Outline

- A strategic framework for facility location
- Multi-echelon networks
- Gravity methods for location
- Plant location models

Network Design Decisions

- Facility role
- Facility location
- Capacity allocation
- Market and supply allocation

Factors Influencing Network Design Decisions

- Strategic
- Technological
- Macroeconomic
- Political
- Infrastructure
- Competitive
- Logistics and facility costs
**Strategic Factors**

- Classification of possible strategic roles:
  1. Offshore facility: low-cost facility for export production.
  2. Source facility: low-cost facility for global production.
  4. Contributor facility: regional production facility with development skills.
  5. Outpost facility: regional production facility built to gain local skills.
  6. Lead facility: facility that leads in development and process technologies.

**Technological Factors**

- If production technology displays significant economies of scale:
  - A few high-capacity locations are most effective.
  - A manufacture of computer chips
  - What about Coca-Cola?

**Macroeconomic Factors**

- Tariffs and Tax Incentives
  - Tariffs
  - Tax incentives
  - Free trade zones
- Exchange Rate and Demand Risk
  - Fluctuations in exchange rates (Yen in 1980’s)
  - Flexibility in production

**Political Factors**

- Politically stable countries
  - Rules of commerce and ownership are well defined.
- Independent and clear legal systems
  - Firms feel they have recourse in the courts should they need it.
- Hard to quantify
  - Firms make subjective evaluations.
Infrastructure Factors

- Availability of sites,
- Labor availability,
- Proximity to transportation terminals,
- Rail service,
- Proximity to airports and seaports,
- Highway access, and congestion,
- Local utilities.

Competitive Factors

- Consider competitors' strategy, size, and location.
  - Locate a facility close to competitors or not?
- Positive Externalities Between Firms:
  - Competing stores in a mall make it more convenient for customers.
  - Presence of a competitor may lead to the development of infrastructure in an area.
- Locating to Split the Market
  - If firms compete on price and customer pays for transportation cost.

Logistics Costs Factors

- Companies must consider inventory, transportation, and facility costs when designing their supply chain networks.
- Also influenced by the transformation occurring at each facility.
  - Iron ore is processed to make steel.

The Cost-Response Time Frontier

- Hi
- Cost
- Low
- Response Time
- Custom production with raw material at suppliers
- Central Raw Material and Custom production
- Central WIP
- Central FG
- Local WIP
- Local FG
- Mix
- Regional FG
Service and Number of Facilities

Response Time

Number of Facilities

Where inventory needs to be for a one week order
response time - typical results → 1 DC

Where inventory needs to be for a 5 day order
response time - typical results → 2 DCs

Where inventory needs to be for a 3 day order
response time - typical results → 5 DCs

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Where inventory needs to be for a next day order response time - typical results --> 13 DCs

Where inventory needs to be for a same day / next day order response time - typical results --> 26 DCs

Costs and Number of Facilities

Cost Buildup as a Function of Facilities

Costs

Facility costs

Transportation

Number of facilities

Total Costs

Percent Service Level Within Promised Time

Facilities

Inventory

Transportation

Labor

Number of Facilities
A Framework for Global Site Location

**PHASE I**
- Competitive STRATEGY
- GLOBAL COMPETITION

**PHASE II**
- Supply Chain Strategy
- TARIFFS AND TAX INCENTIVES
- REGIONAL DEMAND: Size, growth, homogeneity, local specifications
- POLITICAL, EXCHANGE RATE AND DEMAND RISK

**PHASE III**
- Regional Facility Configuration
- AVAILABLE INFRASTRUCTURE

**PHASE IV**
- Desirable Sites
- LOGISTICS COSTS: Transport, inventory, coordination
- LOCATIONS: Final assembly, components, manufacturing, materials

Conventional Network

Models for Location And Capacity

**Goal:**
- Maximize the profit while satisfying customer needs.

**Time Horizon:**
- **Long:** decide on locations and capacity.
- **Short:** Assign demand to available facilities and identify transportation lanes.

**Models:**
- Gravity models
- Network optimization models.
Models for Location And Capacity

- Info needs:
  - 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

Gravity Methods for Location

- Ton Mile-Center Solution
  - \(d_n = \sqrt{(x - x_n)^2 + (y - y_n)^2}\)
  - \(x_n, y_n\): Coordinates of delivery location \(n\)
  - \(d_n\): Distance to delivery location \(n\)
  - \(F_n\): Shipping cost per mile
  - \(D_n\): Annual demand

\[
\begin{align*}
Min & \quad \sum d_n D_n F_n \\
\text{s.t.} & \quad \sum x_{ij} \leq 1, \quad \forall i, \forall j
\end{align*}
\]

Network Optimization Models

- Allocating demand to production facilities
- Locating facilities and allocating capacity
- Key Costs:
  - Fixed facility cost
  - Transportation cost
  - Production cost
  - Inventory cost
  - Coordination cost

- Which plants to establish? How to configure the network?

Demand Allocation Model

- Which market is served by which plant?
- Which supply sources are used by a plant?

\[
x_{ij} = \text{Quantity shipped from plant site } i \text{ to customer } j
\]

\[
\begin{align*}
\text{Min} & \quad \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} \\
\text{s.t.} & \quad \sum_{j=1}^{m} x_{ij} = D_j, \quad j = 1, \ldots, m \\
& \quad \sum_{i=1}^{n} x_{ij} \leq K_j, \quad j = 1, \ldots, n \\
& \quad x_{ij} \geq 0
\end{align*}
\]
Plant Location with Multiple Sourcing

- $y_i = 1$ if plant is located at site $i$, 0 otherwise
- $x_{ij} =$ Quantity shipped from plant site $i$ to customer $j$
- $f_i$: annual fixed cost

Min $\sum_{i=1}^{n} f_i y_i + \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$

s.t.

$\sum_{i=1}^{n} x_{ij} = D_j, j = 1, \ldots, m$

$\sum_{j=1}^{m} x_{ij} \leq K_i y_i, i = 1, \ldots, n$

$y_i \in \{0,1\}$

Summary of Learning Objectives

- What is the role of network design decisions in the supply chain?
- What are the factors influencing supply chain network design decisions?
- Describe a strategic framework for facility location.
- How are the following optimization methods used for facility location and capacity allocation decisions?
  - Gravity methods for location
  - Network optimization models

Homework 1

Chapter 5

- Exercises:
  - 3
  - 5
  - 7