Supply Chain Management

Part 5

Network Design in the Supply Chain

The role of network design in supply chain

The success of any supply chain will depend on the plants, suppliers, warehouses and how the product flows from each of the origins to the final customer.

Network design in supply chain is a systematic approach to determining the best location and optimal size of the facilities to be included in the supply chain, and to ensure an optimal flow of products using advanced mathematical modelling.

The role of network design in supply chain

Supply chain network design decisions are classified as follows:

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?

Factors influencing network design decisions

- Strategic factors: a firm's competitive strategy has a significant impact on network design decisions within the supply chain.
- Technological factors: getting production technologies needs investment. (high investment: few facilities).
- Tariffs and tax incentives:

  Tariff: any duty what a company must pay if a product crosses the border.

  Incentive: is a reduction in tax or tariff or support provided by government.

Factors influencing network design decisions

- Exchange rate: fluctuations in exchange rates are common and have a significant impact on the profits of any supply chain serving global markets. (reason why Japanese carmakers established production facilities in USA in 1980s)

It was reported that every one-cent rise in the euro cost BMW and Mercedes roughly $75 million each per year.

Suitably designed supply chain networks, however, offer the opportunity to take advantage of exchange-rate fluctuations and increase profits. (Keeping production capacities in different countries).

Factors influencing network design decisions

- Freight and fuel costs: the rising cost of crude oil creates an increase in fuel cost, and this creates an increase in the cost to transport products from one location to another.(hedging prices on commodity markets or signing suitable long-term contracts are options to deal with this fluctuation)
- Political factors: companies prefer to locate facilities in politically stable countries where the rules of commerce and ownership are well defined.

Factors influencing network design decisions

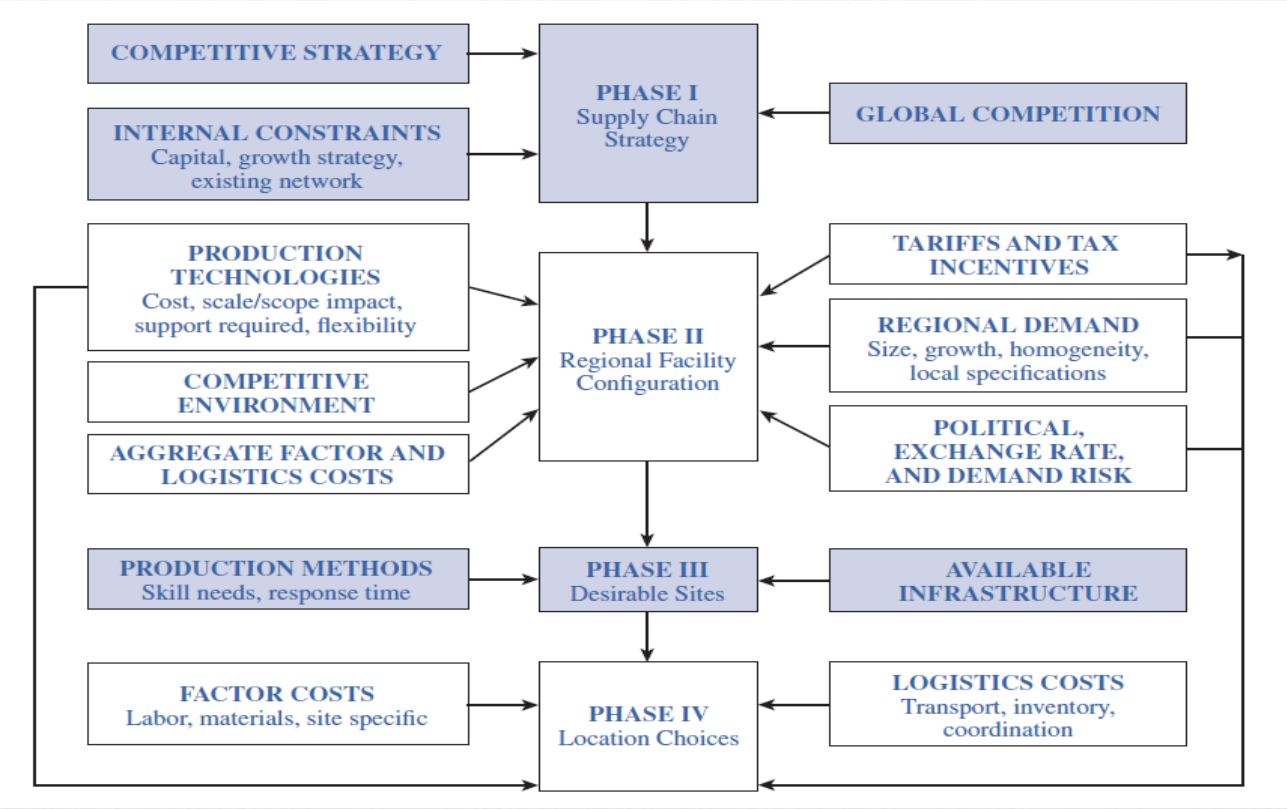
- Infrastructure factors: the availability of good infrastructures (labor, transportation terminals like harbors and airports, railway) are an important prerequisite to locating a facility in a given area.

- Positive externalities between firms: positive externalities occur when the collocation of multiple firms benefits all of them (example. collection of retail stores in a big mall).

Factors influencing network design decisions

- 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.
- Customer response time: firms that target customers who value a short response time must locate close to them.
- 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.

Framework for network design decisions



Phase I: define a supply chain strategy

- Define competitive strategy (how the supply chain aims to satisfy customer needs).
- Specify the network that will best support the competitive strategy.
- Forecast evolution of global competition.
- Determine if competitors will be local or global.
- Identify constraints on available capital.
- Determine if growth will be accomplished by acquisition, building, or partnering.

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.
- Forecast demand by country: Assessment of size of demand, determination of variance in customer requirements across borders (homogeneous = large facility).
- Identify economies of scale or scope. If significant, few facilities serving many markets. If not, distribute facilities across markets.
- Identify demand, exchange-rate, and political risk with different regional markets. Include tariffs, requirements for local production, tax incentives, etc.
- Identify competitors in each region.
- Determine if facilities should be close to competitors'.
- Identify desired response time for each market & logistics costs.

Phase III: select a set of desirable potential sites

- Infrastructure availability to support desired production methods.
- Hard Infrastructure: Availability of suppliers, transportation services, communication, utilities, warehousing, etc.
- Soft Infrastructure: availability of skilled workforce, workforce turnover, community receptivity.

Phase IV: location Choices

- Select precise location and capacity allocation for each facility.
- Design to maximize total profits.

Network optimization model

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 where facilities are to be located.

Consider a manufacture producing products with worldwide sales. The vice president of supply chain is considering several options to meet demand. One option is to set up a facility in each region. Another option is to set up plants in just a few regions. But what is the best decision?

To answer this question, at first, the data regarding demand, production, transportation and fixed costs for each region in collected.

Network optimization model

	Demand Region Production and transportation cost per 1,000,000 units					Fixed cost	Capacity
Supply Region	N. America	S. America	Europe	Asia	Africa		
N. America	81	92	101	130	115	9000	20
S. America	117	77	108	98	100	6750	20
Europe	102	105	95	119	111	9750	20
Asia	115	125	90	59	74	6150	20
Africa	142	100	103	105	71	6000	20
Demand	12	8	14	16	7		

Cost data (in thousands of $) and demand and capacity data (in millions of units)

Network optimization model- Parameters and decision variables

- ***n*** number of potential plant locations/capacity
- ***m*** number of markets or demand points
- $\mathbf{D_j}$ annual demand from market j
- $\mathbf{K_i}$ potential capacity of plant i
- $\mathbf{f_i}$ annualized fixed cost of keeping plant i open
- $\mathbf{c_{ij}}$ cost of producing and shipping one unit from plant i to market j (cost includes production, inventory, transportation, and tariffs)
- Decision variables:
- y_i 1 if plant *i* is open, 0 otherwise
- x_{ij} quantity shipped from plant *i* to market *j*

Network optimization model – Objective function and constraints

Objective function: is minimization of the total cost (fixed + variable)

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

Subject to

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

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

$y_i \varepsilon \{0, 1\}$ for i = 1, . . . , n and $x_{ij} \geq 0$

Network optimization model – Objective function and constraints

- Min $f_1y_1+f_2y_2+f_3y_3+f_4y_4+f_5y_5+c_{11}x_{11}+c_{12}x_{12}+c_{13}x_{13}+c_{14}x_{14}+c_{15}x_{15}+c_{21}x_{21}+c_{22}x_{22}+c_{23}x_{23}+c_{24}x_{24}+c_{25}x_{25}+\ldots+c_{54}x_{54}+c_{55}x_{55}$
- S.t

$x_{11}+x_{21}+x_{31}+x_{41}+x_{51}=12$
$x_{12}+x_{22}+x_{32}+x_{42}+x_{52}=8$
$x_{13}+x_{23}+x_{33}+x_{43}+x_{53}=14$
$x_{14}+x_{24}+x_{34}+x_{44}+x_{54}=16$
$x_{15}+x_{25}+x_{35}+x_{45}+x_{55}=7$

Constraints for satisfying demand at each market

Network optimization model – Objective function and constraints

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} \leq 20y_1$$
$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} \leq 20y_2$$
$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} \leq 20y_3$$
$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} \leq 20y_4$$
$$x_{51} + x_{52} + x_{53} + x_{54} + x_{55} \leq 20y_1$$

Constraints for satisfying capacity

y_1, y_2, y_3, y_4, and y_5 are o or 1

$x_{ij} \geq 0$

Network optimization model – Optimal solution

	Demand region - production allocation (million units)				
Supply Region	N. America	S. America	Europe	Asia	Africa
N. America					
S. America	12	8			
Europe					
Asia			4	16	
Africa			10		7
Demand	12	8	14	16	7

The plant in South America meets the North American demand, whereas the European demand is met from plants in Asia and Africa.