LOCATION PLANNING AND ANALYSIS

Needs and Nature of Location Decision

The place or site where all physical facilities are arranged properly is called location. It determines the supplying capacity of organization. Location decisions represent an integral part of the strategic planning process of virtually every organization. Although it might appear that location decisions are one-time problems pertaining to new organizations, existing organizations often have a bigger stake in these kinds of decisions than new organizations. Location decisions are critical at several levels. At the national level, retail analysts screen and select metropolitan and regional market for new store entry. At the metropolitan level, not only are prime retail sites important but also an optimal distribution of those locations is needed to serve the marketplace. The location of the non-manufacturing operation helps determine how conveniently customers can conduct business with the company. Location of the manufacturing and non-manufacturing company operations can have a great impact on operating cost, thereby affecting profit and perhaps the price at which goods or services can be offered.

One of the key features of a conversion process (manufacturing system) is the efficiency with which the products (services) are transferred to the customers. This fact will include the determination of where to place the plant or facility. The selection of location is a key decision as large investment is made in building plant and machinery. It is not advisable or not possible to change the location very often. So an improper location of plant may lead to waste of all the investments made in building and machinery, equipment.

Existing organizations become involved in location decisions for variety of reasons. Firms such as banks, fast food chains, supermarkets, and retail stores view locations as part of marketing strategy, and they look for locations that will help them expand their markets. Basically, the location decisions in those cases reflect the addition of new locations to an existing system.

A similar situation occurs when an organization experiences a growth in demand for its products or services that cannot be satisfied by expansion at an existing location. The addition of a new location to complement an existing one is often a new location to realistic alternative. Some firms face location decision through depletion of basic inputs. For example, fishing and logging operations are often forced to relocate due to the temporary exhaustion of fish and forest at a given location. Mining
and petroleum operations face the same sort of situation, although usually over a longer horizon. For others firms, a shift in markets causes them to consider relocation, or the costs of doing business at a particular location reach a point where other locations begin to look more attractive.

There are two primary reasons that location decisions are a highly important part of production system design.

- One is that they entail a long-term commitment, which makes mistakes difficult to overcome.
- The other is that location decisions often have an impact on investment requirements, operating costs and revenues, and operations itself.

For instance a poor choice of location might result in excessive transportation costs, a shortage of qualified labor, loss of competitive advantage, inadequate supplies of raw materials, or some similar condition that is detrimental to operations. For services, a poor location could result in loss of customers and/or high operating costs.

Before a location for a plant is selected, long range forecasts should be made anticipating future needs of the company. The plant location should be based on the company’s expansion plan and policy, diversification plan for the products, changing market conditions, the changing sources of raw materials and many other factors that influence the choice of the location decision. The purpose of the location study is to find an optimum location one that will result in the greatest advantage to the organization.

Location decisions for many types of business are made frequently, but they tend to have a significant impact on the organization. Here we shall look at the nature of location decisions, the usual objectives managers have when making location choices, and some of the options that are available to them. Manager can consider four options in location planning.

a) One is to expand an existing facility. This option can be attractive if there is adequate room for expansion, especially if the location has desirable features that are not readily available elsewhere. Expansion costs are often less than those of other alternatives.

b) Another option is to add new locations while retaining existing ones, as is done in many retail operations. In such cases, it is essential to take into account what the impact will be on the total system. Opening a new store in a shopping mall may simply draw customers who already patronize an existing store in the same chain rather than expand the market. On the other hand, adding locations can be a defensive strategy designed to maintain a market share or to prevent competitors from entering a market.

c) A third option is to shut down at one location and move to another. An organization must weigh the costs of a move and the resulting benefits against the costs and benefits of remaining at the existing location. A shift in markets, exhaustion of raw materials, and the cost of operations often cause firms to consider this option seriously.

d) Finally, organizations have the option of doing nothing. If a detailed analysis of potential locations fails to uncover benefits that make one of the previous three alternatives attractive, a firm may decide to maintain the status quo, at least for the time being.
General Procedure of Location Decisions

Following are the major steps necessary in the overall location strategy:

1. Development of the major objectives of the firm necessitating location selection by the management.
2. Isolation of pertinent variables affecting the choice of location.
3. Development of accurate and timely information on each of the variables selected in step 2
4. Design for the location system with detailed timetable for implementation.
5. Completing the location move in an effective and efficient manner by review, testing and feedback control.

1. Development of location objectives

The initial setup in solving location problem concerns the identification of the chief managerial objectives promoting the selection. Generally, the location decision is determined not by operations managers alone but in conjunction with top management decisions. Consequently, the objectives may include several areas of administrative interest that cannot be contained in the operations framework. Some managerial objectives for the proposed location movement may include the following:

- Additional growth-space and layout;
- Better transportation network;
- Reduction in plant operations and service costs;
- Cordial labor situation;
- Better environment in terms of water, air, and land;
- Better community and public relations;
- Greater inter-plant coordination and centralized control;
- Improved logistics; and
- Increased future plant profitability.

These location objectives are not altogether confined to the economics of plant operation. They include several other significant categories of sociological, historical, cultural, religious, and political dimensions to the locational issues. In most instances, the ultimate decision to locate will be an eclectic one and in the final analysis, it will be based upon several reasons.

2. Isolation of pertinent variables

The choice of location will involve substantial research and documentation on the variables, which affect the location decision.

3. Development of accurate and timely information

In this phase a detailed analysis of the relevant factors obtained in step two are made. Care should be taken in the respect of accuracy and timeliness of the data.

4. Design of location system

The fourth step in facilities location system involves the actual preparation of a blueprint for the location. The next step after completing the design concepts listed above is the preparation of a timetable showing the sequential procedure of the location move. It should be noted that such moves could never be accomplished in one single step. If it is a relocation, it does not mean program the closure of all existing facilities, waiting for the pick-up vans to arrive, transfer of all equipment simultaneously, and the erection of the new plant at the relocation site. Such a program will be time consuming and extremely unprofitable since it involves the closure of all plant activity while the fixed cost mount.
5. Review and feedback control

The fifth (and last) step in the location selection process involves the completion of the relocation move by establishing proper review points and control in the industrial relocation system itself. This step ensures that the location has been completed according to established location plans and within specified time. This enables the operation management to determine the efficiency of the total move in terms of production man-hours lost, output curtailed and total cost in terms of equipment and manpower transfers. Non-operational issues such as sociological problems of the transfer, individual employees’ psychological process of readjustment in the new setting and cultural shock to the transferred families can also be observed in this review step. In case of genuine employee hardship and personal difficulties, the management can strive to take appropriate corrective action by the feedback process of information from the aggrieved employees.

Procedures for Facility Location Planning

The general procedure for making location decision consists of the following steps:

i. Decide on the criteria that will be used to evaluate location alternatives, such as increased revenues or community service

ii. Identify important factors, such as location of market or raw materials

iii. Develop location alternatives:
   - Identify the general region for a location
   - Identify a small number of community alternatives
   - Identify site alternatives among the community alternatives
   - Evaluate the alternatives

iv. Make a decision

Factors Affecting Location Decision

The list will be effected by the locations of a company’s other data center facilities, including back-up sites. Based upon our work for clients, the following list summarizes the most important factors influencing the location of data center facilities.

(i) Availability and Cost of Electric Power: Manufacturing and service organizations use a large amount of electricity to run equipment. It is important for a company to select a site which provides multiple sources of power and has the current and future capacity to meet the company’s needs. In addition, it is important to choose a location with affordable and predictable electric rates, on a comparative basis, to ensure the long-term viability of the prospective location.

(ii) Natural Disasters/Weather Events: Generally speaking, companies determining the best location for new plant facilities carefully analyze the potential risk for natural disasters or disruptive weather events. Natural disasters/weather events such as hurricanes, floods, tornados and earthquakes create a lot of concern for plants. These types of weather events can interrupt plant operations for a lengthy period of time, beyond what is addressed through contingency plans.

(iii) Property Tax Rates: In modern days manufacturing companies are capital intensive, and it is important to understand the impact of property taxes on the company’s on-going operating costs. Property taxes can impact both real estate improvements and equipment investment, depending on the geography under consideration. With a thorough understanding of property
tax issues early in the process, a company can make an informed decision regarding where to locate a plant.

(iv) **Corporate Income Tax Rates:** Depending on a state’s income tax apportionment structure, a plant may have a material impact on a company’s corporate income tax liability. A number of states have moved to a single sales factor apportionment structure for corporate income taxes. These states have an advantage when it comes to plant area, states that continue to use a property, people and sales apportionment tax structure hit projects harder due to the fact that they are capital intensive.

(v) **Sales Taxes:** Sales tax rates and applicability to different types of transactions can have a material impact on projects. States that have high sales tax rates that apply to several types of purchases can materially impact a capital intensive project or companies. As a result of sales taxes being charged at the time of transaction, projects are typically impacted well before they are in operation.

(vi) **Labor Availability/Quality:** It is critical for companies considering where to locate plant facilities to carefully analyze the availability and quality of labor in the different geographic areas under consideration for the project. Even though capital intensive companies typically do not require a large number of employees, a company must have confidence in its ability to secure a workforce capable of helping the company be successful in its operations.

(vii) **Construction Costs/Quality:** Due to the costs associated with the construction of plant facilities, companies must understand construction costs in the different geographic areas under consideration. The costs and quality of construction labor has a material impact on projects and companies.

(viii) **Telecommunications Infrastructure Availability:** It is vital for companies locating new plant facilities to have confidence in the ability to be served by superfluous telecommunications infrastructure. Access to multiple points of presence, telecommunications “trunk” lines and national carriers is vital to any company operating manufacturing plants.

(ix) **Economic Development Incentives:** Anytime a company is considering a large capital investment project, economic development incentives are important to help the company lower project and operating costs. States which offer local and state incentives that help lower costs for a company have an advantage when it comes to projects. Economic development incentives can never offset a poor business climate, but they can help to make the difference in where a project locates.

(x) **Quality of Life facilities:** Most of the large scale companies employ highly skilled workers. Highly skilled workers want to live and work in an environment where they can enjoy quality of life facilities. Data center workers typically enjoy many types of pursuits during leisure time, but outdoor recreational, music, museums, sports and culturally diverse facilities typically rate high on the list.

### Behavioral Aspects of Location Decision

Basically, location decisions are made in three stages. At each stage a set of location alternatives is identified, and then an evaluation procedure is used to reduce the set of options. The stages often from a geographic and informational hierarchy and consider, in turn, regional, local, and site decisions.
With view of cost and system analysis of the organization qualitative and quantitative analysis is associated. The behavioral aspects of location play influencing role for success of business. For the selection of location behavioral aspects of each alternative location should be considered. Following are some behavioral aspect affecting location decision.

(a) **Consumer’s Consideration:** Customers are the key to success of an organization. Due to this reason consumers’ behavior should be focused for location decision to fulfill their satisfaction. In other words, the location decision should be made to convince their interest, accessibility and convenience regarding location.

(b) **Cultural difference:** Culture of society reflects the attitude of people. Since, the culture directly affects the performance of business activities; production manager should have awareness about the maintenance of good relationship with the society. It is not necessary to establish a business in a certain location rather transformation of infrastructure, culture and custom in that location counts a lot. Thus, cultural variations, economic condition of the society affect the location decision of the management.

(c) **Job satisfaction:** The reaction upon job itself is the job satisfaction. The satisfaction of needs of the worker regarding their work is job satisfaction. It is perception regarding satisfaction of needs. Hence, it also affects the organizational operation. To ensure the job satisfaction, employees of the organization show the following attitudes like less absenteeism, motivation, efficiency, less delay and less labor grievance etc. The prosperity of location determines the value and attitude of labors. So, management finds variations in job satisfaction in various locations because of different values and attitudes.

### Stages in Location Selection

The location of the facilities is carried out in three stages.

(i) **Selection of a region.** This refers to a selection of a particular geographical zone or state taking into consideration such factors as nearness to market and sources of raw materials, basic infrastructure facilities available, climatic conditions and taxation and laws.

(ii) **Selection of a community:** This refers to the selection of the specific location within the selected region. The factors that influence the selection of community are availability of labor, community attitude, social structure and service facilities. Generally the following alternatives of community are available:

   (a) Urban area
   (b) Sub-Urban area
   (c) Rural area

(iii) **Selection of a particular site:** This refers to the selection of specific site within the community. The factors that influence the site selection are the cost of the land, availability and suitability of the land. The type of manufacturing process may dictate the site selection.

### Evaluating Location Alternatives

During the decision making process of facility location, we need to establish the organization in a particular venue. There is some general analysis to be considered before establishing the venture in a
particular venue, which are called as general procedure for facility location decision or the techniques of location analysis. They are as follows:

(i) **The Preliminary Screening:** This is the first step of location decision. This step involves in identifying all the factors affecting location decision. For some types of facilities, particular environmental or labor considerations are crucial and they are to be evaluated initially. For example, breweries require an adequate supply of clean water. Aluminum producers need electrical power. Besides, following factors we generally consider under preliminary screening of location decision:

- Infrastructure
- Suppliers
- Cost structure of labor and materials
- Quality of labor and materials
- Free trade zone
- Political risk
- Business environment
- Proximate to customer
- Government barriers

(ii) **Detailed Analysis:** After the preliminary screening, more detailed analysis begins. Following four techniques are involved under detailed analysis for analyzing the location alternatives.

(a) **Point Rating / Factor Rating Technique:** It is the most popular and community used method for making decision about the selection of best alternative of location. Under this method, important factors regarding locations are listed first and then each factors are allotted their weights (ranked) as per their importance from 1 to 5. Similarly on the other hand some suitable weights from 1 to 10 are also to be allotted to the location itself on the basis of availability of infrastructures, raw material and labors. Finally, the product of such weights are obtained and aggregated and then we come to know that which location should be selected on the basis of factor rating method.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Kathmandu</th>
<th></th>
<th></th>
<th></th>
<th>Birgunj</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FR × LR</td>
<td>10</td>
<td>8</td>
<td>24</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>115</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where, FR = Factor Rate or Weights
LR = Location Rate or Weights

**Decision:** Since total maximum point is 115, which corresponds to location Birgunj. So Birgunj should be selected as best location to install factory.

(b) **Break Even Analysis Technique:** It is the method for studying and analyzing cost, volume and profit for each alternative of locations. The point on which cost and income are equal is called break even point. In other words, that level of income on which company can recover its total cost, is called break even point. It is also known as the point or level of no profit and
no loss. Under this method, the selection of location depends upon the capacity of producing goods and services of organization.

As per the above diagram, BEP at Kathmandu can be obtained with lower units of production compared to Birgunj. So in short run, Kathmandu may be the better alternative without considering production capacity of the organization. Again 'E' is the equilibrium point of cost for both locations on which OQ₃ units of Output can be produced on both locations at same very cost.

If the organization has greater capacity for producing more than OQ₃ units, then "Birgunj" should be selected in order to minimize total production cost and vice versa.

(c) Transportation Technique: It is quantitative method for making decision about the facility location. This model is more appropriate for large manufacturing concerns which produce physical goods in massive scale. Once the company produces goods, then the goods should be delivered to the final consumers and in order to deliver the physical goods to the final consumers, company requires warehouses in different places. Transportation technique helps the Operations manager to select the best location for warehouse which can minimize the transportation cost during the delivery period from origin to destination. Under transportation technique, we create a cost matrix with equal level of demand and supply of physical goods. Then initial allocation table should be constructed and made some efforts for obtaining optimum solution. The process of obtaining optimum solution leads to select best location which minimizes the total transportation cost.

(d) Central Gravity Technique: This method suggests that particular location which increases the welfare of consumer at all. The plant of the company should be centrally located on which majority of the consumers find optimal distance. Central gravity method also stands with the positive view of employees of organization. The travelling distance for employee and suppliers as well should be optimum. The major objective of central gravity method is to search vicinity (neighborhood) point for the optimal locations.

Calculation of Central Gravity Point
By using following formulae, we can determine central gravity point:

\[
x_{cg} = \frac{\Sigma IX}{\Sigma I} \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots (1)
\]

\[
y_{cg} = \frac{\Sigma IY}{\Sigma I} \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots (2)
\]
Where,

- X and Y = coordinates of each place (given)
- I = Load given to the coordinates (population)
- xcg = central gravity point of x
- ycg = central gravity point of y.

Example:
From the data below suggest the vicinity point to locate a cyber that will keep the optimal distance for five territories:

<table>
<thead>
<tr>
<th>Territories</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x, y) in km</td>
<td>(1,2)</td>
<td>(3,1)</td>
<td>(4,2.5)</td>
<td>(3,1.5)</td>
<td>(6,3)</td>
</tr>
<tr>
<td>population</td>
<td>100</td>
<td>150</td>
<td>75</td>
<td>50</td>
<td>90</td>
</tr>
</tbody>
</table>

Solution:
Computation table:

<table>
<thead>
<tr>
<th>Territories</th>
<th>(x,y) in km</th>
<th>Population(I)</th>
<th>IX</th>
<th>IY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1,2</td>
<td>100</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>B</td>
<td>3,1</td>
<td>150</td>
<td>450</td>
<td>150</td>
</tr>
<tr>
<td>C</td>
<td>4,2.5</td>
<td>75</td>
<td>300</td>
<td>187.5</td>
</tr>
<tr>
<td>D</td>
<td>3,1.5</td>
<td>50</td>
<td>150</td>
<td>75</td>
</tr>
<tr>
<td>E</td>
<td>6,3</td>
<td>90</td>
<td>540</td>
<td>270</td>
</tr>
</tbody>
</table>

TOTAL

ΣI = 645
ΣIX = 1540
ΣIY = 882.5

Now, using formula:

- \( xcg = \frac{\Sigma IX}{\Sigma I} = \frac{1540}{645} \approx 2.39 \)
- \( ycg = \frac{\Sigma IY}{\Sigma I} = \frac{882.5}{645} \approx 1.37 \)

Decision: Since the central gravity point is (2.39, 1.37), so the investor should locate his/her cyber in the vicinity of the central gravity (i.e. 2.39, 1.37).

Qualitative Models for selecting locations

Qualitative models represent the qualitative technique for evaluating location alternatives. If factors affecting locations cannot be measured in terms of money, then this technique becomes suitable for location evaluations. Following two qualitative models are used under this technique.

a) Simple comparison chart analysis model: This model is commonly used for evaluating locations at that condition when subjective factors (intangible factors) are available. Under this critical subjective factors are identified and compared with each other the reference of location alternatives and then we go to the conclusion that which alternative should be selected for the organization. An example of simple comparison chart analysis can be seen in the table below:
Simple comparison chart analysis

<table>
<thead>
<tr>
<th>Locations</th>
<th>Subjective Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labor union activity</td>
<td>Attitude of society</td>
</tr>
<tr>
<td>Pokhara</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Nepalgunj</td>
<td>Average</td>
<td>Average</td>
</tr>
<tr>
<td>Biratnagar</td>
<td>Average</td>
<td>Excellent</td>
</tr>
<tr>
<td>Birgunj</td>
<td>Good</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

As per the above simple comparison chart for subjective factors, we conclude that Biratnagar should be selected as a better alternative.

b) Factor rating model: It is the most popular and community used method for making decision about the selection of best alternative of location. Under this method, important factors regarding locations are listed first and then each factors are allotted their weights (ranked) as per their importance from 1 to 5. Similarly on the other hand some suitable weights from 1 to 10 are also to be allotted to the location itself on the basis of availability of infrastructures, raw material and labors. Finally, the product of such weights are obtained and aggregated and then we come to know that which location should be selected on the basis of factor rating method.

While selecting locations, we need to consider both qualitative and quantitative factors. Managers need to assign weights to these factors in order to make location selection decisions are not equally important for all types of organizations. Factor-rating method is one of the most common location selection method because a wide variety of factors – both qualitative and quantitative, can be objectively included. This involves six steps:

i) Develop a list of relevant factors that are critical for the success of an organization.
ii) Assign a weight to each factor to reflect its relative importance in the company’s objectives.
iii) Develop a scale for each factor as per requirement of conditions.
iv) Using the scale in step “iii” get scores in each location for each factor.
v) Multiply the score by the weights for each factor and total the score for each location.
vii) Make a recommendation based on the maximum point score.

EXERCISE – 6

1. What do you mean by location decision?
2. What steps are required in planning facility location?
3. Describe the quantitative models for facility location.
4. Write down the procedures for facility location planning.
5. Discuss various types of quantitative and qualitative techniques used in facility location decision.
6. Discuss the impact of behavioral aspect in facility location decision?
7. What are the affecting factors of location decision?
8. A newly formed firm must decide on a plant location. There are two alternatives under consideration: locate near the major raw materials or locate near the major customers. Locating near the raw materials will result in lower fixed and variable costs than locating near the market, but the owners believe there would be a loss in sales volume because customers tend to favor local suppliers. Revenue per unit will be $185 in either case. Using the following information, determine which location would produce the greater profit.

<table>
<thead>
<tr>
<th></th>
<th>Omaha</th>
<th>Kansas City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual fixed costs ($ millions)</td>
<td>$1.2</td>
<td>$1.4</td>
</tr>
<tr>
<td>Variable cost per unit</td>
<td>$36</td>
<td>$47</td>
</tr>
<tr>
<td>Expected annual demand (units)</td>
<td>8,000</td>
<td>12,000</td>
</tr>
</tbody>
</table>

9. The owner of Genuine Subs, Inc., hopes to expand the present operation by adding one new outlet. She has studied three locations. Each would have the same labor and materials costs (food, serving containers, napkins, etc.) of $1.76 cents per sandwich. Sandwiches sell for $2.65 each in all locations. Rent and equipment costs would be $5,000 per month for location A, $5,500 per month for location B, and $5,800 per month for location C.

a. Determine the volume necessary at each location to realize a monthly profit of $10,000.

b. If expected sales at A, B, and C are 21,000 per month, 22,000 per month, and 23,000 per month, respectively, which location would yield the greatest profits?

10. A small producer of machine tools wants to move to a larger building, and has identified two alternatives. Location A has annual fixed costs of $800,000 and variable costs of $14,000 per unit; location B has annual fixed costs of $920,000 and variable costs of $13,000 per unit. The finished items sell for $17,000 each.

a. At what volume of output would the two locations have the same total cost?

b. For what range of output would location A be superior? For what range would B be superior?

11. A company that produces pleasure boats has decided to expand one of its lines. Current facilities are insufficient to handle the increased workload, so the company is considering three alternatives, A (new location), B (subcontract), and C (expand existing facilities). Alternative A would involve substantial fixed costs but relatively low variable costs: fixed costs would be $250,000 per year, and variable costs would be $500 per boat. Subcontracting would involve a cost per boat of $2,500, and expansion would require an annual fixed cost of $50,000 and a variable cost of $1,000 per boat.

a. Find the range of output for each alternative that would yield the lowest total cost.

b. Which alternative would yield the lowest total cost for an expected annual volume of 150 boats?

c. What other factors might be considered in choosing between expansion and subcontracting?

12. Rework Problem 4 b using this additional information: Expansion would result in an increase of $70,000 per year in transportation costs, subcontracting would result in an increase of $25,000 per year, and adding a new location would result in an increase of $4,000 per year.

13. A firm that has recently experienced an enormous growth rate is seeking to lease a small plant in Memphis, TN; Biloxi, MS; or Birmingham, AL. Prepare an economic analysis of the three locations given the following information: Annual costs for building, equipment, and
administration would be $40,000 for Memphis, $60,000 for Biloxi, and $100,000 for Birmingham. Labor and materials are expected to be $8 per unit in Memphis, $4 per unit in Biloxi, and $5 per unit in Birmingham. The Memphis location would increase system transportation costs by $50,000 per year, the Biloxi location by $60,000 per year, and the Birmingham location by $25,000 per year. Expected annual volume is 10,000 units.

14. A retired auto mechanic hopes to open a rustproofing shop. Customers would be local new-car dealers. Two locations are being considered, one in the center of the city and one on the outskirts.

The central city location would involve fixed monthly costs of $7,000 and labor, materials, and transportation costs of $30 per car. The outside location would have fixed monthly costs of $4,700 and labor, materials, and transportation costs of $40 per car. Dealer price at either location will be $90 per car.

a. Which location will yield the greatest profit if monthly demand is (1) 200 cars? (2) 300 cars?

b. At what volume of output will the two sites yield the same monthly profit?

15. Using the following factor ratings, determine which location alternative (A, B, or C) should be chosen on the basis of maximum composite score.

<table>
<thead>
<tr>
<th>Location Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor(100 points each)</td>
</tr>
<tr>
<td>Convenience .15</td>
</tr>
<tr>
<td>Parking facilities .20</td>
</tr>
<tr>
<td>Display area .18</td>
</tr>
<tr>
<td>Shopper traffic .27</td>
</tr>
<tr>
<td>Operating costs .10</td>
</tr>
<tr>
<td>Neighborhood .10</td>
</tr>
</tbody>
</table>

16. Determine which location has the highest composite score:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Weight</th>
<th>East #1</th>
<th>East #2</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial cost</td>
<td>8</td>
<td>100</td>
<td>150</td>
<td>140</td>
</tr>
<tr>
<td>Traffic</td>
<td>10</td>
<td>40</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Maintenance</td>
<td>6</td>
<td>20</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>Dock space</td>
<td>6</td>
<td>25</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Neighborhood</td>
<td>4</td>
<td>12</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>

17. A manager has received an analysis of several cities being considered for a new office complex. The data (10 points maximum) are as follows:

<table>
<thead>
<tr>
<th>Location Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td>Business services</td>
</tr>
<tr>
<td>Community services</td>
</tr>
<tr>
<td>Real estate cost</td>
</tr>
<tr>
<td>Construction costs</td>
</tr>
<tr>
<td>Cost of living</td>
</tr>
<tr>
<td>Taxes</td>
</tr>
<tr>
<td>Transportation</td>
</tr>
</tbody>
</table>
a. If the manager weights the factors equally, how would the locations stack up in terms of their composite factor rating scores?

b. If business services and construction costs are given weights that are double the weights of the other factors, how would the locations stack up?

18. A toy manufacturer produces toys in five locations throughout the country. Raw materials (primarily barrels of powdered plastic) will be shipped from a new, centralized warehouse whose location is to be determined. The monthly quantities to be shipped to each location are the same. A coordinate system has been established, and the coordinates of each location have been determined as shown. Determine the coordinates of the centralized warehouse.

<table>
<thead>
<tr>
<th>Location</th>
<th>(x,y)</th>
<th>A 3,7</th>
<th>B 8,2</th>
<th>C 4,6</th>
<th>D 4,1</th>
<th>E 6,4</th>
</tr>
</thead>
</table>

19. A clothing manufacturer produces women’s clothes at four locations in Mexico. Relative locations have been determined, as shown in the table below. The location of a central shipping point for bolts of cloth must now be determined. Weekly quantities to be shipped to each location are also shown in the table. Determine the coordinates of the location that will minimize distribution costs.

<table>
<thead>
<tr>
<th>Location</th>
<th>(x,y)</th>
<th>Weekly Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 5,7</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>B 6,9</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>C 3,9</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>D 9,4</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>