UNIT 15 LOCATION STRATEGY

Objectives

After reading this unit you would be able to

- discuss the steps in location planning;
- discuss the interdependence of location decision and distribution decision; and
- describe various measure for warehouse location.

Structure

15.1 INTRODUCTION

Facilities and their locations are major issues in an organization's logistics system efficiency and its ability to successfully implement its competitive advantage. Facility location decisions are of major importance to a company's ability to compete in the market. Determining appropriate locations for facilities such as plants, warehouses, retail stores, hospitals etc. represents an important strategic decision.

The choice of location for the place of business is one of the earliest problems facing management. Location decisions come under the category of long-term decisions. They involve long-term commitments. A plant location decision cannot be reviewed until after quite sometime as they involve huge investments. Location decisions also have effect on the operating costs/revenues. For example, a bad location decision may call for excessive transportation costs, shortage of skilled workforce, loss of competitive advantage, inadequate supply of raw materials etc.

Organizations are involved in location decisions for a variety of reasons such as the followings:

- Expansion of existing facilities
- Addition of new facilities
- Closing down the plant at one location and moving to another.

Firms may experience growth in business and wish to increase the plant capacities. Addition of new plants to complement an existing system is often contemplated. Firms such as banks, supermarkets, retail stores consider location as a marketing strategy and look for locations that will help them in expanding their markets.

Let us look at the importance of location in the context of business logistics. Business logistics refers to the management of all move-store activities that facilitate product flow to the point of final consumption. Figure 15.1 presents the key elements of a logistics system or the production / distribution system.

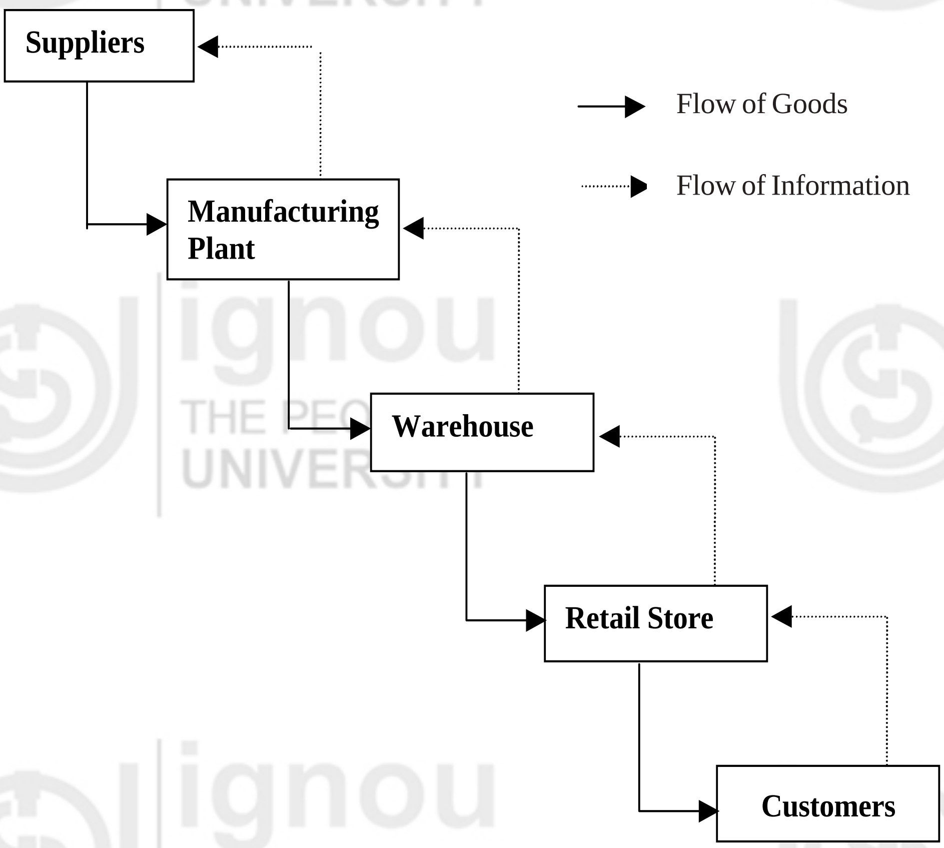


Figure 15.1: Production / Distribution System

The key elements of the production/distribution system are: transportation, inventory and order processing. Raw materials are ordered from the suppliers. These are transported to the manufacturing plant for production into finished goods. Finished goods are shifted to warehouse (also called distribution centers) and finally to retail stores from where they are made available to customers. In order to have an effective production and distribution system, business logistics coordinates the production and marketing efforts. One of the important goals of marketing management is to make the product available to customers at the right place and the right time. Thus the decision of where a product is produced and stored is very important. Production management, on the other hand, is concerned with maintaining high productivity at low cost. A product mix that seeks only to satisfy marketing goals may lead to inefficiencies in production. Similarly, decisions that consider only production efficiencies may lead to high distribution costs and low customer service.

The main objective of location decisions is to position each element of the production /distribution system with respect to the overall system. A manufacturing plant must be strategically positioned between its supplies and customers. The location problem is more complex for large firms; they must position both plants and warehouse simultaneously with respect to suppliers, retail outlets and each other. Rarely, all these facilities are located simultaneously.

The typical case involves locating a new plant with respect to suppliers and a given number of warehouses or locating a set of warehouses with respect to manufacturing plants and markets.

We shall discuss here the problems of plant location, warehouse location, in the distribution system and the special cases of locating retail stores and emergency services.

15.2 PLANT LOCATION

Choice of location for a plant is one of the earliest problems facing management. But location, perhaps, is one of the most neglected aspects of business, although the manufacturing and distribution costs may vary by over 10 percent simply by virtue of choice of location. The golden rule of business applies to location decisions as well. The Golden Rule of Business states that *the ones with gold make the rules.*

There are two types of factors (or criteria) on which location decisions are based: quantitative (or objective) factors and qualitative (or subjective) factors. The objective factors involve cost of land, transportation costs, utilities rates etc. The subjective factors include labour availability, climate, community environment, quality of life, local politics etc.

The presence of objective and subjective factors results in greater degree of complexity in the structure of the plant location problem as well as its solution. A decision made on these factors is difficult as they are consistent over all locations. For example, a plant may be located far from work but have lower utility bills related to the area closer to work. Some factors may be more dominant than others. For example, on mineral production plants, raw materials dominate the situations due to which processing is located near mines. On the other hand, output oriented activities, such as service organizations tend to be located near consumers. Table 15.1 presents a list of some of the important location factors.

Table 15.1: Location Factors Determining Plant Location

Transportation Factors	Utilities Factors	Labor Factors	Climate, Community, Environment etc.	States and Local Political Factors
• Proximity to raw material sources • Closeness to markets • Modes of transportation • Transportation costs	• Power • Water • Fuel • Waste disposal	• Labor supply • Labor management relations • Availability of skilled labor • Labor costs	• Climate and living conditions • Education • Community attitude • Religious factors	• Taxation policies • Tax structure

15.2.1 Steps in Location Planning

Location planning involves the following steps:

1) Determine the criteria to evaluate location alternatives (for example: minimize costs)

2) Identify relevant location factors

3) Develop location alternatives

   a) Identify the general region

   b) Identify a small number of community site alternatives

4) Evaluate the alternatives and make a selection.

15.2.2 Evaluation of Location Alternatives

As stated earlier, the plant location problem involves both qualitative and quantitative factors. Finding the best location alternative considering all the above factors is not an easy one. Attempts have been made to combine the qualitative and quantitative factors and score the alternatives. One of the scoring (or rating) models is outlined below (Table 15.2).

The procedure starts by listing the various factors and assigning weight to each factor to represent the relative importance of various factors. The score for each alternative is found by multiplying each factor's score by its weight and summing the results. Table 15.2 gives the details of this rating approach for two locations A and B.

Table 15.2: Rating Approach

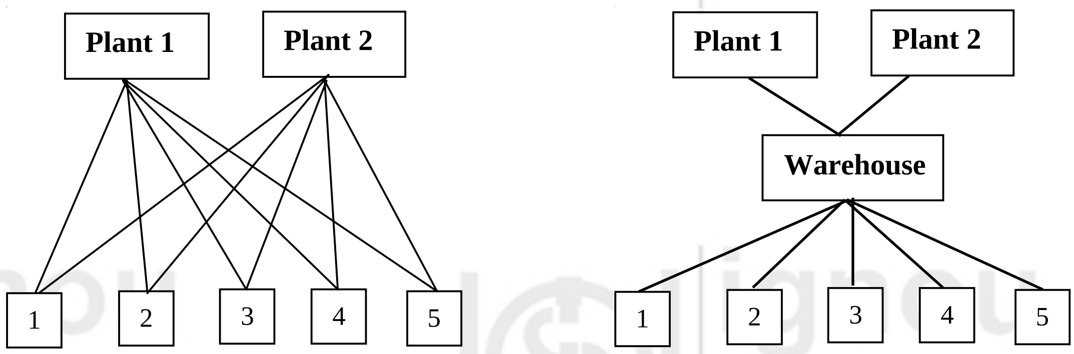
Location factor	Weight	Score (out of 100)		Weighted Score	
		A	B	A	B
1. Labor Costs	0.40	70	90	70 × 0.40=28	90 × 0.40=36
2. Water supply	0.10	80	90	8	9
3. Climate	0.15	80	90	12	13.5
4. Proximity to Raw Materials	0.20	40	70	8	14
5. Transportation Costs	0.10	80	90	8	9
6. Taxes	0.05	80	80	4	4
Total Score				**68**	**85.5**

From Table 15.2, we see that location B that has a higher score is preferred. However one has to be careful in the use of the rating approach because of the assessment of scores, which might have involved some amount of subjectivity. For example, if the total score for location B were 70, which is very close to that of A, one need to go for further analysis before arriving at the final decision.

15.3 DISTRIBUTION PROBLEM

The distribution problem is concerned with the allocation of goods flow to minimize overall distribution cost. Most distribution systems are three-tired structures in which goods start from the plant; flow to warehouse and ultimately to outlets. Warehousing plays a crucial role in the total distribution system. Consider for example, a large chain, which manufactures many products, maintains regional distribution centers and owns a large number of retail store (Figure 15.1). The firm has control over the location of all intermediate members of the logistics system.

In the absence of any warehouse, shipments of finished goods would have to be made directly from the plant to the retail stores. If the plant is located far from the raw material sources, inbound transportation costs would be high and delivery times would be high, thereby increasing the chances of material shortage for production. If the plant is located far from the group of retail stores, then also transportation costs (i.e. outbound transportation costs) would be high and it takes longer to deliver orders to retail stores. This may result in out-of-stock situations thereby reducing the level of customer service. Warehouses placed close to the market can provide quick and efficient delivery to retail stores, while still permitting the plants to be placed near raw material sources. Warehouses and distribution centers play as important intermediaries between plants and retail stores. They allow a company to store finished goods for efficient distribution to points of use. The role of warehouses is illustrated in Figure 15.2.



Retail Stores
(a) Without Warehouse

Retail Stores
(b) With Warehouse

Figure 15.2: Role of Warehouse

It can be seen from Figure 2 that the provision of intermediaries like warehouse reduces considerably the number of interactions from 10 (i.e. 2 x 5) to 7 (i.e. 2 + 5). There are other benefits associated with the provision of warehouses since they support both manufacturing as well as retail stores. For example, warehouse facilitates consolidation of orders.

A number of decisions should be made with regard to warehousing. Among the most important warehousing decisions are the determination of number and location of warehouses. The other decisions include the following:

- Which products should be stored in each warehouse?
- Should public or private warehouses be used?
- What type of material-handling equipment should be used?
- Which customers should be assigned to each warehouse?

We shall discuss the warehouse location problem in the following section.

Activity 1

Write True or False against the following statements.

1.	The facility location decision belongs to the tactical decision area.	
2.	In all location problems, there is a unique location that is superior to all others.	
3.	Business logistics and facility location are unrelated issues.	
4.	Logistics management refers to the management of transportation function.	
5.	In the location of a gasoline station, labor availability is one of the most important factors.	
6.	The location of aluminum reduction industry is energy-oriented.	
7.	For facility location, manufacturing costs are more important than transportation cost, since the latter are going to be incurred anyway.	
8.	For facility location, quality of life in a given location is an irrelevant factor.	
9.	Scoring models are used exclusively in location decisions.	
10.	There is no difference between location decisions for manufacturing and service organizations.	
11.	The major criterion for location of a retail outlet is the volume of demand.	
12.	One of the principal disadvantages of computerized logistics modeling is the ability to easily modify data and perform "what if" analysis.	
13.	The presence of organized labor unions is irrelevant to the location decision.	

15.4 WAREHOUSE LOCATION

In this section we present method(s) for determining the location(s) for warehouse(s). It is assumed that there are a number of existing facilities in place and we wish to find the optimum location of a new facility (or new facilities). The existing facilities could be plants, retail stores. The new facilities could be warehouse. The approaches take into account the locations of plants and markets, volume of goods moved and transportation costs. All these models focus on minimizing transportation costs.

15.4.1 Measures of Distance

Two measures of distance for movement of items are commonly used: Rectilinear distance and Euclidean (straight line) distance.

The rectilinear distance (also known as metropolitan distance) recognizes that streets usually run in a crisscross pattern.

Let the existing facility be located at the point (a, b) and let (x, y) be the location of the new facility. The rectilinear distance between (a, b) and (x, y) is $|x - a| + |y - b|$, whereas

The Euclidean distance is $\sqrt{(x-a)^2 + (y-b)^2}$

Figure 15.3 illustrates the two distance measures.

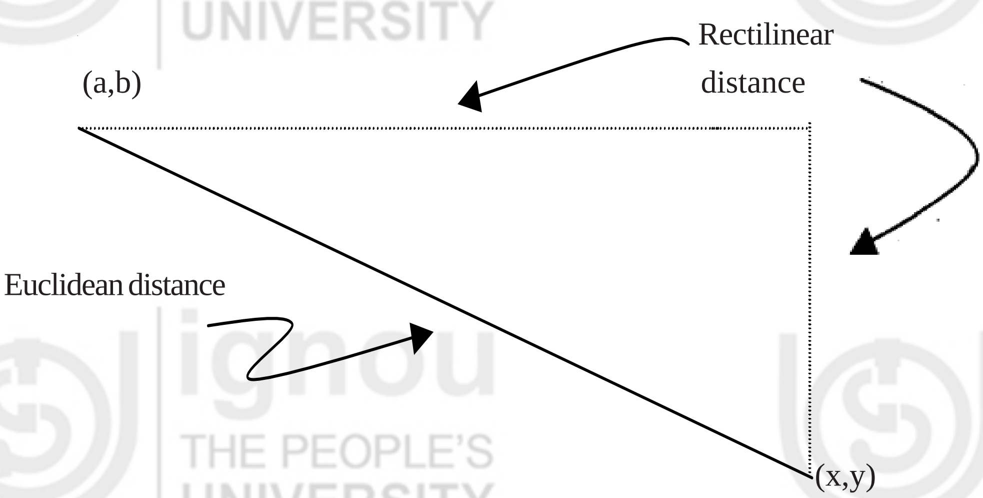


Figure15.3 : Rectilinear and Euclidean Distance

Rectilinear distance is appropriate for many location problems such as in metropolitan areas. In many manufacturing situations, material is transported along aisles arranged in rectilinear pattern. Fortunately, rectilinear distance problem is easier to solve than Euclidean distance problem.

The problem of locating a simple new facility with respect to a number of existing problems is known as the single facility location problem whereas the problem of locating multiple new facilities is known as the multi-facility location problem.

15.4.2 Single Facility Location Problem

In this section you would learn about Single Facility Rectilinear Distance Location Problem, Squared Euclidean Distance Problem (known as the Gravity Problem) and the Straight-Line Distance Problem.

Single Facility Rectilinear Distance Location Problem

Let there be "n" existing facilities located at points (a_1,b_1), (a_2,b_2)………..,(a_n,b_n). The objective is to locate the new facility to minimize a weighted sum of the rectilinear distance from the new facility to existing facilities. The goal is to find the values of x and y such that

$$\text{minimize } f(x,y) = \sum_{i=1}^{n} w_i \left(|x - a_i| + |y - b_i| \right) \text{ , where}$$

w_i is the flow of material / goods between the new facility and i_{th} existing facility. The optimum values of x and y can be determined separately.

$f(x,y) = g_1(x) + g_2(y)$, where

$$g_1(x) = \sum_{i=1}^{n} w_i |x - a_i| \quad \text{and} \quad g_2(y) = \sum_{i=1}^{n} w_i |y - b_i|$$

As we shall see, the x coordinate of the new facility will be same as x coordinate of some existing facility. Similarly y coordinate of new facility coincides with y coordinate of same existing facility. An example of the single facility location problem could be location of a new storage warehouse for a company with an existing network of production and distribution centers.

Let us consider a case in which there are two existing facilities located at (5,10) and (20,30) as shown in Figure 15.4. Assume that w_i values are all equal to one.

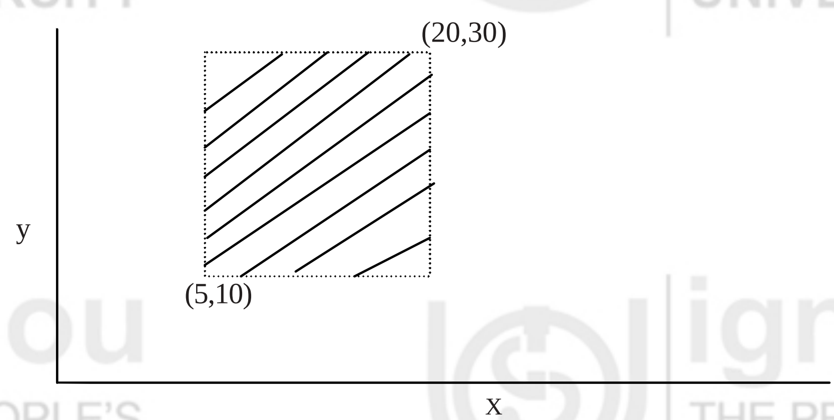


Figure 15.4: Single Facility Rectilinear Location Problem - Two Existing Facilities

The values of $g_1(x)$ is equal to 15 for values of x between 5 and 20.

Similarly $g_2(y)$ is 20 for values of y between 10 and 30.

For example, if x = 10 and y = 10

Then $g_1(x) = |5 - 10| + |20 - 10| = 15$

$g_2(y) = |10 - 10| + |30 - 10| = 20$

It can be seen that the optimum location for the new facility will be anywhere in the area bounded by the lines x = 5, x = 20, y = 10 and y = 30.

Any value of x outside the closed interval [5, 20] and any value of y outside the closed interval [10, 30] gives larger values of $g_1(x)$ and $g_2(y)$. Thus the optimum solution is (x , y) where $5 \le x \le 20$ and $10 \le y \le 30$.

The above analysis leads to the Simple Median model, which can be explained, with the help of the following examples.

Suppose there are four existing facilities located at points (3 , 3), (6 , 9), (12 , 8) and (12 , 10) and the weights are all of value 1 ($w_1 = w_2 = w_3 = w_4 = 1$). Rank the x coordinate in increasing order: 3, 6, 12, 12.

A *median* value is such that half of values lie above it and half lie below it. Any value of x between 6 to 12 is a median location and is optimum for this example problem. The optimum value of g_1 (x) is 15.

Similarly ranking the y values 3, 8, 9, 10 gives the median value as any value between 8 and 9 and the minimum value of g_2 (y) = 8. See Figure 15.5.

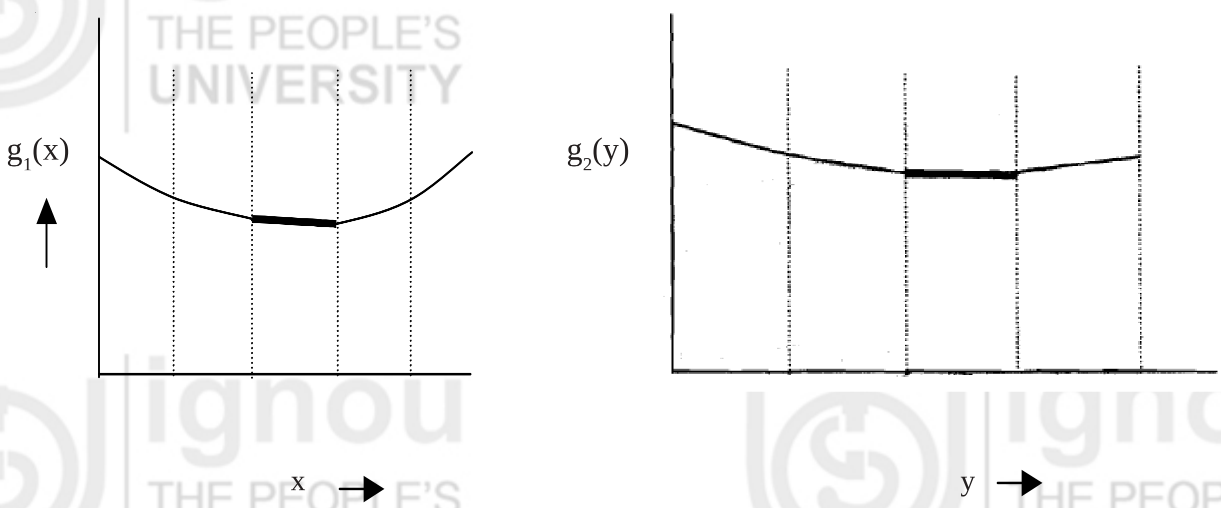


Figure 15.5: Optimum Locations

Let us take another example where there are four existing facilities located at (3,3), (6,9), (12,8) and (12,10). The weightages are: $w_1 = 2$, $w_2 = 4$, $w_3 = 3$ and $w_1 = 1$.

The problem is equivalent to one where there are two facilities at location (3,3), four facilities at (6, 9), three facilities at (12, 8) and one facility at (12,10), with weight equal to 1.

The ranked x value are 3, 3, 6, 6, 6, 6, 12, 12, 12, 12

The median location is x = 6.

The ranked y values are: 3, 3, 8, 8, 8, 9, 9, 9, 9,10.

The median location is any value of y in the interval [8,9].

The optimum value of the objective function is 30 + 16 = 46.

A quicker method of finding the optimum location of the new facility is to compute the accumulated weight and determine the location (s) corresponding to half of the accumulated weight as shown below.

Facility	X coordinate	Weight	Cummulative Weight	Facility	X coordinate	Weight	Cummulative
1	3	2	2	1	3	2	2
2	6	4	6 Optimum X = 6	3	8	3	5 optimum Y is
3	12	3	9	2	9	4	9 between 8 and 9
4	12	1	10	4	10	1	10

(Half of total weight first exceeds at x = 6 Hence optimum x = 6)

(Optimum y is between 8 and 9)

Euclidean Distance Problems

Although the rectilinear distance measure is applicable in many location problems, there are situations in which the appropriate measure is the Euclidean or Straight-line distance. Location of power generating facilities so as to minimize the total length of electric cable that must be laid out to connect the plant and customer is an example where the Euclidean distance measure is appropriate.

We shall discuss here the squared Euclidean Distance Problem (known as the Gravity Problem) and the Euclidean Distance Location Problem.

The Gravity Problem

The Gravity problem corresponds to the case where the distance measure is square of the Euclidean distance. This measure is appropriate for location of emergency facilities. The objective is to find the value of (x, y) to minimize

$$f\,(x, y) = \sum w_i\,[\,(x - a_i)^2 + (y - b_i)^2]$$

The solution to this problem is straight forward and is often used as an approximation to the more common straight-line distance problem.

To find the optimum value of x and y, the partial derivatives of the objective function with respect to x and y are found and equated to zero.

We get $\dfrac{\partial f\,(x,y)}{\partial x} = 2\sum_{i=1}^{n} w_i (x - a_i)$

We get $\dfrac{\partial f\,(x,y)}{\partial y} = 2\sum_{i=1}^{n} w_i (y - b_i)$

Setting these partial derivatives equal to zero and solving for x and y, we get

$$X^+ = \frac{\sum_{i=1}^{n} w_i a_i}{\sum_{i=1}^{n} w_i}$$

$$Y^+ = \frac{\sum_{i=1}^{n} w_i a_i}{\sum_{i=1}^{n} w_i}$$

Thus X^+ and Y^+ are the weighted averages of x and y coordinates and hence the name *Gravity problem.*

The Straight-Line Distance Problem

The straight-line distance measure arises much more frequently than the Gravity problem. The objective is to find (x, y) to minimize

$$f\,(x, y) = \sum_{i=1}^{n} w_i \sqrt{(x - a_i)^2 + (y - b_i)^2}$$

Unfortunately, it is not easy to find the optimum solution mathematically. The partial derivatives become undefined when the location of the new facility coincides with that of an existing facility. There are no known simple algebraic solutions; all existing methods require an iterative procedure. The Gravity solution is usually selected as the starting solution for this iterative process.

15.4.3 Multi-facility Location Problem

The problem of locating multiple new facilities with respect to existing facilities is known as the Multi-facility Location Problem. For example, a countrywide consumer goods manufacturer might be considering where to locate four new regional warehouses. There is interaction among new facilities as well as between new and existing facilities. In some special situations, multi-facility location problem can be solved as a sequence of single facility location problems.

Linear programming can be used to solve the multi-facility rectilinear distance location problem. Assume that there are "n" existing facilities located at points (a_1, b_1), (a_2, b_2),……(a_n, b_n). Suppose the new facilities are to be located at (x_1, y_1), (x_2, y_2), ………., (x_m, y_m).

The objective function to be minimized is written as minimize $f_1(x) + f_2(y)$

$$\text{Where } f_1(x) = \sum_{i \le j \le k \le m} V_{jk} \left| x_j - x_k \right| + \sum_{j=1}^{m} \sum_{i=1}^{n} w_{ji} \left| x_j - a_i \right|$$

$$\text{and } f_2(y) = \sum_{i \le j \le k \le m} V_{jk} \left| y_j - y_k \right| + \sum_{j=1}^{m} \sum_{i=1}^{n} w_{ji} \left| y_j - b_i \right|$$

V_{jk} represents the interaction between new facilities j and k and w_{ji} represents the interaction between new facility j and existing facility i. The optimum x and y values can be determined independently as in the case of single facility location problem.

Multi-facility gravity problems require the solution of a system of linear equations, so that gravity problems involving large number of facilities are easily solved. Multi-facility Euclidean distance location problems are solved by using multi dimensional version of the iteration solution procedure described in the previous section.

Activity 2

Fill in the blanks

1) An approach to location analysis that includes both qualitative and quantitative considerations is ……………………………………………

2) A major advantage of warehousing is that ………………………………………………………………………..

3) The scoring model is both a ……………………………. and ……………………………. model

15.4 RETAIL FACILITY LOCATION

The major criterion used for retail facility location is the volume of demand and hence estimates of demand must be known for potential locations. Statistical techniques such as regression analysis can be used to predict demand. For locating facilities that are oriented toward sales, the principal factors are market related and the important data are demographic in nature. Other intangible factors, which affect retail location, are competition, zoning laws, traffic patterns and accessibility etc. Like in plant location, scoring models may be used to rank potential sites.

15.4 SUMMARY

As we have seen, the location decision and distribution decision are interdependent. By considering only one of these, we get poor solutions. Both the problems should be treated comprehensively.

Comprehensive computerized logistics systems are available to assist management in achieving efficient solutions. Computerized systems help answering questions such as: how many warehouses are needed and where they should be located? How much of each product should be sent to each warehouse from each plant? How should customers be assigned to warehouse? What modes of transportation are most economical? For answering such questions, management needs large amounts of data regarding warehousing and inventory costs, transportation costs, production costs and so on.

15.5 SELF ASSESSMENT QUESTIONS

1) "The most common method for evaluating non-economic factors in a facility location study is to use a scoring model" Why? Justify your answer.

2) Is it true that subjective criteria in plant location models focus on long-run cost effects? If yes, Why?

3) Given the information below, which alternative would you recommend?

Factor	Weight	Location		
		A	B	C
Raw Materials	0.40	50	70	60
Market	0.20	40	40	80
Transportation Cost	0.10	90	70	50
Labor Cost	0.20	40	40	30
Construction Cost	0.10	10	60	30

4) Given the information below, which alternative has the lowest breakeven point?

Alternative	Fixed Cost	Variable cost/unit	Revenue/ Unit
A	30000	10	40
B	40000	15	40
C	50000	20	40
D	60000	30	40
E	70000	40	40

5) Given the following evaluation of subjective factors, find the total score for the location.

Excellent = 8, Good = 6, Fair = 4, Poor = 3

Factor	Rating	Weight
Labor Supply	Good	40%
Community Attitude	Excellent	30%
Government Regulations	Fair	20%
Quality of life	Good	10%

6) Using the following scoring model, select the best location

Location	Attribute	1	2	3	4
	Weight	10	25	35	30
A		Good	Very Good	Bad	OK
B		OK	OK	Very Good	Good
C		Good	Very Good	OK	Good

Very Good = 5 points, Good = 4 points, OK = 2 points, Bad = 1 point

15.8 REFERENCES AND SUGGESTED FURTHER READINGS

1) Ballou R., (1985), *Business Logistics Management*, Prentice Hall.

2) Francis, R. L. & White J. A. (1974). *Facility Layout and Location - An Analytical Approach*, Prentice Hall.