

Supply Chain Management

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MGM 660

Lecture Five



Network Design in the Supply Chain

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Learning Objectives

- 1. Understand the role of network design in a supply chain.**
- 2. Identify factors influencing supply chain network design decisions.**
- 3. Develop a framework for making network design decisions.**
- 4. Use optimization for facility location and capacity allocation decisions.**



Network Design Decisions

Supply chain network design decisions include the assignment of facility role, location of manufacturing, storage, or transportation-related facilities. and the allocation of capacity and markets to each facility.

Supply chain network design decisions are classified as follow :

1. **Facility role**: What role should each facility play? What processes are performed at each facility?
2. **Facility location**: Where should facilities be located?
3. **Capacity allocation**: How much capacity should be allocated to each facility?
4. **Market and supply allocation**: What markets should each facility serve? Which supply sources should feed each facility?

Network Design Decisions

- Network design decisions have a significant impact on performance because they determine the supply chain configuration and set constraints within which the other supply chain.
- Supply chain drivers can be used either to decrease supply chain cost or to increase responsiveness.
- All network design decisions affect one another and must be made taking this fact into consideration.
- Decisions concerning the role of each facility are significant because they determine the amount of flexibility the supply chain has in changing the way it meets demand.
- **For example**, Toyota has plants located worldwide, in each market that it serves. Before 1997, each plant was capable of serving only its local market.

Network Design Decisions

- **Facility location decisions** have a long-term impact on a supply chain's performance because it is expensive to shut down a facility or move it to a different location.
- A good location decision can help a supply chain be responsive while keeping its costs low.
- For example Toyota, built its first U.S. assembly plant in Lexington, Kentucky, in 1988, and has continued to build new plants in the United States since then.
- The U.S. plants proved profitable for Toyota when the yen strengthened and cars produced in Japan were too expensive to be cost competitive with cars produced in the United States. Local plants allowed Toyota to be responsive to the U.S. Market while keeping costs low.

Factors Influencing Network Design Decisions

- **Strategic factors**

- A firm's competitive strategy has a significant impact on network design decisions within the supply chain.
- Firms that focus on cost leadership tend to find the lowest cost location for their manufacturing facilities, even if that means locating far from the markets they serve.
- Global supply chain networks can best support their strategic objectives with facilities in different countries playing different roles.

For example, Zara has production facilities in Europe as well as Asia.

Factors Influencing Network Design Decisions

- **Technological factors**

- Characteristics of available production technologies have a significant impact on network design decisions.
- If production technology displays significant economies of scale, a few high-capacity locations are most effective. This is the case in the manufacture of computer chips, for which factories require a large investment and the output is relatively inexpensive to transport.
- In contrast, if facilities have lower fixed costs, many local facilities are preferred because this helps lower transportation costs.
- **For example**, bottling plants for Coca-Cola do not have a high fixed cost. To reduce transportation costs, Coca-Cola sets up many bottling plants all over the world, each serving its local market.

Factors Influencing Network Design Decisions

- **Macroeconomic factors**

- Macroeconomic factors include taxes, tariffs, exchange rates, and shipping costs that are not internal to an individual firm.
- As global trade has increased, macroeconomic factors have had a significant influence on the success or failure of supply chain networks.
- Thus, it is imperative that firms take these factors into account when making network design decisions.

Factors Influencing Network Design Decisions

- **Political**

- The political stability of the country under consideration plays a significant role in location choice. Companies prefer to locate facilities in politically stable countries where the rules of commerce and ownership are well defined. While political risk is hard to quantify.
- There are some indices, such as the Global Political Risk Index that companies can use when investing in emerging markets.

Factors Influencing Network Design Decisions

- **Infrastructure factors**

- The availability of good infrastructure is an important prerequisite to locating a facility in a given area.
- Poor infrastructure adds to the cost of doing business from a given location.
- Key infrastructure elements to be considered during network design include availability of sites and labor, proximity to transportation terminals, rail service, proximity to airports and seaports, highway access, congestion, and local utilities.

Factors Influencing Network Design Decisions

- **Competitive factors**

- Companies must consider competitors' strategy, size, and location when designing their supply chain networks.
- A fundamental decision firms make is whether to locate their facilities close to or far from competitors.
- The form of competition and factors such as raw material or labor availability influence this decision.

Factors Influencing Network Design Decisions

- **Competitive factors**

- **Positive Externalities Between Firms**

- Positive externalities occur when the collocation of multiple firms benefits all of them.
 - Positive externalities lead to competitors locating close to each other.
 - For example, retail stores tend to locate close to each other because doing so increases overall demand, thus benefiting all parties.
 - By locating together in a mall, competing retail stores make it more convenient for customers, who need drive to only one location to find everything they are looking for.
 - This increases the total number of customers who visit the mall, increasing demand for all stores located there.

Factors Influencing Network Design Decisions

- **Competitive factors**

- **Locating to Split the Market**

When there are no positive externalities, firms locate to be able to capture the largest possible share of the market.

Factors Influencing Network Design Decisions

Customer Response Time and Local Presence

- Firms that target customers who value a short response time must locate close to them.
- Customers are unlikely to come to a convenience store if they have to travel a long distance to get there.
- It is thus best for a convenience store chain to have many stores distributed in an area so most people have a convenience store close to them.
- In contrast, customers shop for larger quantity of goods at supermarkets and are willing to travel longer distances to get to one.

Factors Influencing Network Design Decisions

Logistics and Facility Costs

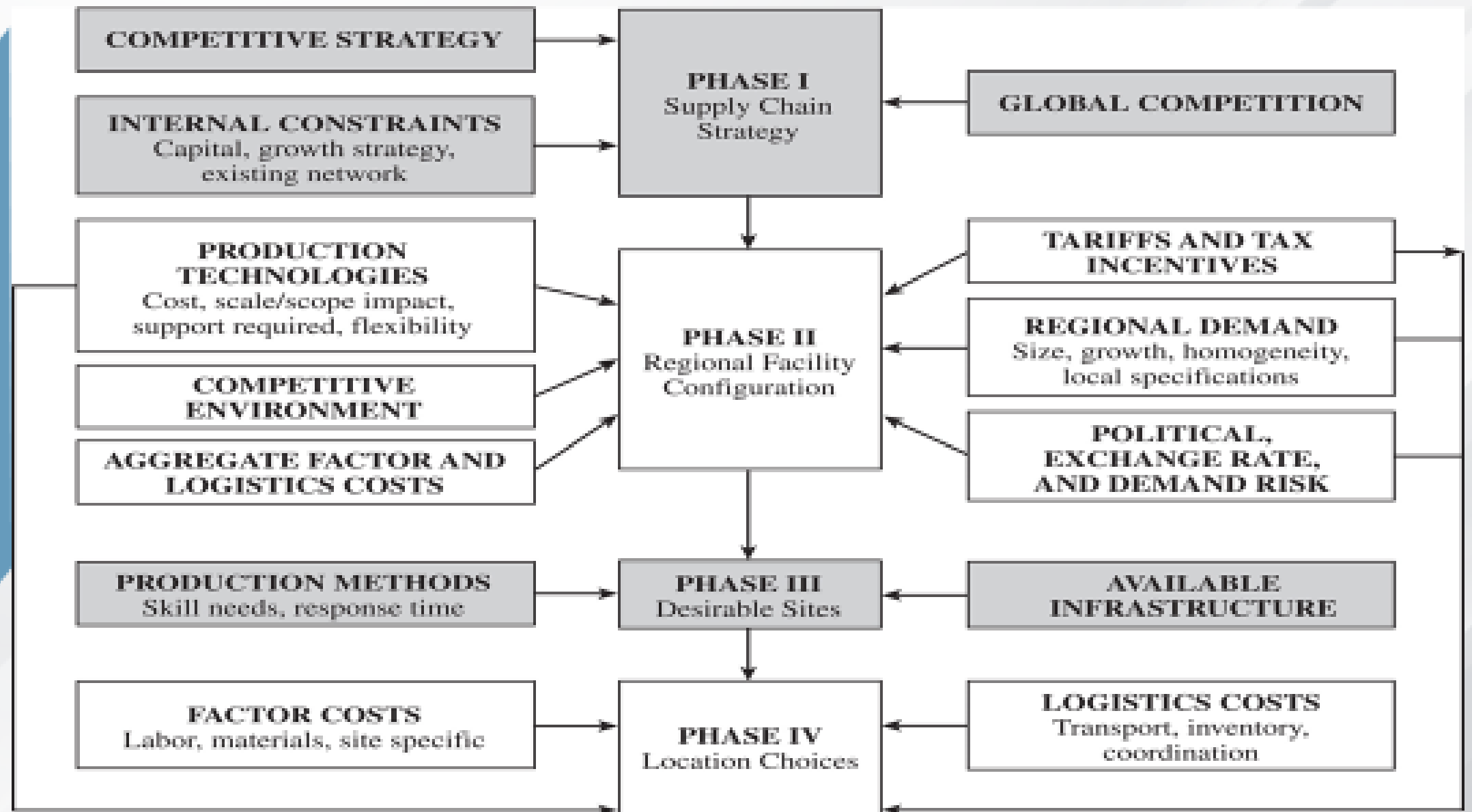
- Logistics and facility costs incurred within a supply chain change as the number of facilities, their location, and capacity allocation change.
- Companies must consider inventory, transportation, and facility costs when designing their supply chain networks.
- Inventory and facility costs increase as the number of facilities in a supply chain increases.

Factors Influencing Network Design Decisions

Logistics and Facility Costs

- Transportation costs decrease as the number of facilities increases.
- If the number of facilities increases to the point at which inbound economies of scale are lost, then transportation costs increase.
- **For example**, with few facilities, Amazon has lower inventory and facility costs than Barnes & Noble, which has hundreds of stores. Barnes & Noble, however, has lower transportation costs.

Framework for Network Design Decisions



- **Phase I: Define a Supply Chain Strategy/Design**

- The objective of the first phase of network design is to define a firm's broad supply chain design.
- This includes determining the stages in the supply chain and whether each supply chain function will be performed in-house or outsourced.
- **Phase I** starts with a clear definition of the firm's competitive strategy as the set of customer needs that the supply chain aims to satisfy.
- The supply chain strategy then specifies what capabilities the supply chain network must have to support the competitive strategy.

- **Phase I: Define a Supply Chain Strategy/Design**
- **Next**, managers must forecast the likely evolution of global competition and whether competitors in each market will be local or global players.
- Managers must also identify constraints on available capital and whether growth will be accomplished by acquiring existing facilities, building new facilities, or partnering.
- Based on the competitive strategy of the firm, its resulting supply chain strategy, an analysis of the competition, any economies of scale or scope, and any constraints, managers must determine the broad supply chain design for the firm.

• Phase II: Define the Regional Facility Configuration

- The objective of the **second phase** of network design is to identify regions where facilities will be located, their potential roles, and their approximate capacity.
- An analysis of Phase II starts with a forecast of the demand by country or region. Such a forecast must include a measure of the size of the demand and a determination of the homogeneity or variability of customer requirements across different regions.
- Homogeneous requirements favor large consolidated facilities, whereas requirements that vary across countries favor flexible facilities or smaller, localized, dedicated facilities.

- **Phase II: Define the Regional Facility Configuration**

- The next step is for managers to identify whether economies of scale or scope can play a significant role in reducing costs, given available production technologies. If economies of scale or scope are significant, it may be better to have a few facilities serving many markets.
- **For example**, semiconductor manufacturers such as Advanced Micro Devices have few plants for their global markets, given the economies of scale in production.
- If economies of scale or scope are not significant, it may be better for each market to have its own facility.

- **Phase III: Select a Set of Desirable Potential Sites**

- The objective of **Phase III** is to select a set of desirable potential sites within each region where facilities are to be located.
- Sites should be selected based on an analysis of infrastructure availability to support the desired production methodologies.
- Hard infrastructure requirements include the availability of suppliers, transportation services, communication, utilities, and warehousing facilities.
- Soft infrastructure requirements include the availability of a skilled workforce, workforce turnover, and the community receptivity to business and industry.

- **Phase IV: Location Choices**

- The objective of Phase IV is to select, from among the potential sites, a precise location and capacity allocation for each facility.
- The network is designed to maximize total profits, taking into account the expected margin and demand in each market, various logistics and facility costs, and the taxes and tariffs at each location.

Models for Facility Location and Capacity Allocation

- A manager's goal when locating facilities and allocating capacity should be to maximize the overall profitability of the resulting supply chain network while providing customers with the appropriate responsiveness.
- Revenues come from the sale of product, whereas costs arise from facilities, labor, transportation, material, and inventories.
- The profits of the firm are also affected by taxes and tariffs.
- Ideally, profits after tariffs and taxes should be maximized when designing a supply chain network.

Models for Facility Location and Capacity Allocation

- **A manager must consider many trade-offs during network design.**

For example, building many facilities to serve local markets reduces transportation cost and provides a fast response time, but it increases the facility and inventory costs incurred by the firm.

- **Managers use network design models in two situations.**

First, these models are used to decide on locations where facilities will be established and determine the capacity to be assigned to each facility. Managers must make this decision considering a time horizon over which locations and capacities will not be altered (typically in years).

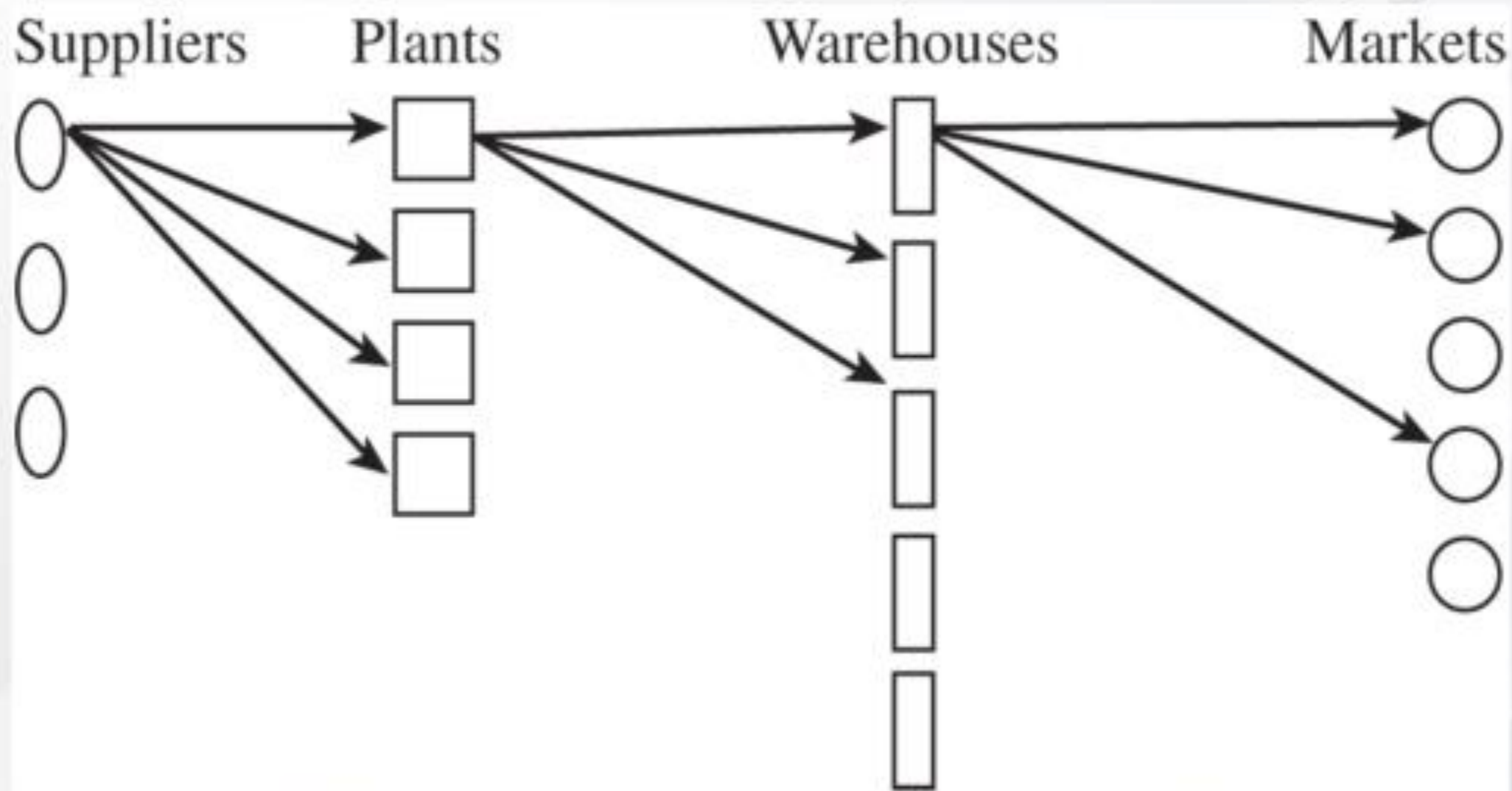
Models for Facility Location and Capacity Allocation

- **Second**, these models are used to assign current demand to the available facilities and identify lanes along which product will be transported.
- Managers must consider this decision at least on an annual basis as demand, prices, exchange rates, and tariffs change
- In both cases, the goal is to maximize the profit while satisfying customer needs

Models for Facility Location and Capacity Allocation

- **The following information ideally is available in making the design decision**
 - Location of supply sources and markets
 - Location of potential facility sites
 - Demand forecast by market
 - Facility, labor, and material costs by site
 - Transportation costs between each pair of sites
 - Inventory costs by site and as a function of quantity
 - Sale price of product in different regions
 - Taxes and tariffs
 - Desired response time and other service factors

Locating Plants and Warehouses Simultaneously



Locating Plants and Warehouses Simultaneously

- **Model inputs**

- m = number of markets or demand points
- n = number of potential factory locations
- l = number of suppliers
- t = number of potential warehouse locations
- D_j = annual demand from customer j
- K_i = potential capacity of factory at site i
- S_h = supply capacity at supplier h
- W_e = potential warehouse capacity at site e
- F_i = fixed cost of locating a plant at site i
- f_e = fixed cost of locating a warehouse at site e
- c_{hi} = cost of shipping one unit from supply source h to factory i
- c_{ie} = cost of producing and shipping one unit from factory i to warehouse e
- c_{ej} = cost of shipping one unit from warehouse e to customer j

Locating Plants and Warehouses Simultaneously

- Goal is to identify plant and warehouse locations and quantities shipped that minimize the total fixed and variable costs

Accounting for Taxes, Tariffs, and Customer Requirements

- A supply chain network should maximize profits after tariffs and taxes while meeting customer service requirements modified objective and constraint

❑ **Do not underestimate the life span of facilities.**

- It is important to think through the longterm consequences of facility decisions because facilities last a long time and have an enduring impact on a firm's performance.
- Managers must consider not only future demand and costs but also scenarios in which technology may change. Otherwise, facilities may become useless within a few years.

For example, an insurance company moved its clerical labor from one location to another to lower costs.

- With increasing automation, however, the need for clerical labor decreased significantly, and within a few years the facility was no longer needed.

- **Do not gloss over the cultural implications.**
- Network design decisions regarding facility location and facility role have a significant impact on the culture of each facility and the firm.
- The culture at a facility will be influenced by other facilities in its vicinity. Network designers can use this fact to influence the role of the new facility and the focus of people working there.
- **For example**, when Ford Motor Company introduced the Lincoln Mark VIII model, management was faced with a dilemma. At that time, the Mark VIII shared a platform with the Mercury Cougar.

- **Do not ignore quality-of-life issues.**
- The quality of life at selected facility locations has a significant impact on performance because it influences the available workforce and its morale.
- In many instances, a firm may be better off selecting a higher-cost location if it provides a much better quality of life.
- Failure to do so can have dire consequences. For example, an aerospace supplier decided to relocate an entire division to an area with a lower standard of living in order to reduce costs. Most of the marketing team, however, refused to relocate. As a result, customer relations deteriorated, and the company had a very difficult transition.
- The effort to save costs hurt the company and effectively curtailed the firm's status as a major player in its market

❑ Focus on tariffs and tax incentives when locating facilities.

- Managers making facility location decisions should consider tariffs and tax incentives carefully. When considering international locations, it is astounding how often tax incentives drive the choice of location, often overcoming all of the other cost factors combined.
- **For instance**, Ireland has developed a large high-tech industry by enticing companies with low taxes. Even within nations, local governments may offer generous packages of low to no taxes and free land when firms decide to locate facilities within their jurisdiction.
- **Toyota, BMW, and Mercedes** have all chosen their facility locations in the United States due in large part to tax incentives offered by different states.

Summary of Learning Objectives

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Essential Reference

Chopra, S., & Meindl, P. (2016). Global Edition.
Pearson Education Limited

Chapter Five.



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