Chapter 3
Locating Facilities

Dr. Vin Pheakdey
Ph.D. in Economics, France

Contents

1. Importance of Location
2. Choosing the Geographic Region
3. Infinite Set Approaches
4. Feasible Set Approaches
5. Network Models
6. Location Planning
Learning Objectives
After learning this chapter, you should be able to:

- Understand the importance of location decisions
- Discuss factors that affect the choice of location
- Describe a hierarchical approach to locating facilities
- Use an infinite set approach, such as the center of gravity
- Compare locations using costing and scoring models
- Use models for locating facilities on networks
- Combine location decisions into a broader approach to planning

1. Importance of Location

- Facilities location finds the best geographic locations for the different elements in a supply chain.
- Location decisions are needed whenever an organization opens new facilities.
- The right location does not guarantee success, but the wrong location will certainly guarantee failure.
1. Importance of Location

- Organizations have to consider many factors when making location decisions:
  - operating costs, wage rates, taxes, currency exchange rates, number of competitors, distance from current locations, development grants, population, reliability of supplies.
  - other non-quantifiable factors: the quality of infrastructure, political stability, social attitudes, industrial relations, legal system, future developments of the economy, and so on.

When new facilities are clearly needed, there are several alternatives that are not so expensive:

1. Licensing or franchising: local organizations make and supply the company’s products in return for a share of the profit.
2. Exporting: the company makes the product in its existing facilities and sells it to a distributor working in the new market.
3. Local distribution and sales: the company makes the product in its existing facilities, but sets up its own distribution and sales force in the new market.
1. Importance of Location

4. Local assembly and finishing: the company makes most of the product in existing facilities, but opens limited facilities in the new market to finish or assemble the final product.

5. Full local production: the company opens complete facilities in the new market.

Example:

Warwick Supplies is planning to expand into Europe. It is considering a number of options, each of which has a fixed annual payment (for rent, electricity, and other overheads) and a variable cost that depends on throughput (handling, depreciation, staff, and so on). The following table shows a simplified view of these costs.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Fixed cost</th>
<th>Variable cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A exporting from existing facilities</td>
<td>€800,000</td>
<td>€900</td>
</tr>
<tr>
<td>B using a local distributor</td>
<td>€2,400,000</td>
<td>€700</td>
</tr>
<tr>
<td>C open a facility for local finishing</td>
<td>€9,000,000</td>
<td>€520</td>
</tr>
<tr>
<td>D open limited production facilities</td>
<td>€8,000,000</td>
<td>€360</td>
</tr>
<tr>
<td>E open larger production facilities</td>
<td>€12,000,000</td>
<td>€440</td>
</tr>
</tbody>
</table>

Alternatively, Warwick can avoid entering the market by licensing a local manufacturer to make the product in return for a royalty of about 2% of sales. How might it approach this decision, if it is planning on selling about 10,000 units a year with a contribution to profit of 10%?
2. Choosing the Geographic Region

- Facility location involves a hierarchy of decisions.
- At the top of this are the broad decisions about which geographic regions to work in.
- Then come more local views that consider alternative countries or areas within this region.
- Then we look more closely at alternative towns and cities within this area.
- Finally we consider different sites within a preferred town.

Hierarchy of Decisions for Locations

- Business strategy
- Geographical regions for locations
  - Culture, costs, customers, suppliers, etc.
  - Countries and areas
    - Local conditions
    - Cities and towns
      - Available sites
      - Individual sites
2. Choosing the Geographic Region

Organizations have to consider many factors when choosing the general regions to work in.

- **Location of customers:** service providers, some manufactured products which have a cost of delivery to final customers.

- **Location of suppliers and materials:** manufacturers with heavy or bulky supplies of raw materials close to suppliers, coal burning power stations close to coalmines, pulp mills close to timber forests, frozen seafood companies near to fishing ports.

- **Culture:** It is easier to expand into an area that has a similar language, culture, laws and costs, than to expand into a completely foreign area.

- **Government attitudes:** National and local government policies can seriously affect an area’s attractiveness.

- **Direct costs:** These are the costs of operations, including wages, materials, overheads and utilities. The most attractive locations offer a combination of low direct costs and high performance.
2. Choosing the Geographic Region

- **Indirect costs:** There can be many indirect costs of doing business, including local taxes and charges on the payroll such as social insurance, pension and social costs. There may also be controls on company ownership (often including a controlling local partner), currency exchange and repatriation of profits.

- **Social attitudes:** Some countries put more emphasis on social welfare than others, and there may be higher union membership or emphasis on individual rather than corporate benefits.

---

2. Choosing the Geographic Region

- **Organization:** an organization can keep a close check on new operations by controlling these from existing headquarters and giving local operations very little autonomy. Alternatively, a company might become multinational (opening subsidiary headquarters around the world so that each area is largely independent).

- **Operations:** some organizations keep identical operations in all their locations in the world. Other organizations blend into the local environment and adapt their operations so they are more familiar to their host countries.
3. Infinite Set Approaches

- Now we look in more detail at the areas, towns, cities and individual sites.
- Two distinct approaches to location decisions are:
  1. **Infinite set approach** – which uses geometric arguments to find the best location, assuming that there are no restrictions on site availability.
  2. **Feasible set approach** – where there are only a small number of feasible sites, and an organization has to choose the best.
- These approaches are often used together, with an infinite set approach finding the best location in principle, and then a feasible set approach comparing available sites near to this.

Simple Models

- Three basic alternatives for location. **First**, a facility can be located near to customers; this gives good customer service and low costs for transport out to customers, but high cost for transport in from suppliers.
Simple Models

- **Second**, it can be located near to suppliers; this moves products quickly into the supply chain, gives low costs for inward transport, but high costs for outward transport.

- **Third**, it can be located at some point between suppliers and customers, giving a compromise with reasonable service and lower costs.
Simple Models

Variation in Transport Cost with Location

A simple way of finding the best compromise location calculates the center of gravity of supply and demand.

\[ X_0 = \frac{\sum X_i W_i}{\sum W_i} \quad Y_0 = \frac{\sum Y_i W_i}{\sum W_i} \]

- \((X_0, Y_0)\): coordinates of the center of gravity which gives the facility location
- \((X_i, Y_i)\): coordinates of each customer and supplier, \(i\)
- \(W_i\): expected demand at customer \(i\), or expected supply from supplier \(i\)
Simple Models

Ex: Van Hendrick Industries is building a central logistics center that will collect components from three suppliers, and send finished goods to six regional warehouses. The locations of these and the amounts supplied or demanded are shown in the following table. Where should they start looking for a site?

<table>
<thead>
<tr>
<th>Location</th>
<th>X,Y coordinates</th>
<th>Supply or Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier 1</td>
<td>91,8</td>
<td>40</td>
</tr>
<tr>
<td>Supplier 2</td>
<td>93,35</td>
<td>60</td>
</tr>
<tr>
<td>Supplier 3</td>
<td>3,86</td>
<td>80</td>
</tr>
<tr>
<td>Warehouse 1</td>
<td>83,26</td>
<td>24</td>
</tr>
<tr>
<td>Warehouse 2</td>
<td>89,54</td>
<td>16</td>
</tr>
<tr>
<td>Warehouse 3</td>
<td>63,87</td>
<td>22</td>
</tr>
<tr>
<td>Warehouse 4</td>
<td>11,85</td>
<td>38</td>
</tr>
<tr>
<td>Warehouse 5</td>
<td>9,16</td>
<td>52</td>
</tr>
<tr>
<td>Warehouse 6</td>
<td>44,48</td>
<td>28</td>
</tr>
</tbody>
</table>
Limitation

- Organizations don’t know exactly who their customers will be until they start local operations.
- Location suggested might not be practical because there may be no suitable site available anywhere near the solution, or available sites may be too expensive, or further development may be prohibited, or there may be no roads or workforce, or the solution might be at the top of a mountain or in the sea.

To solve such problems, we can use the alternative approach of identifying available sites and choosing the best.

4. Feasible Set Approaches

- Feasible set approaches identify available sites, compare them, and find the best.
- There are two models:
  - Costing models
  - Scoring models
Costing Models

- Costing model calculates the total cost of working from each location and finds the cheapest.
- As many of the costs of running a facility are fixed regardless of its location, we can concentrate on variable costs.
- **Total variable cost = operating cost + inward transport cost + outward transport cost**
- Locations near to customers have higher costs of inward transport, and those near to suppliers have higher costs of outward transport, so the best location is likely to be somewhere in between.

Costing Models

- An obvious problem is that we do not know the real costs before we actually open a facility.
- The cost calculations are useful for comparisons, but they are not necessarily the costs that will actually be incurred.
- In this model, we can assume that the transport cost is proportional to the distance moved, although in practice, of course, the cost depends on more than distance, and is also affected by the type of vehicles, frequency of journeys, routes taken, ways of combining customer orders, and so on.
Costing Models

- **Rectilinear Distance** = Difference in X coordinates + Difference in Y coordinates

- *With this simple measure, we can identify the location with the lowest total value of load x rectilinear distance moved.*

---

**Ex:** Bannerman Industries want to build a depot to serve seven major customers located at coordinates (100, 110), (120,130), (220, 150), (180, 210), (140, 170), (130, 180) and (170, 80). Average weekly demands, in vehicle loads, are 20, 5, 9, 12, 24, 11 and 8 respectively. Three alternative locations are available at A (120, 90), B (160, 170) and C (180,130). Which is the best site if operating costs and inward transport costs are the same for each location?
Weaknesses of Costing Model

- The difficulty of finding accurate costs, data that depends on accounting conventions, costs that vary over time
- Customer locations not being known in advance
- Order sizes not known in advance, factors that cannot be costed
- Etc.

Scoring Models

- Scoring models emphasize the factors that are important for locations, but which cannot easily be costed or quantified.
- Ex: an attractive lifestyle in one location would certainly benefit employees, reduce employee turnover and assist in recruiting – but we could not assign a realistic cost or measure to the lifestyle.
Scoring Models

List of important factors in location decisions:

- **In the region and country**
  - availability, skills and productivity of workforce
  - local and national government policies, regulations, grants and attitudes
  - political stability
  - economic strength and trends
  - climate and attractiveness of locations
  - quality of life – including health, education, welfare and culture

- location of major suppliers and markets
- infrastructure – particularly transport and communications
- culture and attitudes of people.
Scoring Models

- **In the city or area**
  - population and population trends
  - availability of sites and development issues
  - number, size and location of competitors
  - local regulations and restrictions on operations
  - community feelings
  - local services, including transport and utilities.

Scoring Models

- **In the site**
  - amount and type of passing traffic
  - ease of access and parking
  - access to public transport
  - organizations working nearby
  - total costs of the site
  - potential for expansion or changes.
Scoring Models

- **There are five steps in the scoring models:**
  - **Step 1:** decide the relevant factors in a decision
  - **Step 2:** give each factor a maximum possible score that shows its importance
  - **Step 3:** consider each location in turn and give an actual score for each factor, up to this maximum
  - **Step 4:** add the total score for each location and find the highest
  - **Step 5:** discuss the result and make a final decision.

Ex: Williams-Practar considered five alternative locations for a new warehouse for their music distribution business. After many discussions they compiled a list of important factors, their maximum scores, and actual scores for each site. What is the relative importance of each factor? Which site would you recommend?
Scoring Models

<table>
<thead>
<tr>
<th>Factor</th>
<th>Maximum score</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>20</td>
<td>12</td>
<td>16</td>
<td>15</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Accessibility</td>
<td>10</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Construction cost</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Community attitude</td>
<td>10</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Government views</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Closeness to suppliers</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Closeness to customers</td>
<td>20</td>
<td>12</td>
<td>10</td>
<td>15</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Availability of workforce</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

5. Network Models

- Sometimes it is difficult to relate the two approaches we have described to actual road layout and geographic features.
- There are, however, many databases of road networks that automatically find the best routes between two points, such as Microsoft AutoRoute Express and Softkey Journey Planner.
- Typically, we supply the postcode of starting and finishing locations, and the package finds the shortest, fastest or cheapest route, or route with some other features.
5. Network Models

- We will illustrate a typical approach to location by **single median problem**.

*The single median problem is a common measure of average travel distance or time, and finding the shortest.*

- In practice, we can find this from route planning software, or using some surrogate measure such as the straight-line distance.

5. Network Models

- To find the shortest average distance, we have to combine these distances with the loads carried. So we multiply the distances by the demands at each town, to get a matrix of the weight-distances. Then we add these for each town, and find the lowest overall value.
Ex: Ian Bruce delivers goods to eight towns, with locations and demands as shown in Figure below. He wants to find the location for a logistics center that minimizes the average delivery time to these towns. Where should he start looking?
6. Location Planning

A formal procedure for planning location has the following five steps:

- **Step 1**: identify the features needed in a new location, determined by the business and logistics strategies, structure of the supply chain, aims, customers, and other relevant factors. Look for regions and countries that can best supply these.

- **Step 2**: within the identified region, use an infinite set approach – such as the center of gravity or similar model – to find the best area for locations.

- **Step 3**: search around this area to find a feasible set of available locations.

- **Step 4**: use a feasible set approach – such as a costing model or scoring model – to compare these alternatives.

- **Step 5**: discuss all available information and come to a decision.
End