

Supply chain Management

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Lecture 5

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MGM 660

Network Design in the Supply Chain



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Learning Objectives

After reading this chapter, you will be able to:

- 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.**

The role of network design in the supply chain

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.

Cont.

- 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?

The role of network design in the supply chain

Network design decisions have a significant impact on performance:

- **because they determine the supply chain configuration**
- **set constraints within which the other supply chain drivers can be used either to decrease supply chain cost or to increase responsiveness.**

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- All network design decisions affect each other 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.

Cont.:

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. This hurt Toyota when the Asian economy went into a recession in the late 1990s. The local plants in Asia had idle capacity that could not be used to serve other markets that were experiencing excess demand.

Cont.:

What happened?

Toyota has added flexibility to each plant to be able to serve markets other than the local one.

This additional flexibility helps Toyota deal more effectively with changing global market conditions.

Facility location decisions have a long-term impact on a supply chain's performance because it is very expensive to shut down a facility or move it to a different location.

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. For example, in the early 1980s, many apparel producers moved all their manufacturing out of the United States to countries with lower labor costs, in hope of lowering costs.**
- **With the drop in apparel quotas in 2005, most of the manufacturing is now moving to low-cost countries such as China.**

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Global supply chain networks can best support their strategic objectives with facilities in different countries playing different roles.

For example, Nike has production facilities located in many Asian countries. Its facilities in China and Indonesia focus on cost and produce mass-market lower-priced shoes for Nike.

Cont.

- In contrast, facilities in Korea and Taiwan focus on responsiveness and produce higher priced new designs.
- This differentiation allows Nike to satisfy a wide variety of demands in the most profitable manner.
- It is important for a firm to identify the mission or strategic role of each facility when designing its global network

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 very large investment.**

As a result, most semiconductor companies build few high-capacity facilities.

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.

Global companies have located their factories in China near Shanghai, Tianjin, or Guang Zhuo-even though these locations do not have the lowest labor or land costs because there is good infrastructure at these locations.

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 competitors or far from them.**
- **The form of competition and factors such as raw material or labor availability influence this decision.**

Framework for network design decisions

The goal when designing a supply chain network is to:

- **maximize the firm's profits**
- **satisfying customer needs in terms of demand and responsiveness.**

Global network design decisions are made in four phases we describe each phase in greater detail.

Phase 1: 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.**
- **The supply chain strategy then specifies what capabilities the supply chain network must have to support the competitive strategy**

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Next, managers must:

- **forecast the likely evolution of global competition and whether competitors in each market will be local or global players.**
- **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 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.**

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Such a forecast must include:

- a measure of the size of the demand
- determination of whether the customer requirements are homogenous or variable across different countries.
- Homogenous requirements favor large consolidated facilities, whereas requirements that vary across countries favor smaller, localized facilities.

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 very 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.**

Managers must identify competitors in each region and make a case for whether a facility needs to be located close to or far from a competitor's facility.

- **The desired response time for each market and logistics costs at an aggregate level in each region must also be identified.**

Based on all this information, managers identify the regional facility configuration for the supply chain network using network design models discussed in the next section.

PHASE III: SELECT A SET OF DESIRABLE POTENTIAL SITES



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- 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 infrastructure.
- Soft infrastructure requirements include the availability of skilled workforce, workforce turnover, and the community receptivity to business and industry.

Phase iv: location choices

- The objective of Phase IV is to select a precise location and capacity allocation for each facility.
- Attention is restricted to the desirable potential sites selected in Phase III.

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**
- **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.

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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 different situations. First, these models are used to decide on locations where facilities will be established and the capacity to be assigned to each facility.

Cont.

Managers must make this decision considering a time horizon over which locations and capacities will not be altered (typically in years).

➤ **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.

Cont.

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

Given those information, either gravity models or network optimization models may be used to design the network.

We organize the models according to the phase of the network design framework at which each model is likely to be useful.

PHASE II: NETWORK OPTIMIZATION MODELS

PHASE IV: NETWORK OPTIMIZATION MODELS

PHASE III: GRAVITY LOCATION MODEL

PHASE II: NETWORK OPTIMIZATION MODELS

During Phase II of the network design framework:

a manager considers regional demand, tariffs, economies of scale, and aggregate factor costs to decide the regions in which facilities are to be located. As an example, consider Sun Oil, a manufacturer of petrochemical products with worldwide sales. The Vice President of Supply Chain can consider several different options to meet demand.

One possibility is to set up a facility in each region. The advantage of such an approach is that it lowers transportation cost and also helps avoids duties that may be imposed if product is imported from other regions.

The disadvantage of this approach is that plants are sized to meet local demand and may not fully exploit economies of scale. An alternative approach is to consolidate plants in just a few regions. This improves economies of scale but increases transportation of scale but increases transportation cost

The Capacitated Plant Location Model

The capacitated plant location network optimization model requires the following inputs:

n = number of potential plant locations/capacity (each level of capacity will count as a separate location)

m = number of markets or demand points

D_j = annual demand from market

K_i = potential capacity of plant

f_i = annualized fixed cost of keeping factory i open

c_{ij} = cost of producing and shipping one unit from factory i to market j (cost includes production, inventory, transportation, and tariffs)

and shipping one unit from factory i to market

Cont.

The supply chain team's goal is to decide on a network design that maximizes profits after taxes.

For the sake of simplicity, however, we assume that all demand must be met and taxes on earnings are ignored. The model thus focuses on minimizing the cost of meeting global demand. It can, however, be modified to include profits and taxes.

PHASE IV: NETWORK OPTIMIZATION MODELS

During Phase IV,

a manager decides on the location and capacity allocation for each facility. Besides locating the facilities, a manager also decides how markets are allocated to facilities.

This allocation must account for customer service constraints in terms of response time. The demand allocation decision can be altered on a regular basis as costs change and markets evolve. When designing the network, both location and allocation decisions are made jointly.

PHASE III: GRAVITY LOCATION MODEL

During Phase III , a manager identifies potential locations in each region where the company has decided to locate a plant. As a preliminary step, the manager needs to identify the geographic location where potential sites may be considered.

Gravity location models can be useful when identifying suitable geographic locations within a region. Gravity models are used to find locations that minimize the cost of transporting raw materials from suppliers and finished goods to the markets served.

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Gravity models assume that both the markets and the supply sources can be located as grid points on a plane.

All distances are calculated as the geometric distance between two points on the plane.

These models also assume that the transportation cost grows linearly with the quantity shipped.

The role of IT in network design

In this chapter, we discuss a variety of methodologies in Excel that can be used to solve network design problems. For much larger problems, there are four ways that an IT system can help with network design relative to the use of a general-purpose tool such as Excel.

Even though IT may seem at first glance that the strategic nature of the network design problem makes information technology systems less valuable, good IT systems can significantly improve the capability of a network designer.

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- 1. A good network design IT system makes the modeling of the network design problems much easier than in a general-purpose tool such as Excel. These applications have many built-in tools that facilitate an accurate description of a large supply chain network and incorporate realistic features that would be time consuming and difficult to build in Excel.**
- 2. An IT system contains high-performance optimization technologies, which deliver a high-quality solution for large problems in a reasonable amount of time.**

Cont.

3. A good network design application also allows for an analysis of various "what if" scenarios. Given the uncertainty associated with forecasts, the ability to evaluate network designs in a variety of scenarios is a very powerful tool for a designer.

A network designer may find it much more appropriate to select a design that gives very good costs in many likely scenarios rather than a design that is optimal in one scenario but very poor in another.

Making network design decisions in practice

Managers should keep the following issues in mind when making network design decisions for a supply chain.

- **Do not underestimate the life span of facilities. It is important to think through the long-term 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.**

Making network design decisions in practice

facilities may become useless within a few years.

For example,

- **an insurance company moved its clerical labor from a metropolitan location to a suburban location to lower costs.**
- **With increasing automation, the need for clerical labor decreased significantly and within a few years the facility was no longer needed.**

Making network design decisions in practice

Within most supply chains, production facilities are harder to change than storage facilities.

- **Supply chain network designers must consider that any factories that they put in place will stay there for an extended period of a decade or more.**
- **Warehouses or storage facilities, particularly those that are not owned by the company, can be changed within a year of making the decision. A good location decision can help a supply chain be responsive while keeping its costs low.**

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Facility location decisions have a long-term impact on a supply chain's performance because it is very expensive to shut down a facility or move it to a different location.

For example, Toyota built its first U.S. assembly plant in Lexington, Kentucky, and has used the plant since then.

- The Lexington plant proved very 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.
- The Lexington plant allowed Toyota to be responsive to the U.S. market while keeping costs low.

Reference

Supply chain management

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Chapter 5