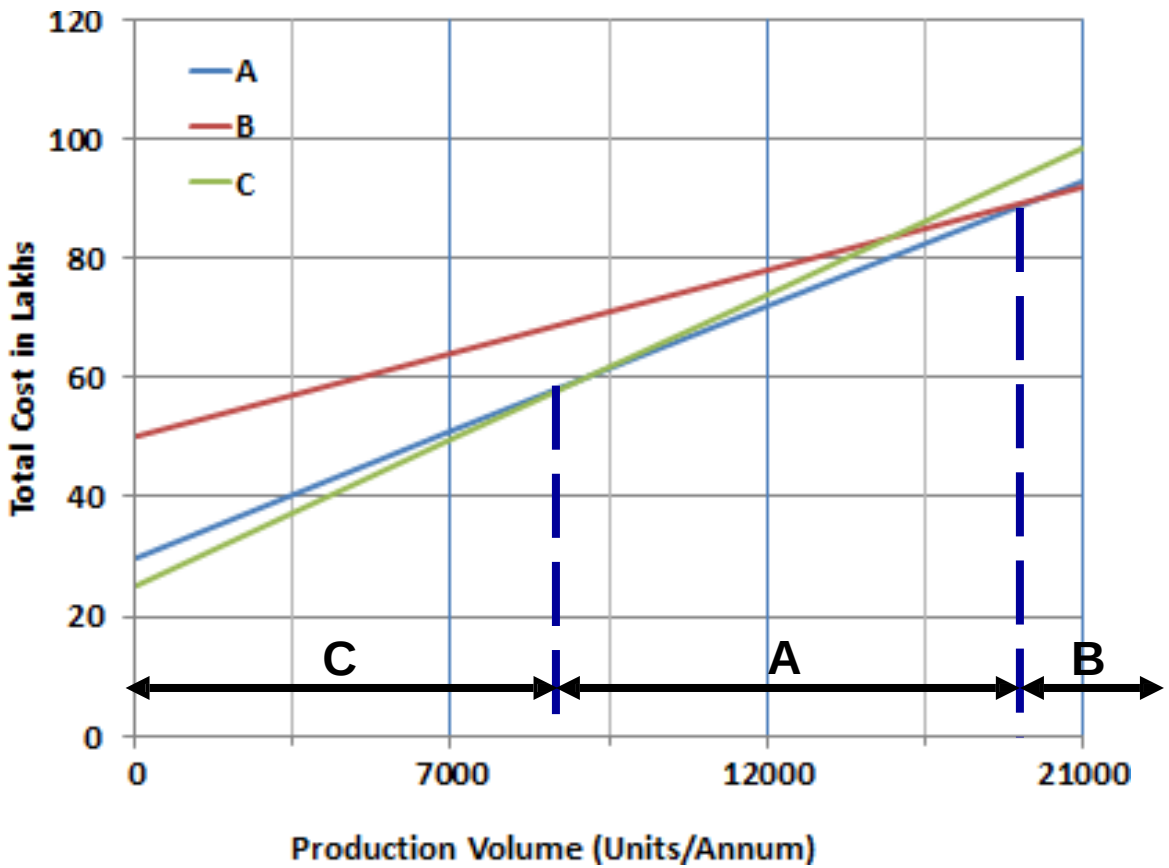
Location Model - Break Even Analysis

- **Step-3**: Plot the total cost lines for all the locations on a single graph



Location Model - Break Even Analysis

- **Step-4**: Identify the approximate ranges for locations with lowest total cost



Location Model - Break Even Analysis

- **Q1:** The range of annual sales/production volume for which each location is most suitable
  - ✓ From 0 to 9000 (Approx.) - C is the most suitable location
  - ✓ From 9000 to 20000 (Approx) - A is the most suitable location
  - ✓ Beyond 20,000 (Approx) - B is the most suitable location

- **Q2:** Which one of the three is the best location at a production/sales volume of 5000 units.
  - ✓ From 0 to 9000 (Approx.) - 5000 Units falls in this range, hence C is the most suitable location

Location Model - Factor Rating Method

Step-1: Identify the important location factors

Example:

Location Factors
Close Proximity to Market
Close Proximity to Raw Materials
Good Transportation Facilities
Government Policies
Availability of Labour
Availability of Land

Location Model - Factor Rating Method

Step-2: Rate each factor according to its relative importance, (on a 10 scale)

i.e., higher the ratings is indicative of prominent factor

Example:

Location Factors	Factor Rating
Close Proximity to Market	8
Close Proximity to Raw Materials	9
Good Transportation Facilities	7
Government Policies	7
Availability of Labour	8

Location Model - Factor Rating Method

Step-3: Assign rating for each location according to the merits of the location for each factor

Example:

Location Factors	Factor Rating	Location-1 Rating	Location-2 Rating
Close Proximity to Market	8	4	5
Close Proximity to Raw Materials	9	5	4
Good Transportation Facilities	7	3	3
Government Policies	7	4	5
Availability of Labour	8	5	4

Location Model - Factor Rating Method

Step-4: Calculate the rating for each location by multiplying
factor assigned to each location with basic factors considered

Example:

Location Factors	Factor Rating (1)	Location-1		Location-2	
		Rating (2)	Total (1) * (2)	Rating (2)	Total (1) * (2)
Close Proximity to Market	8	4	32	5	40
Close Proximity to Raw Materials	9	5	45	4	36
Good Transportation Facilities	7	3	21	3	21
Government Policies	7	4	28	5	35
Availability of Labour	8	5	40	4	32

Location Model - Factor Rating Method

Step-5: Find the sum of product calculated for each factor and select best location having highest total score

Example:

Location Factors	Factor Rating (1)	Location-1		Location-2	
		Rating (2)	Total (1) * (2)	Rating (2)	Total (1) * (2)
Close Proximity to Market	8	4	32	4	32
Close Proximity to Raw Materials	9	5	45	4	36
Good Transportation Facilities	7	3	21	3	21
Government Policies	7	4	28	3	21
Availability of Labour	8	5	40	4	32
		Total	**166**	**Total**	**142**

Total Score of Location-1 is higher than Location-2. Location-1 is the best choice

Location Model - Weighted Factor Rating Method

Step-1: Identify the important location factors

Example:

Location Factors
Close Proximity to Market
Close Proximity to Raw Materials
Good Transportation Facilities
Government Policies
Availability of Labour
Availability of Land

Location Model - Weighted Factor Rating Method

Step-2: Weight each factor according to its relative importance, (total = 100)

Example:

Location Factors	Weight
Close Proximity to Market	25
Close Proximity to Raw Materials	25
Good Transportation Facilities	25
Government Policies	10
Availability of Labour	15

Location Model - Weighted Factor Rating Method

Step-3: Assign score (1 for poor, 5 for excellent) for each location according to the merits of the location for each factor

Example:

Location Factors	Weight	Location-1 Score	Location-2 Score
Close Proximity to Market	25	4	3
Close Proximity to Raw Materials	25	4	5
Good Transportation Facilities	25	3	3
Government Policies	10	2	3
Availability of Labour	15	4	2

Location Model - Weighted Factor Rating Method

Step-4: Calculate the weighted score for each location by multiplying weight assigned assigned to each location with scores

Example:

Location Factors	Weight (1)	Location-1		Location-2	
		Score (2)	Weighted score (1) * (2)	Score (2)	Weighted score (1) * (2)
Close Proximity to Market	25	4	100	3	75
Close Proximity to Raw Materials	25	4	100	5	125
Good Transportation Facilities	25	3	75	3	75
Government Policies	10	2	20	3	30
Availability of Labour	15	4	60	2	30

Location Model - Weighted Factor Rating Method

Step-5: Find the sum of product calculated for each factor and select best location having highest total score

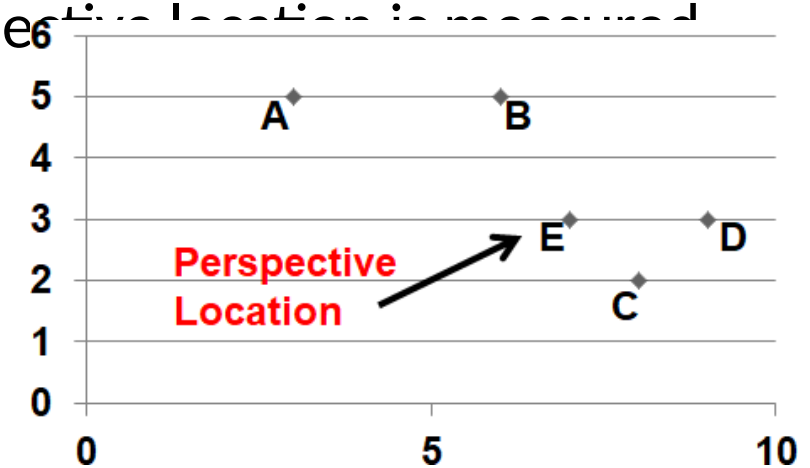
Example:

Location Factors	Weight (1)	Location-1		Location-2	
		Score (2)	Weighted score (1) * (2)	Score (2)	Weighted score (1) * (2)
Close Proximity to Market	25	4	100	3	75
Close Proximity to Raw Materials	25	4	100	5	125
Good Transportation Facilities	25	3	75	3	75
Government Policies	10	2	20	3	30
Availability of Labour	15	4	60	2	30
		Total	**355**	**Total**	**335**

Total Score of Location-1 is higher than Location-2, Location-1 is the best choice

Location Model - Load Distance Method

- A mathematical model used to evaluate locations based on proximity factors
- The objective is to select a location that minimizes the total
  weighted loads moving into and out of the facility
- Grid Positions of various locations are taken and their distance from the perspective location is measured



- The minimum value of sum of the product of each perspective location is selected as a best location

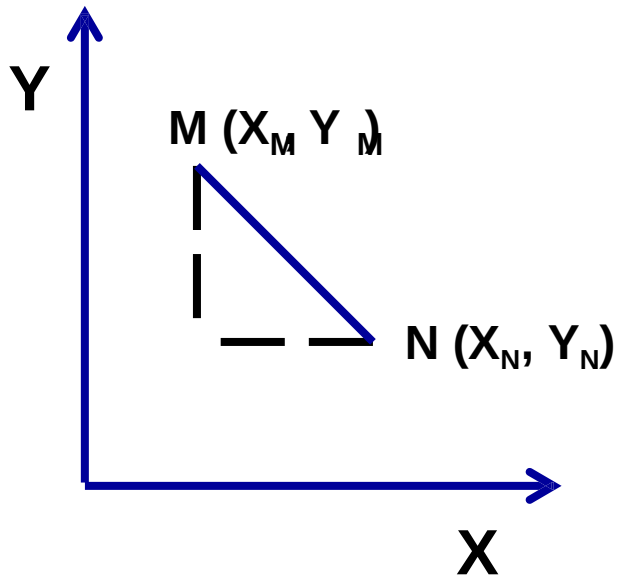
Location Model - Load Distance Method

- **Methods**:
  - ✓ **Euclidean** - Straight line estimate of distance
  - ✓ **Rectilinear** - Distance allowing only horizontal or vertical movement

Location Model - Load Distance Method

Euclidean Method

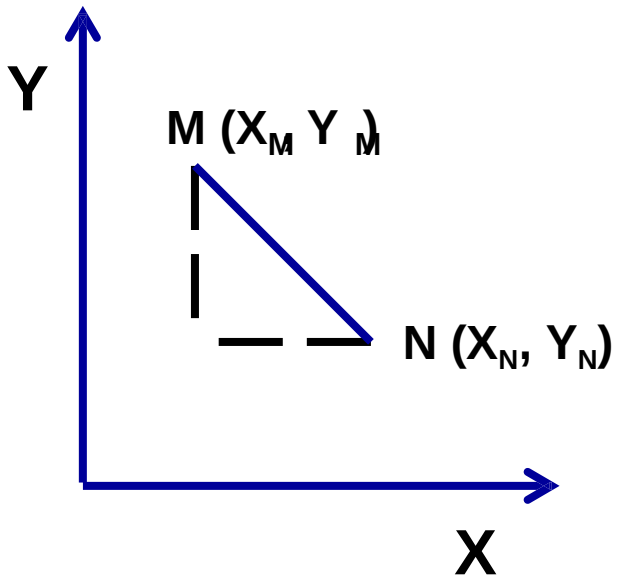
- X_M = x-coordinate of Point M
- Y_M = y-coordinate of Point M
- X_N = x-coordinate of Point N
- Y_N = y-coordinate of Point N



Distance between M and N, d_{MN} = $\sqrt{(X_M - X_N)^2 + (Y_M - Y_N)^2}$

Location Model - Load Distance Method

Rectilinear Method



- The distance is the sum of the two dashed lines representing the base and side of the triangle
- X_M = x-coordinate of Point M
- Y_M = y-coordinate of Point M
- X_N = x-coordinate of Point N
- Y_N = y-coordinate of Point N

- Distance travelled in X-direction = $|X_M - X_N|$
- Distance travelled in Y-direction = $|Y_M - Y_N|$
- Total Distance $D_{MN} = |X_M - X_N| + |Y_M - Y_N|$

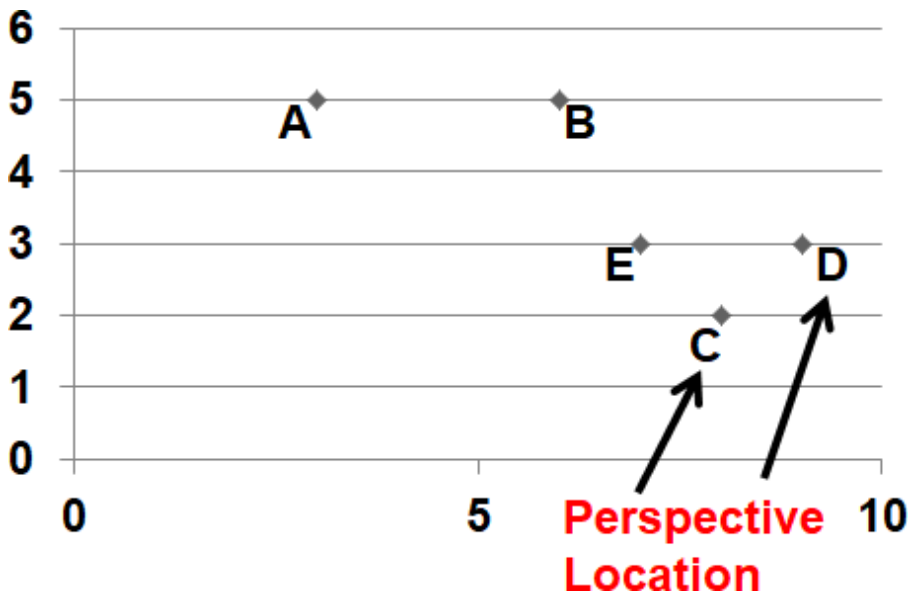
Location Model - Load Distance Method

Rectilinear Method: Steps Involved

Step-1: Find the (X, Y) co-ordinates of existing and perspective locations

Example:

Location	(X, Y)
A (Existing)	(3, 5)
B (Existing)	(6,5)
C (Perspective)	(8,2)
D (Perspective)	(9,3)
E (Existing)	(7,3)



Location Model - Load Distance Method

Steps Involved

Step-2: Find the load at each location. This can be number of people served or the amount of goods to be transported

Example:

Location	(X, Y)	Load
A (Existing)	(3, 5)	2
B (Existing)	(6,5)	5
C (Perspective)	(8,2)	10
D (Perspective)	(9,3)	7
E (Existing)	(7,3)	20

Location Model - Load Distance Method

Steps Involved

Step-3: Measure the distance of the perspective locations from each of the existing locations

Example:

Location	(X, Y)	Load	Locate at C (8,2)	Locate at D (9,3)
			Distance	Distance
A (Existing)	(3, 5)	2	5+3=8	6+4=10
B (Existing)	(6,5)	5	2+3=5	3+4=7
C (Perspective)	(8,2)	10	0	1+1=2
D (Perspective)	(9,1)	7	1+1=2	0
E (Existing)	(7,3)	20	1+1=2	2+2=4

Location Model - Load Distance Method

Steps Involved

Step-4: Find the product of load and distance from each location

Example:

Location	(X, Y)	Load (1)	Locate at C (8,2)		Locate at D (9,3)	
			Distance (2)	Load * Distance (1)*(2)	Distance (2)	Load * Distance (1)*(2)
A (Existing)	(3, 5)	2	8	16	10	20
B (Existing)	(6,5)	5	5	25	7	35
C (Perspective)	(8,2)	10	0	0	2	20
D (Perspective)	(9,3)	7	2	14	0	0
E (Existing)	(7,3)	20	2	40	4	80

Location Model - Load Distance Method

Steps Involved

Step-5: Find the sum of the product of each perspective location

Example:

Location	(X, Y)	Load (1)	Locate at C (8,2)		Locate at D (9,3)	
			Distance (2)	Load * Distance (1)*(2)	Distance (2)	Load * Distance (1)*(2)
A (Existing)	(3, 5)	2	8	16	10	20
B (Existing)	(6,5)	5	5	25	7	35
C (Perspective)	(8,2)	10	0	0	2	20
D (Perspective)	(9,3)	7	2	14	0	0
E (Existing)	(7,3)	20	2	40	4	80
			Total	**95**	**Total**	**155**

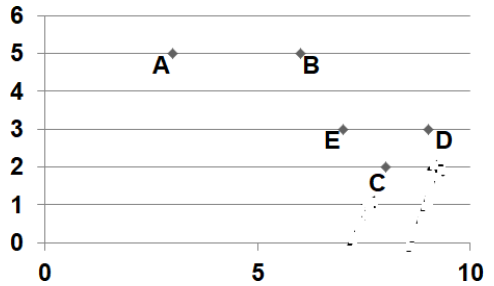
Location Model - Load Distance Method

Step-6: Select the smallest value of the sum as the most suitable location

Location	(X, Y)	Load (1)	Locate at C (8,2)		Locate at D (9,3)	
			Distance (2)	Load * Distance (1)*(2)	Distance (2)	Load * Distance (1)*(2)
A (Existing)	(3, 5)	2	8	16	10	20
B (Existing)	(6,5)	5	5	25	7	35
C (Perspective)	(8,2)	10	0	0	2	20
D (Perspective)	(9,3)	7	2	14	0	0
E (Existing)	(7,3)	20	2	40	4	80
			Total	**95**	**Total**	**155**

Location is C is a better location since the load distance score is

Location Model - Centre of Gravity Method



- It takes into account
  - ✓ the locations of plants and markets
  - ✓ the volume of goods moved and
  - ✓ transportation costs in arriving at the best location for a single intermediate warehouse
- The centre of gravity is defined to be the location that minimizes the weighted distance between the warehouse and its supply and distribution points
- It finds location of single distribution centre serving several destinations
- This method assumes that the distribution cost is a function of the volumes shipped and the rectilinear distances.

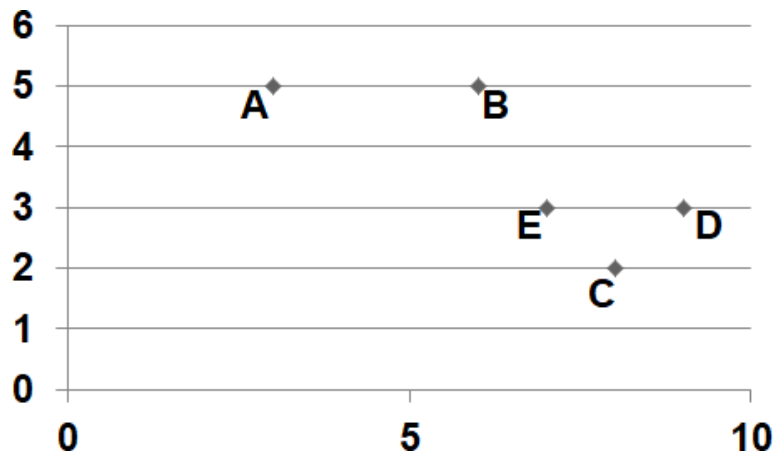
Location Model - Centre of Gravity Method

Steps involved:

- **Step-1:** Place the locations on the coordinate system and note down the (X, Y) coordinates of each location

Example:

Location	(X, Y)
A	(3, 5)
B	(6,5)
C	(8,2)
D	(9,3)
E	(7,3)



Location Model - Centre of Gravity Method

- **Step-2:** Find the load at each location

Example:

Location	(X, Y)	Load
A	(3, 5)	2
B	(6,5)	5
C	(8,2)	10
D	(9,3)	7
E	(7,3)	20

Location Model - Centre of Gravity Method

- **Step-3:** Find the product of load and distance (X and Y separately) from each location

Example:

Location	(X, Y) (1)	Load (2)	X-Distance * Load (1) * (2)	Y-Distance * Load (1) * (2)
A	(3, 5)	2	3 * 2 = 6	5 * 2 = 10
B	(6,5)	5	6 * 5 = 30	5 * 5 = 25
C	(8,2)	10	8 * 10 = 80	2 * 10 = 20
D	(9,1)	7	9 * 7 = 63	1 * 7 = 7
E	(7,3)	20	7 * 20 = 140	3 * 20 = 60

Location Model - Centre of Gravity Method

- **Step-4:** Find the sum of the load, product of load and distance (X and Y seperately) from each location

Example:

Location	(X, Y) (1)	Load (L_i) (2)	X-Distance ($X_{i)}$ * Load (L) (1) * (2)	Y-Distance ($Y_{i)}$ * Load (L) (1) * (2)
A	(3, 5)	2	6	10
B	(6,5)	5	30	25
C	(8,2)	10	80	20
D	(9,1)	7	63	7
E	(7,3)	20	140	60
	Total	**44**	**319**	**122**

Location Model - Centre of Gravity Method

- **Step-5:** Calculate Centre of Gravity (C_x, C_y)

Location	(X, Y) (1)	Load (L_i) (2)	X-Distance ($X_{i)}$ * Load (L) (1) * (2)	Y-Distance ($Y_{i)}$ * Load (L) (1) * (2)
A	(3, 5)	2	6	10
B	(6,5)	5	30	25
C	(8,2)	10	80	20
D	(9,1)	7	63	7
E	(7,3)	20	140	60
	Total	**44**	**319**	**122**

$$C_x = \frac{\sum X_i L_i}{Li} = \frac{319}{44} = 7.25 \qquad C_y = \frac{\sum Y_i L_i}{Li} = \frac{122}{44} = 2.77$$

Using the centre of gravity (C_x, C_y) as a starting point, search in its vicinity for the optimal location

Thank you