UNIT - II

Designing the supply chain network.

The Role of distribution in the Supply chain:-

- The Distribution refers to the steps taken to move and store a product from the supplier stage to a customer stage in the supply chain.
- Distribution occurs between every pair of stages in the supply chain.
  Raw materials and components are moved from suppliers to manufacturers, where as finished products are moved from the manufacturer to the end customers.
  - Distribution is a key driver of the overall profitability of a firm because it affects both the supply chain cost and the customer experience directly.
  - Distribution-related costs make up about 10.5 percent of the U.S economy. and about 20% of the cost of manufacturing. For commodity products distribution forms an even higher fraction of the product cost. In India. The outbound distribution cost of cement is about 30% of the cost of producing and selling cement.

Ex:- Wal-Mart and Seven-Eleven Japan, have build the success of their entire-business around outstanding distribution design and operation. In the case of Wal-Mart, distribution allows the company to provide high availability levels of relatively common products at a very low cost. In the case of Seven-eleven Japan, effective distribution provides a very high level of customer responsiveness at a reasonable cost.

→ The appropriate distribution networks can be used to achieve a variety of supply chain objectives. Ranging from low cost to high responsiveness. As a result, companies in the same industry often select very different distribution networks.

Ex:- 1. Dell distributes its PC's directly to end consumers, where as companies such as HP distribution through resellers. Dell customers wait several days to get a P.C, where as customers can walk away with an HP PC from a reseller.
- Gateway opened Gateway country stores, where customers could examine the products and have sales people help them.

configure a P.C that suited their needs. Gateway however, chose to sell no products at the stores. all pc were shipped directly from the factory to the customers. In 2001, Gateway closed several of these stores because of their poor financial performance.

- APPLE computers, in contrast, has operated many retail stores where computers are sold.

∴ These Pc companies have choosen different distribution models.

P&G (Procter & Gamble)

Factors influencing Distribution Network design:-

~~The for~~

at the highest level, Performance of a distribution network should be evaluated along two dimensions.

1. customer needs that are met
2. cost of meeting customer needs.

① The firm must evaluate the impact on customer service and cost as it compares different distribution network options. The customer needs that are met influence the company's revenues, which along with cost decide the Profitability of the delivery network.

customer service consist's of many components, we focus on those measures that are influenced by the structure of the distribution network

- Response time.
- Product variety.
- Product availability.
- customer experiance.
- Time to market.
- Order visibility.
- Returnability.

Response time is the amount of time it takes for a customer to recive an order.

Product variety is the number of different product's/configuration's that are offered by the distribution network.

Product availability is the probability of having a product in stock when a customer order arrives.

- customer experience includes the ease with which customers can place and receive orders as well as the extent to which this experience is customized.

- Time to Market is the time it takes to bring a new product to the Market.

- Order visibility is the ability of customers to track their orders from placement to delivery.

- Returnability is the ease with which a customer can return unsatisfactory merchandise and the ability of the network to handle such returns.

- customer always wants the highest level of performance along all these dimensions. In practice, however, this is not the case.

- The customers ordering a book at Amazon.com are willing to wait longer than those who drive to a nearby Borders Store to get the same book. In contrast customers can find a much larger variety of books at Amazon compared to the Borders Store. Amazon customers trade off fast response times for high levels of variety.

→ . Firm target customers who can tolerate a long response time require only a few locations that may be far from the customer. These companies can focus on increasing the capacity of each location.

→ In contrast, firms that target customers who value short response times need to locate facilities close to them. These firms must have many facilities, each with a low capacity. Thus, a decrease in the response time customer desire increase the number of facilities required in the network.

Changing the distribution network design affects the following supply chain costs. (Notice that these are four of the six supply chain drivers.)

1. Inventory
2. Transportation
3. Facilities and handling
4. Information

The other two drivers, sourcing and pricing, also effect the distribution system.

⇒ Inventory

→ As the number of facilities in a supply chain increases, the inventory and resulting inventory cost will increases.

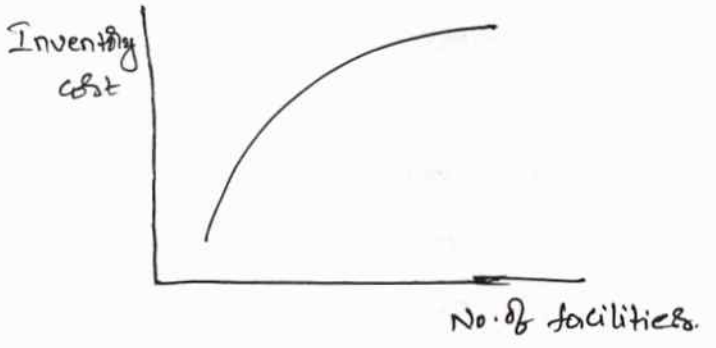


fig: Relation b/w No. of facilities and inventory cost.

→ To decrease inventory costs, firm try to consolidate and limit the number of facilities in their supply chain network.

Ex: Amazon is able to turn it's inventory 12 times a year. Where as Borders with about 400 facilities, achieved only about two turns/year.

→ Transportation:

→ Inbound transportation costs are the costs incurred in bringing materials into facility.

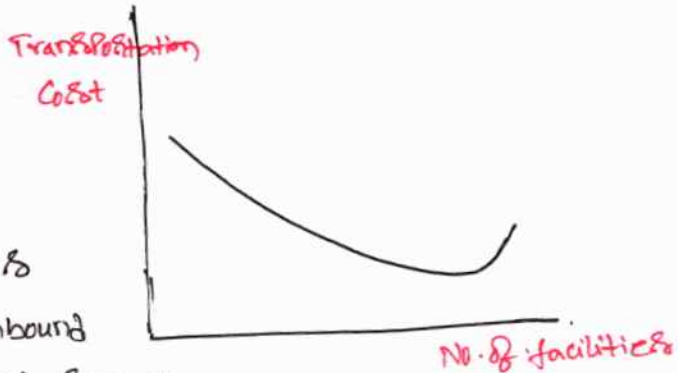
→ Out bound transportation costs are the costs of sending Material out of a facility.

→ out bound transportation cost/unit tend to be higher than inbound costs because inbound lot sizes are typically larger.

Ex:- The Amazon warehouse full truckload shipments of books inbounded side, but ships out small packets with only a few books / customer on the outbound side.

Increasing the number of warehouse locations decreases the average outbound distance to the customers. and makes outbound transportation distance a smaller fraction of the total distance traveled by the product.

Thus as long as inbound transportation economies of scale are maintained, ~~incr~~ increasing the number of facilities decrease total ~~total~~ transportation cost,



→ if the number of facilities is increased to a point where inbound lot sizes are also very small and result in a significant loss of economies of scale in inbound transportation.

Increasing the Number of facilities increases total transportation cost.

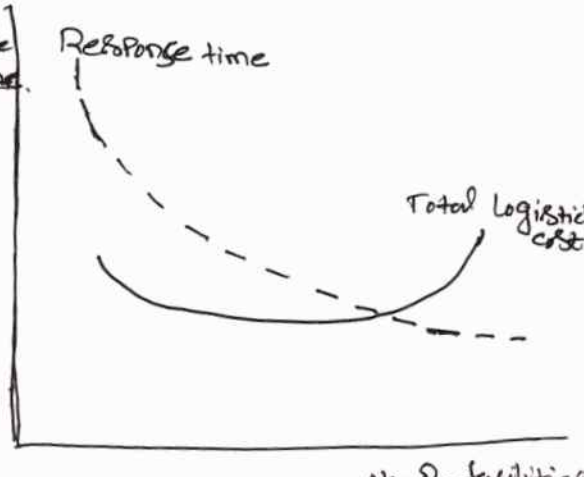
→ Facilities:

Facilities cost is decreased. as the number of facilities ~~is~~ is reduced. because a consolidation of facilities allows a firm to exploit economies of scale.

∴ Total logistics cost is the sum of inventory, transportation, and facilities cost for supply chain network.

→ As the number of facilities increases, ~~Response~~ Response time ~~time~~ decreases. The total logistics costs first decrease and then increase.

Each firm should have at least the number of facilities that minimize total logistics cost.



Eg:- Amazon has more than one warehouse primarily to reduce its logistics costs (and improve response time). As a firm wants to reduce the response time to its customers further, it may have to increase the number of facilities beyond the point of that minimizes logistics cost. A firm should add facilities beyond the cost-minimizing point only if managers are confident that the increase in revenues because of better responsiveness is grater than the increase in cost's because of additional facilities.

Design options for a distribution network:

When considering distribution between any two pairs of stages, such as supplier to manufacturer or even a service company serving it's customers through a distribution network, many of the same options still apply.

Managers must take two key decisions when designing a distribution network.

1. Will product be delivered to the customer location or picked up from a predesignated site?
2. Will product flow through an intermediary (or) intermediate location?)

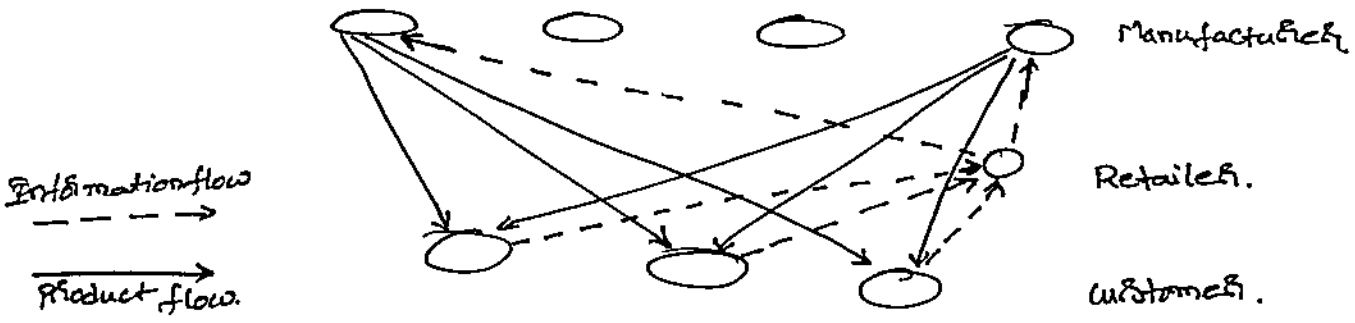
Based on the firm's industry and the answers to these two questions one of six distinct distribution network designs may be used to move products from factory to customer, which are classified as follows.

1. Manufacturer storage with direct shipping
2. Manufacturer storage with direct shipping and in-transit merge
3. Distributor storage with package carrier delivery.
4. Distributor storage with last-mile delivery.
5. Manufacturer/distributor storage with customer pickup
6. Retail storage with customer pickup.

1. Manufacturer storage with direct shipping

- Product is shipped directly from the manufacturer to the end customer, bypassing the retailer.
- This option is also referred to as drop-shipping. With product delivered directly from the manufacturer to the customer. The retailer is independent of the manufacturer, carries no inventories. Information flows from the customer via the retailer, to the manufacturer and product is shipped

directly from the manufacturers to the customers.



- The advantage of drop-shipping is the ability to centralize inventory at the manufacturers. A manufacturer can aggregate demand across all retailers that it supplies. As a result, the supply chain is able to provide a high level of product availability with low level of ~~inventories~~ inventory.

+ Benefit of aggrigation is achieved only if the manufacturer can allocate at least a portion of the available inventory across retailers on an as-needed basis.

+ Benefits from centralization are highest for high-value, low-demand items with unpredictable demand.

+ Drop-shipping also offers the manufacturer the opportunity to post-pone customization until after a customer has placed an order. Postponement if implemented, further, lowers inventory by aggregating to the component level. Build-to-order companies such as Dell hold the inventory as a common-components and post pone product customization. Thus lowering the level of inventory carried.

~~Perfect~~

- Performance characteristics of manufacturer. Storage with direct shipping network :-

Cost factor.	Performance.
Inventory ↓	→ low cost because of aggrigation. Benifits of aggregation are highest for low-demand, high value item's. → Benifits are very large if product customization can be postponed at the manufacturer.
~~Facilities & handling~~ ~~Transportation~~:	→ ~~High transportation costs because of aggregation~~ ~~Some saving on handling costs, if manufacturer can manage small shipments or ship from production line.~~
Transportation: ↑	High transportation costs because of increased distance and disaggregate shipping.
Facilities & handling: ↓	low facilities costs because of aggregation. Some saving on handling costs if Manufacturer. can Manage small. Shipments or ship from Production line.
Information:-	Significant investment in information infrastructure to integrate manufacturer and Retailer.

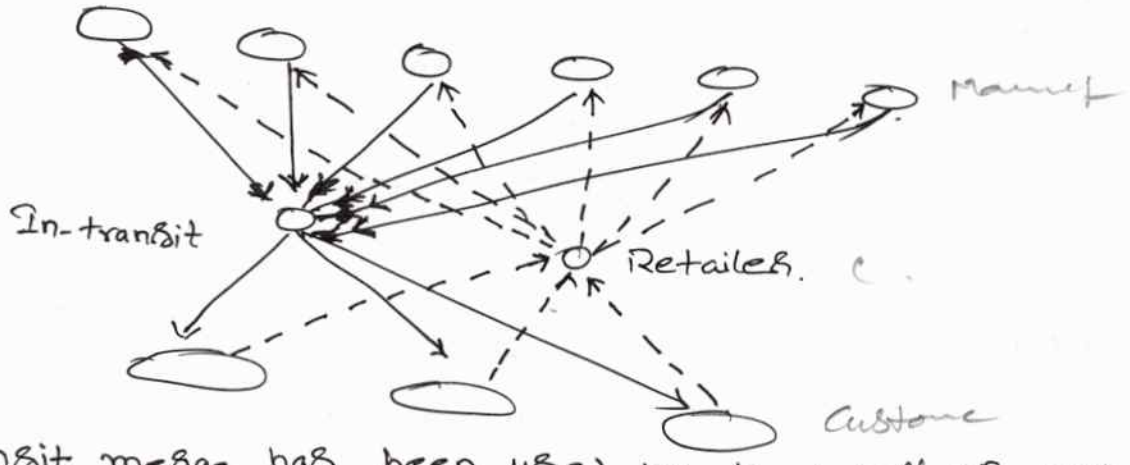
service factor.	Performance
Response time ↑	: long response time of one to two week's because of increased distance and two stages for order. Processing. Response time may vary by product. Thus complicating receiving.
Product variety(Good)	: Easy to provide a very high level of variety.
Product availability(Good)	Easy to provide a high level of product availabili
customer experience(Good)	Good interms of home delivery
Time to market	: fast, with the product available as soon as the first unit is produced.

Order. visibility : More difficult but also more important from a customer. service perspective.

Returnability : Expensive and difficult to implement.

2. Manufacturer. Storage with Direct Shipping and in-transit merge:-

In-transit merge combines pieces of the order. coming from different location's so that the customer. gets a single delivery.



In-transit merge has been used by direct sellers such as Dell and can be used by companies implementing drop-shipping. (Dell & Sony)

→ When a customer. order. a PC from Dell. along with Sony monitor, The package carrier. pick's up The PC from The Dell factory and The monitor from The Sony factory. it Then merges. The two together. at a hub before making a single delivery to The customer.

→ In-transit merge allows. Dell and Sony to hold all their inventory's at The factory. This approach has The greatest benifit's for. product's with ~~value~~ high value whose demand is difficult to forecast, particularly if product customization can be postponed.

- Performance Characteristics & in-transit merge:

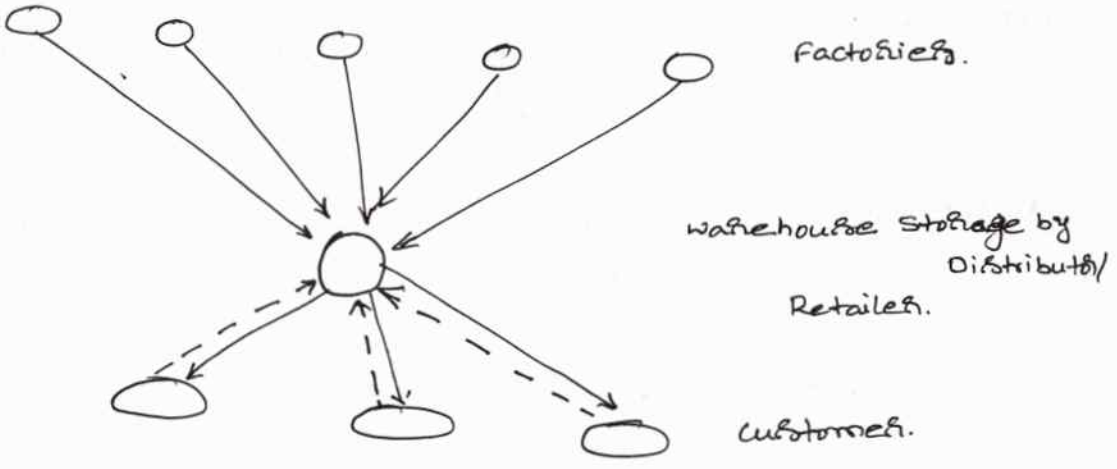
Cost factor.	Performance
Inventory	: Similar to Drop-Shipping (correct)
Transportation	: Some what lower. transportation costs than drop-shipping.
Facilities & ~~locati~~ handling	: Handling costs higher. Than drop-shipping. at ~~collect~~.
Information :	: Investment is. Somewhat higher. Than for drop-shipping.

Service factor.	Performance.
Response time	: Similar. to drop-shipping; May be Marginally high.
Product variety	: Similar to Drop-Shipping.
product availability	: " " "
customer experience	: Better than drop-shipping because a single delivery has to be received.
Time to market	: Similar to drop-shipping.
Order visibility	: " "
Returnability	: " "

3. Distributor storage with carrier delivery:-

- under this option, inventory is not held by manufacturer's at the factories but is held by distributor's / retailer's in the intermediate warehouses, and Package carrier's are used to transport products from the intermediate location to the final customer.

- Amazon, as well as industrial distributors such as W.W. Grainger and Mc-Master-Carr, have used this approach combined with drop-shipping from a manufacturer.



Relative to manufacturer storage, distributor storage requires a high level of inventory, as the distributor/ retailer warehouse generally aggregates demand uncertainty at a lower level than the manufacturer that is able to aggregate demand across all distributor/ retailers. from an inventory perspective, distributor storage makes sense for products with somewhat higher demand. This is seen in the ~~this~~ operations of both Amazon and W.W. Grainger. They stock only the medium-to-fast-moving items at their warehouses, with slow moving item's stocked further upstream. In some instances, Postponement can be implemented with distributor storage, but it does require that the warehouse develop some assembly capability.

✓ - Distributor storage requires much less inventory than a retail network.

- Amazon achieves about 12 turns of inventory annually using warehouse storage. where as borders achieves about two turns using retail stores.

Performance characteristics of Distributed Storage with carrier delivery:

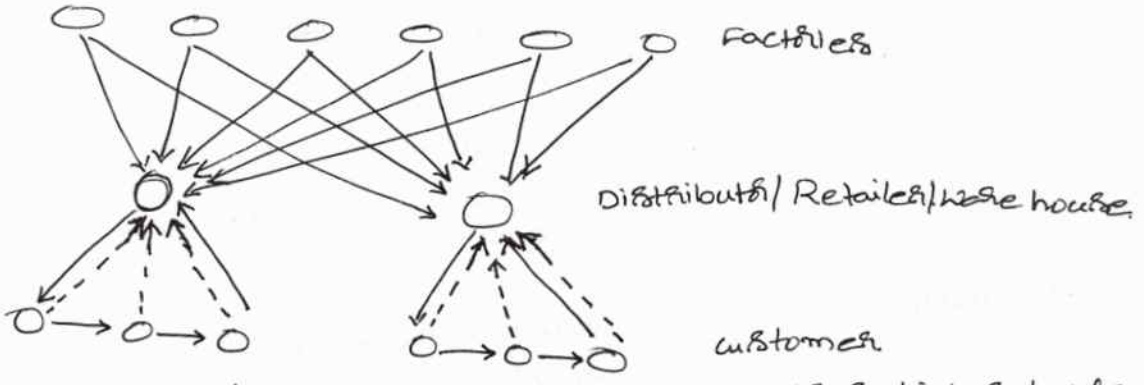
Cost factor		Performance
Inventory ↑ (M)	:	Higher than manufacturer storage. Difference is not larger for faster-moving items.
Transportation ↓ (M)		Lower than manufacturer storage. Difference Regarding Reduction is higher for fast moving items.
Facilities & handling ↑ (M)		Some what higher than manufacturer storage. The difference can be larger for very slow-moving items.
Information	:	Similar infrastructure compared to manufacturer storage.

Service factor		Performance
Response time ↑ (M)	:	Faster than manufacturer storage.
Product variety ↓ (M)		Lower than manufacturer storage
Product availability	:	Higher. Cost to provide the same level of availability as manufacturer storage
Customer experience	:	Better than manufacturer storage with drop-shipping.
Time to market	:	Higher than manufacturer storage
Order visibility	:	Easier than manufacturer storage
Returnability	:	Easier than manufacturer storage.

4. Distributor storage with last-mile Delivery:-

Last-mile delivery refers to the distributor/retailer delivering the product to the customer's home instead of using a Package carrier.

- Last mile delivery requires the distributor warehouse to be much ~~closer~~ closer to the customer. Given the limited radius that can be served with last-mile delivery, more warehouses are required compared to the case when Package delivery is used.



- Distributor storage with last-mile delivery requires higher levels of inventory than the other options (except for retail stores) because it has a lower level of aggregation. From an inventory perspective, warehouse storage with last-mile delivery is suitable for relatively fast-moving items's for which disaggregation does not lead to a significant increase of inventory.
- staple items in the grocery industry fit this description.

Performance characteristics of Distributor storage with last-mile delivery:

Cost factor	Performance
Inventory	: Higher than distributor storage with Package carrier delivery.
Transportation	: Very high cost given minimal scale economies. Higher than any other distribution ~~economy~~ options.
Facilities & Handling	: Facility costs higher than manufacturer storage & distributor storage with Package carrier delivery. but lower than a chain of retail stores.
Information.	: Similar to distributor storage with Package carrier delivery.

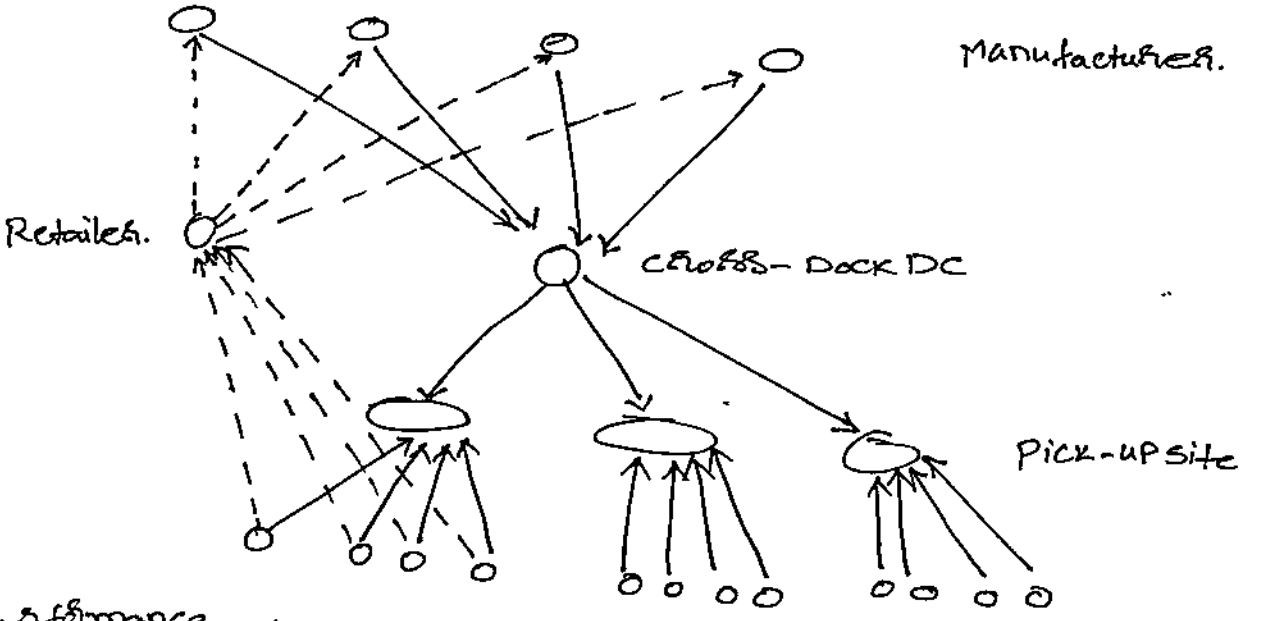
Service factor	Performance
Response time	: very quick same day to next day delivery.
Product variety	: Some what less than distributor. storage with package carrier. delivery but larger. than retail stores.
Customer. experience	: very good, particularly for bulk items.
Time to market:	: slightly higher than distributor. storage with package carrier delivery.
Order. traceability	: less of an issue and easier. to implement than manufacturer. storage & distributor. storage with package carrier. delivery.
Returnability	: Easier. to implement than other. options. Harder and more expensive than a retail network.

5. Manufacturer. or Distributor. Storage with Customer. Pick up.

- In this approach, inventory is stored at the manufacturer. & distributor. warehouse. but customers place their. orders online & on the phone and then travel to designated PICKUP points to collect their. products.
- Orders are shipped from the storage site to the PICKUP points as needed.

Ex:- 7dream.com, operated by Seven-Eleven Japan, which allows customers to PICKUP online orders at a designated stores.

- A business-to-business ex:- W.W. Grainger, whose customers can PICKUP their orders at one of the W.W. Grainger retail outlets.
- In case of 7dream.com the order is delivered from manufacturer or distributor. warehouse to the PICKUP location. In case of W.W. Grainger., some items are stored at the PICK up location
- Seven-Eleven has a distribution center. where product from manufacturer. is cross-docked and sent to retail outlets on a daily basis.



Performance characteristics of network with customers Pickup Site:-

Cost factor	Performance
~~Inventory~~ Transportation.	: lower than the use of Package Carriers, ~~easily~~ especially if using an existing delivery network.
Inventory	: can match any other option, depending on the location of inventory.
Facilities and handling	: Facility cost can be very high if new ~~Product~~ facilities have to be built. costs are lower if existing facilities are used. The increase in handling cost at the Pickup Site can be significant.
Information	: Significant investment in infrastructure required.

Service	Performance
Response time	: Similar to Package carriers. delivery with manufacturers. & distributors. storage. Same day delivery possible for items stored locally at Pickup Site.
Product variety	: Similar to other manufacturers. & distributors storage options.
Product availability	: " " "
customers experience	: lower than other options because of the lack of home delivery. In areas with high density of population, loss of convenience may be small.

Time to market : similar to manufacturer storage options.

Order visibility : difficult but essential.

Returnability : Some what easier pick up location can handle returns.

6. Retail storage with customer pickup:

In this option, often viewed as the most traditional type of supplychain, inventory is stored locally at retail stores.

customers walk into the retail stores & place an order online & by phone and pickup at the retail store.

Ex: companies that offer multiple options of order placement include Albertsons, ~~with~~ which uses part of the facilities as a grocery store and part of the facility as an online fulfillment center.

2. Customers can walk into the store & order online. A B2B W.W. Grainger's ~~retail outlet's~~ customers can order online, by phone, & in person and pickup their order ~~of~~ at one of W.W. Grainger's retail outlets.

Albertsons keeps its inventory at the pickup location itself.

W.W. Grainger stores some items at the pickup locations where as others may come from a central locations.

Performance characteristics of local storage at consumer pickup site:

Cost Factor.

Performance

Inventory : Higher than all other options.

Transportation : lower than all other options

Facilities & handling : Higher than other options. The increase in handling cost at the pickup site can be significant for online and phone orders.

Information : Some investment in infrastructure required for online and phone orders.

Service Facts	Performance
Response time	: Same-day pickup possible for items stored locally at pickup site
Product variety	: Lower than all other options.
Product availability	: More expensive to provide them all other options.
Customer experience	: Related to whether shopping is viewed as a positive or negative experience by customer.
Time to market	: Highest among distribution options.
Order visibility	: Travel for in-store orders. Difficult, but essential for online and phone orders.
Returnability	: Easiest than other options given that pickup location can handle returns.

The Role of

The Role of network design in the supply chain:-

The S.C. network design decisions include the assignment of facilities role, location of manufacturing, storage, & transportation related facilities, and the allocation of capacity and markets to each facility. supply chain network design decisions are classified as follows.

1. Facility role:- what role should each facility play' what process 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 in supply chain

We focus on the fundamental questions of facility location, capacity allocation and market allocation with in a supply chain network

Role of N.D in Supply chain!

includes the assignment of facility role, location of manufacturing, storage, or transportation-related facilities, and capacity allocation of capacity and the allocation of capacity and markets to each facility.

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   Which supply sources should feed each facility?

Factors influencing Network Design decisions:-

1. Strategic factors:-

A firm's competitive strategy has a significant impact on network design decision 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 very far from the markets they serve.

Ex:- In earlier 1980' Many apparel producers Moved all their manufacturing out of the U.S to countries with lower labour costs in hope of lowering costs.

Date : .....

To

The Branch Manager
Andhra Bank
New Boyanapalli branch

Sir,

Sub : **Request for issue of cheque book**

I request you kindly issue a cheque book to above mentioned account number to operate my account

Thanking you,

Yours faithfully,

Signature.....

Name : .....

Account No .....

→ 2005, most of the manufacturers is now moving to low-cost countries such as china.

→ Global supply chain network can best support their strategic objectives which facilitates in different countries playing different role

Eg:- Nike has production facilities located in many Asian countries.

It's facilities in chain & Indonesia focus on cost and produce Mass-Market at low priced shoes for Nike

→ facilities in Korea, & Taiwan focus on responsiveness and produce higher-priced New design. 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 & strategic role of each facility. when designing its global network.

Kasra Ferdows:-(1997) suggests the following classification of possible strategic roles for various facilities in a global supply chain network.

1. offshore facility :- low-cost facility for export product.
The role of being a low cost supply source for markets located outside the countries. where the facility is located.

The location selected for an offshored facility should have low labor and other costs to facilitate low-cost production.

2. Source facility:- low-cost facility for global production:-

① A source facility is a primary source of product for their entire global network.

① → strategic role is broader than that of an offshore facility.

② Source facility tend to be located in places where production costs are relatively low, infrastructure is well developed, and skilled workers is available. Good offshore facilities migrate over time into source facilities.

Factors influencing Network design decisions:

1. Strategic factors.
   a) Offshore facility: low-cost facility for export production
   b) Source facility: low-cost facility for global production
   c) Server facility: ~~Regional~~ Regional Production facility (Maruti & Suzuki) to avoid & overcome high tariffs on imported cars in India
   d) Contributor facility:- ~~Relating to~~ Regional Production facility with development skills.
   e) Out Post facility: Regional Production facility built to gain local skills.
   f) Lead facility: facility that leads in development and process technologies.

2. Technological factors:
3. Macroeconomic factors:- (taxes, tariffs & exchange rates,
4. Exchange Rate and Demand Risk:-
5. Political Factors: Rules of commerce and ownership
6. Infrastructure factors:-
7. Competitive factors: close to the competitors or far from them
   a) +ve externalities b/w firms
   b) Locating to split the markets
8. Socio economic Factors:-
9. Customer Response time and Local Presence:
10. logistics and ~~Facto~~ Facility costs:

Date : .....

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Thanking you,

Yours faithfully,

Signature.....

Name :

Account No.....

3. Server facility:- Regional Product facilities:-

A Server facility's objective is to supply the market where it is located.

A Server facility is built because of tax incentives, local content requirement, tariff barriers (or) high logistics cost to supply the region from elsewhere.

Ex:- In 1970's Suzuki partnered with the indian government to set up maruti udyog. Maruthi was set up as a service facility and produced cars only for the indian market. Maruthi facility allowed Suzuki to overcome high tariffs on imported cars in India

4. Contributor facility: Regional Production facility with ~~delive~~ development skills

contributor facility serves the market where it is located but also assumes responsibility for product customization, process improvement, product modification's (&) Product development.

Ex. The Maruthi facility in India today develops many new products for both the India and the overseas markets and has moved from being a server to a contributor facility in the Suzuki network.

5. Outpost facility: Regional Production facility built to gain local skills.:-

An outpost facility is located primarily to obtain access to knowledge & skills that may exist within a certain region. Given its location, it also plays the role of a server facility. The primary objective remains one of being a source of knowledge and skills for the entire network. Many global firms have set up outpost production facilities in Japan despite the high operating costs.

6. Lead facility: facility that leads in development and process technology

Lead facility creates new products, process, technologies for the entire network. Lead ~~fi~~ facilities are located in areas with good access to a skilled work force and technological resources

2. Technological factors:-

characteristics of available production technologies have a significant impact on network design decision. If production technology displays significant economies of scale, a few high capacity locations are most effective.

flexibility in the production technology affects the degree of consolidation that can be achieved in the network.

3. Macroeconomic factors:-

it includes taxes, tariffs, exchange rates, and other economic factors that are not internal to an individual firm.

tariffs & tax incentives:-

- tariffs refers to any duties that must be paid when products and/or equipment are moved across international, state or city boundaries
- tariffs have a strong influence on location decisions within a supply chain.
- If a country has very high tariffs companies either do not serve the local market or setup manufacturing plants within the country to save on duties.

~~Tax incentives~~:-

- High tariff leads to more production locations with in supply chain network.

Tax incentives:- are a reduction in tariffs & taxes that countries, states, and cities often provided to encourage firms to locate their facilities in specific areas.

- Many country vary incentives from city to city to encourage investment in areas with lower economic development such incentives are often a key factor in the final location decision for many plants.

4. Exchange Rate and Demand Risk:

Fluctuations in exchange rates are common and have a significant impact on the profits of any supply chain serving global markets.

- Exchange rate risks may be handled using financial instruments that limit, or hedge against, the loss due to fluctuations.
- ~~Suitably design supply chain networks, however, offers the~~
- An effective way to do this is to build some overcapacity into the network and make the capacity flexible so that it can be used to supply different markets. This flexibility allows the firm to react to exchange-rate fluctuations by altering production flows within the supply chain to maximise profits.

5. Political factors:

- 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.

6. Infrastructure ~~facilities~~ 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 for a given location.
- Key infrastructure elements to be considered during network design include availability of sites, labor availability, proximity to transportation terminals, rail service, proximity to airports and seaports, highway access, congestion, local ~~uniti~~ utilities.

7. Competitive factors:

- Companies must consider competitors strategy, size, and location when designing their supply chain network.
- Fundamental decision firms make is whether to locate close to ~~each other because doing so in~~ competitors or far from them. The form of competition and factors such

as raw material & labour availability influences these decisions.

(a) Positive externalities b/w firms:- are instances where the collocation of multiple firms benifits all of them.

Positive externalities lead to competitors locating close to each other.

(b) Locating to split the market:- No positive externalities, firms locate to be able to capture the largest possible share of the market.

(8) Socioeconomic factors:-

The government of India has as a matter of State Policy, promoted industrial development of industrially backward areas in the country concentrating in particular on the Northeastern Region, Jammu & Kashmir, Himachalpradesh, Uttaranchal.

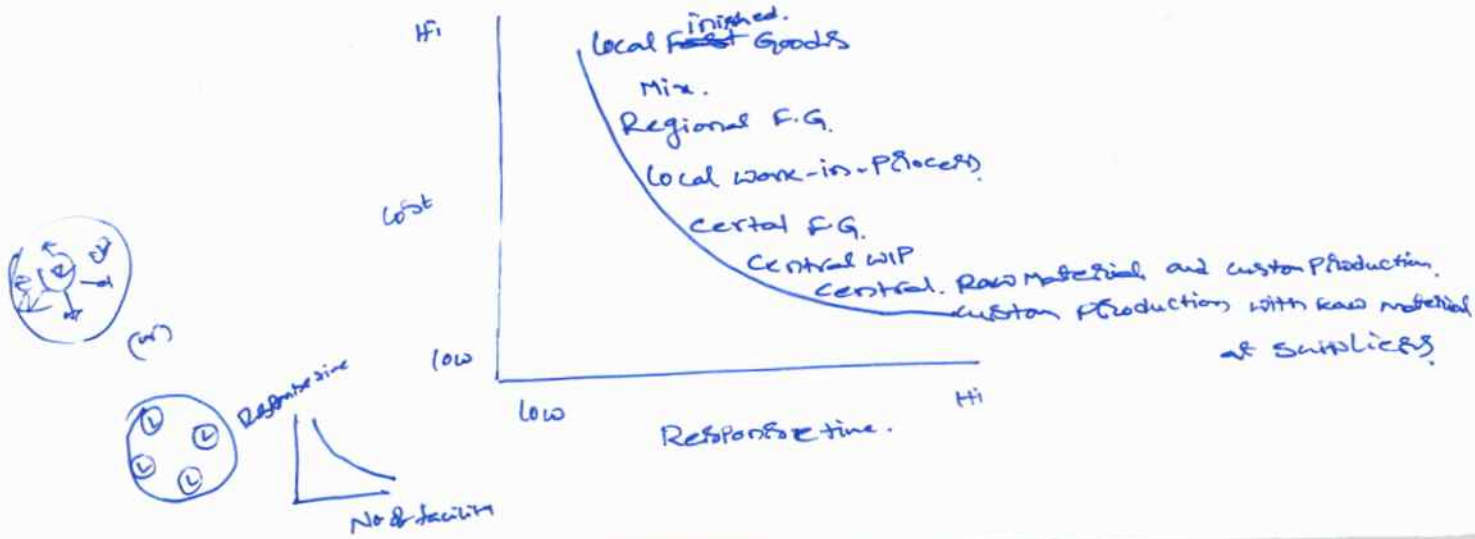
(9) Customers Response time and local presence

The firms that targets customers who value a short response time must locate close to them.

(10) logistics and Facility costs:-

logistics and facilities costs incurred within a supply chain change as number of facility location, and capacity allocation is changed.

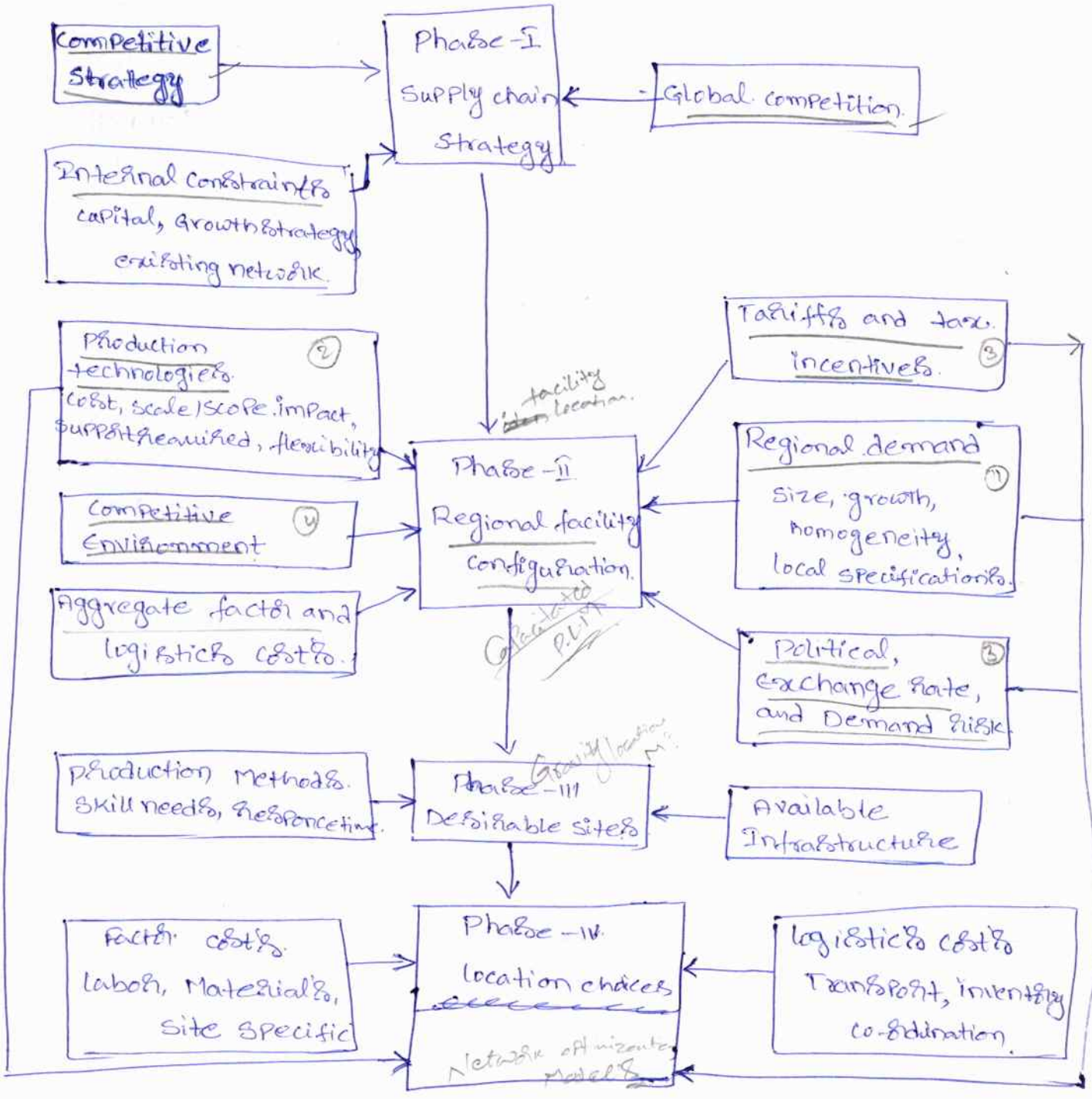
->company's must consider inventory, transportation, and facility costs when designing their supplychain network.



Frame work for network design decisions:-

The goal when designing a supply chain network is to maximise the firm's profits while satisfying customer needs in terms of demand and responsiveness.

- To design a effective network a manager must consider all the factors
- Global network design decisions are made in four phases



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.
- Supply chain Strategy then specifies what capabilities the supply chain network must have to support the competitive strategy.
- 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 supply chain design for the firm.

Phase-II: Define the Regional Facility configuration:-

The objective of second phase of network design is to identify regions where facilities will be located. their potential roles, and their approximate capacity.

① An analysis of phase-II starts with a forecast of the demand by country such a forecast must include a measure of the size of the demand as well as a 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.

(2) 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 & scope are significant, it may be better to have a few facilities serving many markets.

(3) → Next managers must identify demand risk, exchange-rate risk, and political risk associated with different regional markets. They must also identify regional tariffs, any requirements for local production, tax incentives, and any export & import restrictions for each market.

(4) Tax and tariff information is used to identify the best location to extract a major share of the profits. In general, it is best to obtain the major share of profits at the location with the lowest tax rate.

(5) Managers must identify competitors in each region and make a case for whether a facility needs to be located close to & far from a competitor's facility (6) 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 config~~

Phase-III Select a set of desirable Potential Sites:

- 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 supplies, transportation service, communication, utilities, and warehousing infrastructure.

→ Soft infrastructure requirements include the availability of skilled workforce, work force turnover, and 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.

- The network is designed to maximize total profits taking into account the expected Margin and demand in each market and various logistics and ficility costs, and the taxes and tariffs at each location.

Learning objectives

1. understand the Role of network design in a S.C
2. Identify

$B_1, B_2, C_1, C_2, C_{11}, 25, 26,$

z

UNIT- III

Facility Location:

Facility like, Plant and machineries, warehouses etc. while performing the task of producing product/ services. A proper planning of these facilities would definitely reduce their cost of operations and maintenance.

Reasons for plant location study.

1. Establishment of a new venture
2. expansion of existing business
3. Significant change in existing demand supply & Marketing location.
4. Significant change in the cost structure
5. Government Policies.

Factors influencing plant location:-

General factors:-

1. Availability of land for present and future needs and cost of land and land development and building etc.
2. Availability of inputs such as labour, raw Material etc.
3. closeness to the market Places.
4. Stability of demand
5. Availability of communication facilities.
6. Availability of necessary modes ~~like~~ of transportation like Road, Rail, airport, waterways.
7. Availability of infrastructure facilities such as Power, water, financial institutions, banks etc.
8. Disposal of water and effluent and their impact on the environment.
9. Government support, grant, subsidy, tax structure.
10. Availability of housing facility and Recreational facilities.
11. Demographic factors like population, trained man power, academic institutions, standards of living, income level. etc
12. Security, culture & society.
13. Fuel cost.

Specific factors:- A Multinational company, desiring to setup Plant

Should consider the following aspects in addition to the normal factors

1. The economic stability of the country and the concern of the country towards outside investments are to be considered

2. The success of operation of the factory depends on the cultural factors, language and cultural differences which can present operating, control and even political problems. units of measurement is also very important in international business.

3. Analysis must be based on the factors like wage rate, Policy, duties .etc.

4. The company can set up joint ventures with any leading local giants that will solve many operational problems

Break-even analysis:-

The objective of any location problem is to maximize profit. In comparing several potential location's on an economic basis, only revenues and costs need to be considered. These will be varing from one location to another location.

An economic analysis can be done by using break-even analysis. This uses fixed costs and variable costs

Generalised methodology for locational break even analysis is given below.

1. Determine all relevent costs for each of the location's.
2. Classify the cost's for each location into annual fixed cost and variable cost's.
3. Plot the total costs associated with each location on a single chart of annual cost versus annual volume
4. Select the location with the lowest total annual cost at the expected production volume.

Ex: Potential locations A, B, C have the cost structures shown below for manufacturing a product which is expected to sell for Rs 7000/unit. Find the most economical location for an expected volume of 2000 units/year.

	Fixed cost/year (Rs)	Variable cost/unit (Rs)
A	6000,000	1500
B	7000000	500
C	5000000	4000

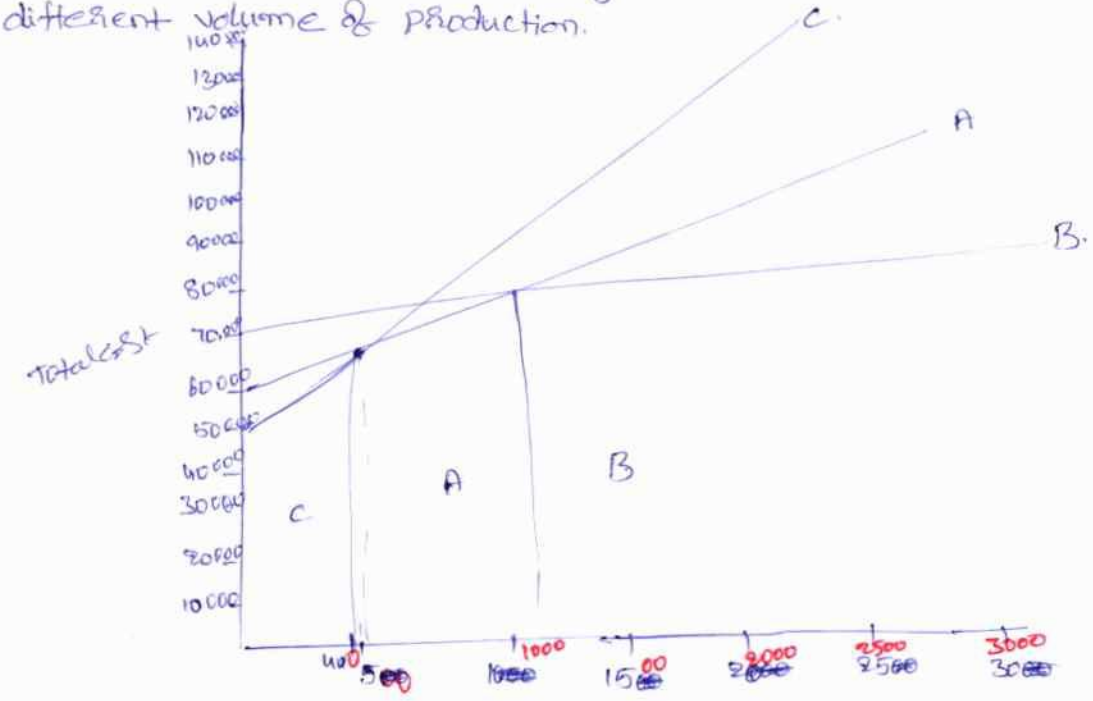
Sol:- Find the total cost for each Plant

$TC = FC + (VC/unit)(Volume)$

location	Total cost (TC)
A	$60000 + 15 \times 2000 = 90000$
B	$70000 + 5 \times 2000 = 80000$
C	$50000 + 40 \times 2000 = 130000$

from the above table, it is clear that the cost for the location 'B' is the minimum. Hence it is to be selected for locating the Plant.

The Graph can act as a Ready made chart to Provide Solution for different volume of Production.



from the Graph the different ranges of production volumes over which the best location to be selected are summerized in the following table.

Range of Production volume	Best plant Selected
$0 \le q \le 1000$	C
$1000 \le q \le 2000$	A
$2000 \le q$	B

Single facility location Problem:-

We are given a set of existing facilities with their co-ordinates on x-y plane and the movement of materials from a new facility to all these existing facility. Then the objective is to determine optimal location of the new facility. Generally, we follow rectilinear distances for such decision. The rectilinear distance between any two points whose co-ordinates are (x_1, y_1) and (x_2, y_2) is given by the following formula.

$$d_{12} = |x_1 - x_2| + |y_1 - y_2|$$

Some properties of an optimum solution to the rectilinear distance location problems are as follows.

1. The x-co-ordinate of the new facility will be same as the x-co-ordinate of some existing facility similarly the y-co-ordinate of the new facility will coincide with the y-co-ordinate of some existing facility.

   It is not necessary that both co-ordinates of the new facility be same as that of some existing facility.

2. The optimum x-coordinate (y-coordinate) location for the new facility is a median location.

   A median location is defined to be a location such that no more than one half the item movement is to the left (below) of the new facility location and no more than one half the item movement is to the right (above) of the new facility location.

Eg:- an example of a rectilinear distance location problem, Consider the location of new plant which will supply raw materials to a set of existing plants in a group of companies. Suppose that there are 5 existing plants, which have a material movement relationship with the new plant. let the existing plants have locations of (400, 200) (800, 500) (1100, 800) (200, 900) (1300, 300) Furthermore suppose that the numbers of tons of materials transported / year from the new plant to various existing plants 450, 1200, 300, 800, 1500, respectively. Then our objective is to determine optimum location for the new plant

such that distance moved is minimized.

Sol:- Let (x, y) be the co-ordinate of the new plant

The optimum x-co-ordinate for the new plant is determined as follows.

The data of existing plants are ordered according to their x-co-ordinate values, Next. the weights are accumulated. The total Number of tons transported/year. is 4250.

Existing Plant	x-co-ordinate	weight	cumilative weight
4	200	800	800
1	400	450	1250
2	800	1200	2450
3	11,00	300	2750
5	13,00	1500	4250.
		Total =	4250 tons

The median location corresponds to the cumulative weigh. $4250/2 = 2125$ from the above table the corresponding x-coordinate value is 800 . weight = 2125

y-coordinate

Existing Plant	y-coordinate	weight	Cumilative.
1	200	450	450
5	300	1500.	1950
2	500	1200	3150
3	800	300	3450
4	900	800	4250
		Total	4250 tons

The median location on y-axis corresponding to the cumulative weight $\cdot 4250/2 = 2125$ is 500

$\therefore$ The optimal $(x, y) = (800, 500)$

(The objective was to locate a single new facility in relation to the set of existing facilities such that the total cost of transportation between the new facility and set of existing facility is minimized)

Network optimization models. (Multi facility location Model)

Manager considers Regional demand, tariffs, economics of scale, and aggregate factor costs to decide the regions in which facilities are to be located.

Ex:- ~~Sunflower oil products with India wide sales~~

~~→ The Manager considers.~~

Sun oil; manufacturer of Petrochemical Products with world wide sales. The vice President of Supply chain, can consider Several different options to meet demand.

① one Possibility is to setup a facility in each Region.

② An alternative approach is to consolidate plants in first few regions.

① - The advantage of such an approach is that it lowers transportation cost and also helps avoids duties that may be imposed if product is imposed from other regions.

- The disadvantage is of this approach is that plants are sized to meet local demand and may not fully exploit economics of scale.

② - An alternative approch is to consolidate plants in first few region's ~~to~~ This improves the economics of scale but increases transportation cost and duties. During phase-II The Manager must consider these quantifiable trade-offs along with non quantifiable factors such as the competative environment and political risk.

Step-I is to collect the data in a form that can be used for a Quantitative model.

Sun oil The vice President of supplychain decides to view the world wide demand in terms of five regions - N. America, S. America, Europe, Africa, Asia.

	A	B	C	D	E	F	G	H	I	J
1	Inputs - Costs, capacities, Demands.									
2		Demand Region.								
3	Supply Region	Production & Transportation cost ~~per~~ 10,00,000 units. N.A.	S.A.	EUROP	ASIA	Africa	Fixed cost (Rs)	low capacity	fixed cost	High capa
4	NA	81	92	101	130	115	6,000	10	9000	20
5	SA	117	77	108	98	100	4,500	10	6,750	20
6	E	102	105	95	119	111	6,500	10	9,750	20
7	Asia	115	125	90	59	74	4,100	10	6,150	20
8	Africa	142	100	103	105	71	4000	10	6000	20
9	to	12	8	14	16	7				

Annual demand for each of five regions is shown in cells B9; F9. cells B4; F9 contains variable production and inventory, transportation cost & producing in one region to meet demand in each individual region.

The fixed cost as well as variable costs associated with facilities, transportation, and inventories, at each facility.

Fixed costs are those that are incurrent no matter how much is produced & shipped from facility.a facility. variable costs are those that are incurred in proportion to the quality produced & shipped from a given facility.

facility, transportation, and inventory costs generally display economics of scale and the managerial cost decreases as the quantity produced at a facility increases.

→ Sunoil is considering two different plant sizes in each location
- low capacity plant produces 10 million units and
- high capacity plant produces 20 million units.
- high capacity plants exhibits some economics of scale. and have fixed costs that are less than twice the fixed cost of low capacity plant.

The capacitated plant location model:

The capacited plant location network optimization model requires the following ~~data~~ input.

n = number of potential plant location's / capacity
m = number of markets and demand points.
D_j = annual demand from market j
K_i = potential capacity of plant i
C_{ij} = cost of producing and shipping one unit from factory i to market j

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

This model thus focuses on minimizing the cost of meeting

of meeting global demand. It can however, be modified to include profits and taxes.

Define the following decision variables:-

y_i = '1' if plant 'i' is open, '0' otherwise

x_{ij} = Quantity shipped from plant i to Market j

The problem is then formulated as the following integer programming.

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

Sub. to

$$\sum_{i=1}^{n} x_{ij} = D_j \quad \text{for } j = 1, \dots m. \quad \text{---} \quad 5.1 \quad (1)$$

$$\sum_{j=1}^{m} x_{ij} \leq K_i y_i \quad \text{for } i = 1, \dots n. \quad \text{---} \quad 5.2 \quad (2)$$

$$y_i \in [0,1] \quad \text{for} \quad i = 1, \dots n; x_{ij} \geq 0. \quad \text{---} \quad 5.3 \quad (3).$$

The objective function minimizes the total cost (fixed + variable) of setting up and operating the network. The constraint in eq 5.1 requires demand at each regional Market be satisfied. The constraint in eq 5.2 states that no plant can supply more than its capacity. (clearly, the capacity is 0 if the plant is closed and K_i if it is open. The product of term $K_i y_i$ captures this effect.) The contraint in eq 5.3 enforces that each plant is either open ($y_i = 1$) or close ($y_i = 0$). The solution identifies the Plants that are to be kept open, their capacity, and the allocation of regional demand to these plants.

Gravity location model:-

a Manager identifies Potential locations in each region. where the company has decided to locate a plant. As a preliminary step, the manager need to identify the geographic location where potential sites may be considered. Gravity location models can be usefull. when identifying suitable geographic locations within a region.

- Gravity Model's are used to find locations that minimize the cost of transporting raw materials from suppliers. and finished goods to the Markets served. Next, we discuss a typical scenario in which gravity Models can be used.

x_n, y_n: co-ordinate location of either a market or supply source 'n'

F_n: cost of shipping one unit for one Mile between the facility and either, Market or supply source 'n'

D_n: quantity to be shipped between facility and Market or supply source n.

if (x, y) is the location selected for the facility, The distance d_n b/w the facility at location (x, y) and the supply source or Market 'n' is given by.

$$d_n = \sqrt{(x - x_n)^2 + (y - y_n)^2}$$

The total transportation cost (TC) $TC = \sum_{n=1}^{K} d_n D_n F_n$

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

Sub to

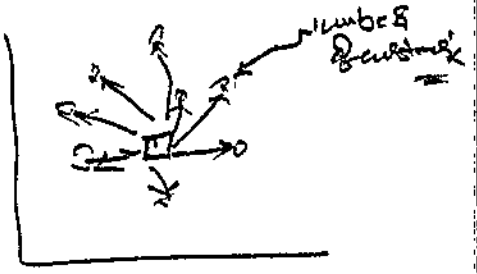
$$\sum_{i=1}^{n} x_{ij} = D_j$$

$$\sum_{j=1}^{n} x_{ij} = K_i y_i$$

$$y_i \in [0,1]$$

$$= 6000 \times 1 + \sum_{i=1}^{n}\sum_{j=1}^{n} 81 \times 100$$

Gravity location model:-



location model is used as a gravity method.

(minimise the sum of the weited distances and → distances are calculated from the facility that are located ~~for~~ to the customers.)

$$\min \sum_i w_i d_i$$

w_i = number of trip's.

w_i = Total annual shipments

$C_1 (x_1, y_1)$

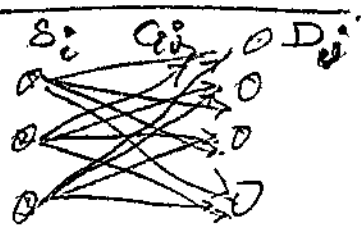
$C_2 (x_2, y_2)$

$C_m (x_m, y_m)$

a facility located $F(x_0, y_0)$

distances from facilities: $d_i = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2}$

⇒ Transportation Problem



C_{ij} = cost of Goods from Supply i to customer j

$$\min \sum_i \sum_j C_{ij} X_{ij} \rightarrow$$

$$\sum_i x_{ij} \leq C_i \; ; \; \sum_i x_{ij} \geq D_j \; ; \; x_{ij} \geq 0.$$

i- Models for facility location and capacity allocation:

Manager's goal ~~is to~~ when locating facilities and allocating capacities should be maximize the overall profitability of the resulting supplychain network. while providing customers with the appropriate responsiveness. Revenues come from the sales of product, whereas costs arise from facilities, labour, transportation, material, and inventories. The profit of the firm are also affected by taxes and tariffs. Ideally, profits after tariffs and taxes should be maximised when designing a supply chain network.

Manager must consider many trade-offs during network design. building many facilities to serve local markets reduces transportation cost and provides a fast response time., but it increases ~~a~~ facility and inventory costs incured by the firm.

Managers use network design models in two different situations.

1. First these models are used to decide on locations where ~~facility~~ facilities will be established and 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.

2. These models ~~are~~ ~~to two de~~ are used to assign current demand to the available facilities and identify lanes along which product will be ~~that~~ transported. Managers must consider this decisions at least an annual basis as demand, prices, exchangerate, and tariffs change. In both cases, the goal is to maximize the profit while satisfying customer.

~~location of supply~~

Managerial use Network design models in 2 diff situations

1. These models are used to decide on locations where facilities will be established and 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.
2. These models are used to assign current demand to the available facilities and identify lanes along which products will be transported. Managers must consider this decision at least on an annual basis as demands, prices, exchanges rates, and tariffs change.

→ Both objective maximize the Profit and while satisfying customer needs.

The following information ideally is available in Marketing ~~the~~ The design decision.

- location of supply sources and markets
- location of Potential facility sites
- Demand forecast by Market
- Facilities, labour, and material costs by site
- Transportation costs b/w 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

Network design in supply chain.

Focus on the fundamental questions of facility location, capacity allocation and market allocation with in a supply chain network.

Role of Network Design in supply chain:-

S.C.N.D. decisions includes the assignment of facility role, location of manufacturing, storage, & Transportation - related facilities, and the allocation of capacity and markets to each facility. S.C. network design decisions 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 serves? which supply sources should feed each facility?

① Each role of each facility are significant because they determine the amount of flexibility the supply chain has in changing the way it meets demand.

② Facility location decisions have a long-term impact on supply chain performance because it is very expensive to shut down a facility & move it to a desired location. A good location decision can help a S.C be responsive while keeping it's costs low.

in contrast to a poorly located facilities makes it very difficult for a supply chain to perform close to the efficient frontier.

③ capacity allocation decisions also have a significant impact on S.C performance. where as capacity allocation can be altered more easily than location, capacity decisions do tend to stay in place for several years. Allocating too much capacity to a location results in poor utilization, and as a result, higher

costs. Allocating too little capacity results in poor responsiveness if demand is not satisfied. Or high cost if demand is filled from a distant facility.

(4) The allocation of supply sources and markets to facilities has a significant impact on performance because it effects total production, inventory, and transportation costs ~~including~~ incurred by the supply chain to satisfy the customer demand.

UNIT-VI

Transportation and Pricing Products

Transportation refers to the movement of product from one location to another as it makes its way from the bringing of a supply chain to the customers. Handle Transportation is an important supply chain driver. because Products are rarely produced and consumed in the same location. Transportation is the significant of the cost's incurred by most supply chain's.

Role of transportation:-

The Role of transportation is even more significant in global supply chains. Dell currently has suppliers world wide and sell's to customer's all over the world from just few plants. Transportation allow's products to move across Dell's global network. similarly global transportation allow's wall-mart to sell products manufactured all over the world. in the united states.

- Any supply chain success is closely linked to the appropriated use of transportation.

Ex:- Seven-Eleven Japan. company used transportation to achieve it's strategies goal's. company has a goal. of carrying product's in it's storage to match the customers as they vary by geographic location or time of day.

→ supply chain also use responsive transportation to centralize inventories and operate with fewer facilities.

Ex:- Amazon.com relias on package carriers and postal. system to deliver customer orders from centralized. warehouse.

- The shipper is the party that requires the movement of the product b/w two point's in the supply chain.
The carrier is the party that moves & transport's the product

Ex: Dell - shipper. UPS - carrier.

"Transportation network as a collection of nodes and links. Traffic originates and ends at nodes and travels on links. For most modes of transportation, infrastructure, such as ports, roads, waterways, and airports, is required both at the nodes and links. Most transportation infrastructure is owned and managed as a public good throughout the world.

- Transportation policy also aims to ~~provide~~ prevent ~~abuse~~ abuse of monopoly power, ~~&~~ promote fair competition and balance environmental, energy, and social concerns in transportation.

Factors affecting transportation decisions:-

1. Carrier (Party that moves (or) transports the products)
   - Vehicle-related costs, fixed operating costs, Trip-related costs
   - often incurs huge investments.
2. Shipper. (Party that requires the movement of the product b/w two points in the supply chain)
   - May need to balance transportation costs with inventory and facility costs.
3. Consignee (Party that receives the shipment)
   - may have certain responsiveness needs.
4. The owners of the infrastructure (ports, highways, railroads)
5. Govt / bodies that set worldwide transportation policy.

Modes of transportation and their performance characteristics:-

Sec. 03.

supply chain use a combination of the following Modes of transportation.

1. Air.
2. Package carriers.
3. Truck.
4. Rail.
5. Water
6. Pipe line
7. Inter & modal.

The effectiveness of any mode of transportation is affected by equipment investments and operating decisions by the carriers. as well as the available infrastructure. and transportation Policies. The carriers primary objective is to ensure good utilization of its assets while Providing customers with an acceptable level of service. carrier. decisions are affected by equipment cost, fixed operating cost, variable operating costs, The responsiveness the carrier. seeks to provide its target segment, and the prices that the market will bear.

AIR:-

Airlines have a high fixed cost in infrastructure and equipment, labor, and fuel costs are largely trip related and independent of the Number of passengers or amount of cargo carried on a flight.

An airline's goal is to maximize the daily flying time of a plane and the revenue generated/trip. ~~Given the large fixed costs and relatively low variable costs, revenue management is.~~

Air carriers offer a very fast and fairly expensive mode of transportation. Small, high-value items or item-sensitive emergency shipments that have to travel

along distance are best suited for air transportation. Air carriers normally move shipments under 500 pounds, including high-value but lightweight high tech products. (Given the growth in high technology, the weight of freight carried by air has diminished diminished over the last two decades even as the value of the freight increased some what.)

Key issues that air carriers face include identifying the location and number of hubs, assigning planes to routes, setting up maintenance schedules for planes, scheduling crews, & managing prices and availability at different prices

② Package carriers:-

Package carriers use air, truck, and rail to transport time-critical, smaller packages. Package carriers are expensive and cannot compete with LTL carriers on price for large shipments. The main service they offer shippers is rapid and reliable delivery. Thus shippers use package carriers for small and time-sensitive shipments. Package carriers also provide other value-added services that allow shippers to speed inventory flow and track orders status. By tracking orders, shippers can proactively inform customers about their packages. Package carriers also pick up the package from the source and deliver it to the destination site. With an increase in (J,T) deliveries and focus on inventory reduction, demand for package carriers has grown

Ex:- Dell, Amazon, etc business

Key issue in this industry includes the location and capacity of transfer points as well as information capability to facilitate and track package flow. For final delivery to a customer, an important consideration is the scheduling and routing of the delivery trucks.

Truck:

T-L operations relatively low fixed costs, and owning a few trucks is often sufficient to enter the business.

T-L pricing displays economics of scale with respect to the distance traveled. Given trailers of different size, pricing also displays economics of scale with respect to the size of the trailer used. TL shipping is suited for transportation b/w manufacturing facilities and warehouse & b/w suppliers and manufacturers.

→ T-L tends to be cheaper for large shipments. Prices display some economies of scale with the quantity shipped as well as the distance traveled.

→ Key issue of the LTL industry include location of consolidation centers, assigning of loads to trucks, and scheduling and routing of pickup and delivery.

→ Goal is to minimize costs through consolidation while having delivery time and reliability

Rail:

Rail carriers incurs incure a high fixed cost in terms of rails, locomotives, cars, and yards.

There is also a significant trip-related labor and fuel cost that is independent of the No. of cars but does vary with the distance traveled and the time taken. Any idle time, once a train is powered, is very expensive because labor, and fuel costs are incurred even though train is not moving.

(The price structure and the heavy load capability makes Rail an ideal mode for carrying large, heavy & high density products over long distances. + transportation time by rail, can be longer. Rail is thus idle for very heavy low-value shipments that are not very time sensitive. Coal, for ex is a major part of each Rail Roads shipments small, time-sensitive short distance & short + lead-time shipments rarely go by rail

Water:- and significantly delays occure at ports and terminals. This makes water transport difficult to operate for short haul trips.
Water transportation is ideally suitable for carrying very large loads at low cost. Water transportation is used primarily for the movement of large bulk commodity shipments and is the cheapest mode for carrying such loads. Slowest of all modes.

Pipeline:- typically operations are about 90% of pipe line capacity. Pipe line is best suitable when relatively stable and large flows are required. Sending gases or crude oil,

Intermodal:-

Intermodal transportation is the use of more than one mode of transport to move a shipment to its destination

Key issues in the intermodal industry involve the exchange of information to facilitate shipment transfers b/w different

Transportation refers to the movement of product from one location to another as it makes it's way from the Beginning of a supplychain to the customer's handle. ~~In this Exciting~~

Any supply chain's success is closely linked to the appropriate use of transportation. Wall-Mart has effectively used A responsive transportation system to lower it's transportation cost's.

Factors affecting Transportation decisions:-

1. The vehicle - Related is incurred whether the vehical is operating or not & is considered fixed for short term operational decision's By the carrier.
2. Fixed operating cost's is generally proportional to the size of operating facilities. This includes any cost associated with terminal's, Airport Gates & labor that are Incurred whether vehicles are operating or not.
3. Trip- Related cost includes the price of labour & Fuel Incurred for each trip Independent of the quantity transported
4. Quantity Related cost are loading/unloading cost's & A portion of the Fuel cost that varies with the quantity Being transported.
5. Over head cost Includes the cost of planning & scheduling A transportation Network as well as any investment In Information technology.

Modes because those transfers often involve considerable delays, hurting delivery time performance.

Design options for A transportation network:-

The design of a transportation network affects the performance of a supply chain by establishing the infrastructure within which operational transportation decisions regarding scheduling and routing are made. A well-defined transportation network allows a supply chain to achieve the desired degree of responsiveness at a low cost.

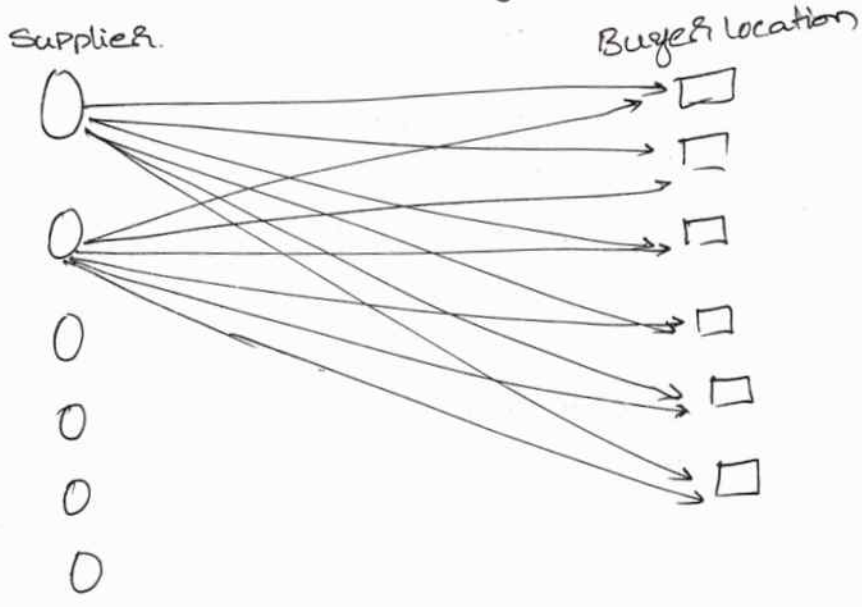
These design options may be implemented b/w any two stages of a supply chain.

1. Direct Shipment Network:- 2. Direct shipment with milk Runs:-

3. All shipments via central DC. 4. ~~Shipment~~ Shipping via DC using Milk Run's, 5. Tailored network.
~~using Milk Runs~~..

1. Direct shipment network:-

With the direct shipment network option the buyer structures has transportation network so that all shipment's come directly from each supplier to each buyer location.



With a direct shipment network the routing of each shipment is specified and the supplychain manager only needs to decide on quantity to ship and mode of transportation to use. This decision involves a trade-off b/w transportation & Inventory costs.

→ Major advantage of a direct shipment ~~is~~ transportation network is the elimination of intermediate warehouses and it's simplicity of operation and co-ordination.

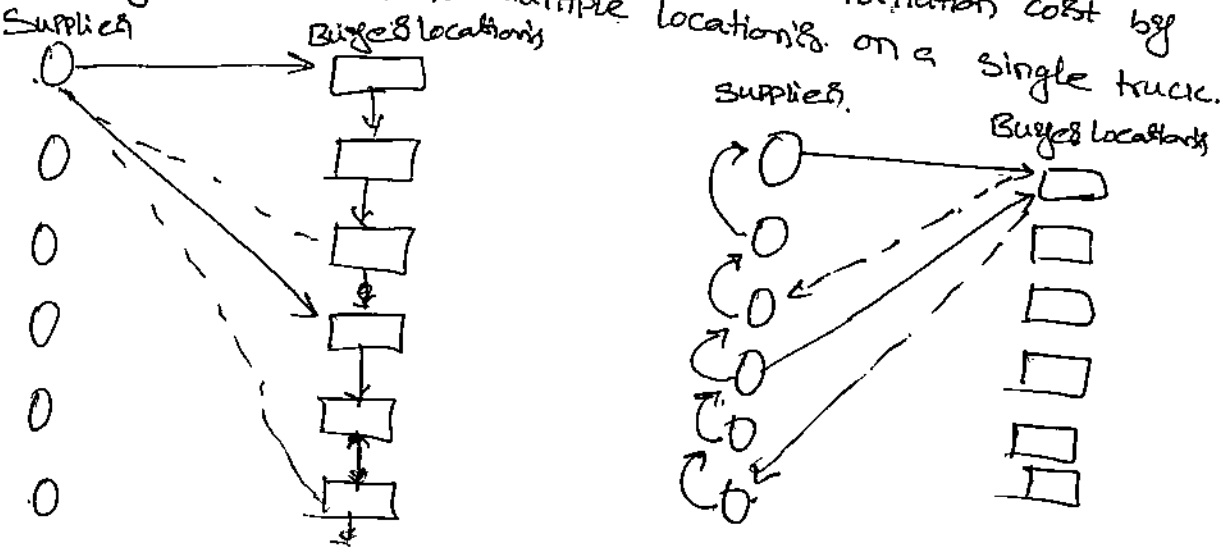
The decision made for one shipment does not influence others.
- The transportation time from suppliers to buyer location is short because each shipment goes direct.

- With small buyer locations, a direct shipment network tends to have high costs. If a TL carriers is used for transportation, the high fixed cost of each truck results in large lots moving from suppliers to each buyer location, resulting in high supply chain inventories. If a LTL carrier is used the transportation cost and the delivery time increase, Through inventories are lower. If package carriers are used, the transportation costs are very high.
- With direct deliveries from each supplier, receiving costs are high because each supplier must make a separate delivery.

Direct shipping with milk runs:-

A milk run is the route on which a truck either delivers products from a single supplier to multiple retailers or goes from multiple suppliers to a single buyer location.

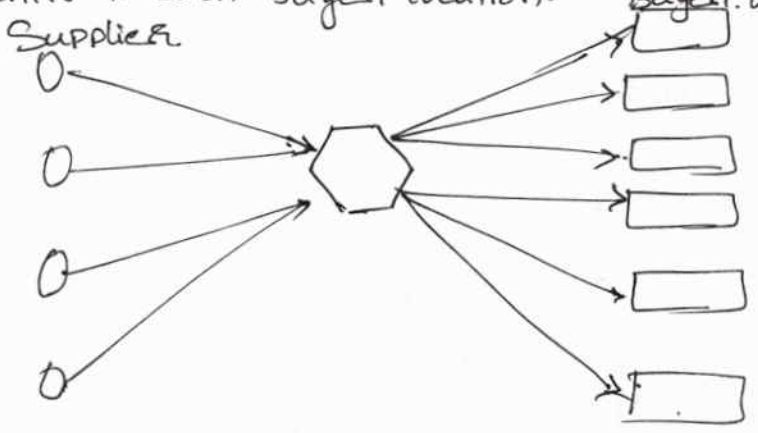
- In Direct shipping with milk runs, a supplier delivers directly to the multiple buyer locations on a truck or a truck picks up deliveries destined for the same buyer location from many suppliers. When using this option, a supply chain manager has to decide on the routing of each milk run.
- Direct shipping provides the benefit of eliminating intermediate warehouses, whereas milk runs lower transportation cost by consolidating shipments to multiple locations on a single truck.



Ex:- Toyota uses milk runs from suppliers to support it's JIT Manufacturing in both Japan and the united states. In Japan Toyota has many assembly plants located close together and thus uses milk runs from a single supplier to many plants.

All Shipments VIA Central DC :-

under this option suppliers do not send shipments directly to buyer locations. The buyer ~~dividing~~ divides locations by Geographic region and a DC is built for each region. suppliers send their shipments to the DC and the DC then forwards appropriate shipments to each buyer location.



The D.C is an extra layer between suppliers and buyer locations and can play two different roles. one is to store inventory and the other is to serve as a transfer location. → In either case, The → The Presence of DC's can help reduce supply chain cost when suppliers are located far from the buyer locations and transportation costs are high. ~~The~~

→ The Presence of DC allows a supply chain to achieve economies of scale for inbound transportation to a point close to the final destination, because each supplier sends a large shipment to the DC that contains product for all locations the DC serves. Because DC's serve locations ~~nearby~~ nearby, the outbound transportation costs are not very large.

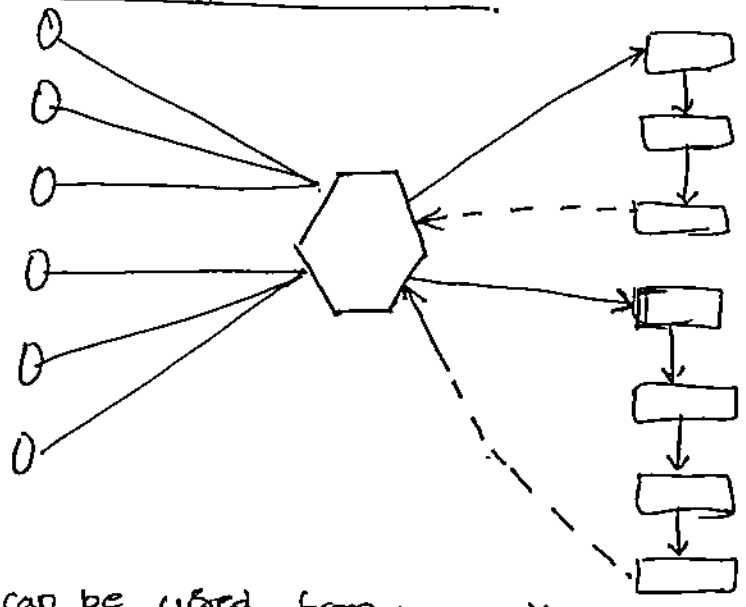
Ex:- W.W. Grainger has it's suppliers ship products to one of nine DC's ~~with~~ which in turn replenish their almost 400 branches

If transportation economies require very large shipments on the inbound side, DC's hold inventory and send product to buyer locations in smaller replenishment lots.

- cross-docking is appropriate for products with large, predictable demands and requires that DC's be set up such that economies of scales in transportation are achieved on both inbound and outbound sides.

→ As a result, the total lot size to all stores from each supplier fill's trucks on the inbound side to achieve economies of scale. on the outbound side, the sum of lot size from all suppliers to each retail store fills up the truck to achieve economies of scale.

Shipping via. DC using Milk Runs:-



Milk runs can be used from a DC if lot sizes to be delivered to each buyer location are small. Milk runs reduce ~~without~~ outbound transportation cost's by consolidating small shipments.

Ex: Seven-Eleven Japan cross-dock's deliveries from it's fresh-food suppliers at it's DC's and sends out milk runs to the retail outlet's because the total shipment to a store from all suppliers.

Tailored network:-

63, 381, 391, A1, 320, 98, 99, 86, 347, 375.

Tailored network operation is a suitable combination of previous operations. That reduces the cost and improves responsiveness of the supply chain. Here transportation uses a combination of cross-docking, milk runs and TL, LTL carriers, along with package carriers in some case.

The goal is to use the appropriate ~~effi~~ option in each situation, high-demand products to high-demand retail outlets may be shipped directly, where as low-demand products & shipments to low-demand retail outlets are consolidated to and from the DC.

- The complexity of managing this transportation network is high because ~~difficult~~ different shipping procedures are used for each product and retail outlet.

→ Operating a tailored network requires significant investment in information infrastructure to facilitate the co-ordination.

Such a network, however, allows for the selective use of a shipment method to minimize the transportation as well as inventory costs.

Trade-offs in transportation design:-

All transportation decisions made by shippers in a supply chain network must take into account their impact on inventory costs, facility and processing costs, the cost of co-ordinating operations, as well as the level of responsiveness provided to customers.

Ex:- Dell ~~its~~ using of Package carriers to deliver PC's to customers increases the transportation cost, but allow's Dell to centralize it's ~~facility~~ facilities and reduce inventory cost's. If Dell wants to reduce its transportation costs, the company must either sacrifice responsiveness to customers & increase the number of facilities and ~~reducing~~ resulting inventory's to move closer to customer's.

The cost of co-ordinating operation's is generally hard to quantify. Shippers should evaluate different transportation operations in term's of various costs as well as revenues and then rank them according to co-ordination complexity. A manager can then make the appropriate transportation decision.

Managers must consider the following trade-offs when making Transportation decisions

① → Transportation & Inventory cost trade-off
② → " & customer responsive trade-off.

① Transportation & Inventory Cost Trade-off:-

The trade-off b/w transportation & Inventory cost's is significant when designing a supply chain network. Two fundamental supply chain decision's involving this trade-off.

a. choice of transportation mode
b. Inventory aggrigation.

a. Choice of Transportation mode:-

For both decision's shipper must balance transportation and inventory cost's.

The mode of transportation that result's in ~~the~~ the lowest transportation cost doesn't necessarily lower total

Trade-off in Transportation ~~Design~~

Managers must consider the following trade off when making transport decisions:

1. Transportation and inventory cost trade off ← Choice of transportation mode / Inventory aggregation.
2. Transportation cost and customer responsiveness trade off.

Tailored Transportation:

1. Density to distance
2. Tailored transportation by size of customer.
3. Tailored transportation by product demand & value

~~total~~ cost's for a supply chain.

→ ~~eff~~ cheaper modes of transportation typically will have longer lead times and larger minimum shipment quantities. Both of which result in higher levels of inventory in the supply chain.

→ Modes that allow for shipping in small quantity lower Inventory level's. But tends to be more expensive.

* → When selecting mode of transportation, Managers must account ~~of~~ for cycle, safety, and in-transit inventory costs. That results from using each mode. Modes with high transportation cost can be justified if they result in significantly lower inventory cost:

(b) Inventory aggregation:-

Firms can significantly reduce the safety inventory they require by physically aggregating ~~inventory~~ inventories in one location. Most e-businesses use this technique to gain advantage over firms with facilities in many locations.

ex: Amazon.com has focused on decreasing it's ~~facilities~~ facility and Inventory cost by holding inventory in a

few warehouse, where as book sellers such as Borders and Barnes & Noble have to hold inventory in many retail stores. (inbound & out bound transportation cost)

Inventory aggregation is a good idea when inventory and facility costs from a large fraction of supply chin ~~cost~~ total costs. Inventory aggrigation is useful for products with a ~~large~~ large value-to-weight ratio and for products with high demand uncertainty.

ex:- Inventory aggrigation is very valuable for new products in the PC industry. Because PC's have a large value-to-weight ratio and demand for new product is uncertain.

- Inventory aggregation is also a good idea if customers orders are large enough to ensure sufficient economies of ~~sc~~scale on outbound transportation. When the products have a low ~~valu~~ value-to-weight ratio and customers orders are small. Inventory aggrigations may hurt a supply chain performance because of high transportation costs.

2. Trade ~~off~~ between transportation cost and customer responsiveness

The transportation cost a supply chain incurs a closely linked to the degree of responsiveness. The supply chain aims to provide. If a firm has high responsiveness and ships all orders within a day of receipt from the customers, It will have small outbound shipments results in a high transportation cost. If it decreases it's ~~order~~ responsiveness and aggregates order over a longer time horizon before shipping them out. It will be able to exploit economies of scale and lower transportation cost because large shipments.

temporal aggrigation is the process of combining orders across time. Temporal aggrigation decreases a firm's responsiveness & because a shipping delay but also decreases transportation cost ~~because of shipping delay but also decreases transportation cost~~. because of economies of scale that results

from large shipments. Thus a firm must consider trade off b/w responsiveness and transportation cost when designing its transportation network.

Tailored transportation:-

Tailored transportation is the use of different transportation network's and modes based on customer and product characteristic's. Most firms sell a variety of product's and serve many different customer segment's.

A firm can meet customer needs at a lower cost by using tailored transportation to provide the appropriate transportation choice based on customer and product characteristic's.

(a) Density and distance:-

A firm must consider customer density and distance from warehouse when designing transportation network. The ideal transportation option's based on density and distance.

Transportation options Based on customer Density and distance:-

	Short distance	Medium distance	Long distance
High density	Private fleet with milk run	Cross-dock with Milk Runs	Cross-dock with Milk Runs
Medium density	Third Party Milk Run	LTL carriers	LTL & Package carriers
low density	Third Party Milk Runs & LTL Carriers	LTL & Pacage carriers	Pacage car

(a) Tailored Transportation by Size of customers:-

Firms must consider customer size and location when designing transportation networks. Very large customers can be supplied using TL carriers, whereas smaller customers will require an LTL carriers or milk runs,

1. Transportation cost based on total route distance.
2. Delivery cost based on number of deliveries.

(c) Demand & value:-

Product type	High value	Low value
High demand :	Disaggregate cycle Inventory aggregate safety inventory Inexpensive mode of transportation for replenishing cycle inventory and fast mode when using safety inventory.	Disaggregate all inventory and use inexpensive Mode of transportation for replenishment
low demand.	Aggregate all inventory if needed. use fast mode of transportation for filling customer orders	Aggregate only safety Inventory use inexpensive mode of transportation for replenishing cycle Inventory

(b) A firm can Partition customers into Last & Medium & ~~Small~~ Small, based on the demand at each.

- ~~Optimum~~ Optimal. frequency of visits can be evaluated. If the large customers are to be visited every milk run, medium customers every other milk run's, low demand customers every three m.r.

Suitable MilkRuns can be ~~evaluated~~ designed by combining large, Medium, Small. (L, M, S_1) $(L, M_2 S_2)$ $(L M_1 S_3)$ $(L, M_2 S_1)$ $(L, M_1 S_3)$ $(L, M_2 S_3)$

This tailored Secuence has the advantage that each truck carriers about the same load and larger customers and provided more frequent delivery than Small ~~customers~~ customers.

consistent with their relative costs of delivery.

Role of Pricing in and Revenue management in a supply chain :-

Pricing is an important lever to increase supply chain profits. by better matching supply and demand. Pricing influences the amount of product demand and the total revenue generated.

Revenue management is the use of pricing to increase the profit generated from a limited supply of supply chain assets. Supply chain assets exist in two forms. → Capacity
→ Inventory.

- Capacity assets in the supplychain exist for production, transportation and storage.
- Inventory assets exist throughout the supply chain and are carried to improve product availability.

To increase the total margin earned from these assets, managers must use all available ~~levels~~ levers, including price. This is the primary role of revenue management. Traditionally firms have often invested in & eliminated assets to reduce the imbalance between supply and demand.)

Firms build additional capacity during the growth part of a business cycle and shut down some capacity during a ~~downfall~~ downturn.

Ideas from revenue management suggest that a firm should first use pricing to achieve some balance b/w supply and demand and only then invest in & eliminate assets.

- using revenue management a firm would seek to do much more ① one approach is to charge a lower price to customers willing to commit their orders far in advance and a higher price to customers looking for transportation capacity at the last minute.

(2)

- Another approach is to charge a lower price to customers with long term contracts and high price to customers looking to purchase capacity at the last minute.
- Third approach is to charge a higher price during periods of high demand and lower prices during periods of low demand.

(1) ⇒

- Revenue Management adjusts the pricing and available supply of assets to maximize profits. Revenue Management has a significant impact on supply chain profitability when one or more of the following four conditions (for R.M.) exist:
  1. The value of the product varies in different market segments.
  2. The product is highly perishable & product wastage occurs
  3. Demand has seasonal and other peaks.
  4. The product is sold both in bulk and on the spot market.

→ ~~R.M. is the use of pri~~

- Simply R.M. may also be defined as offering different prices based on customer segment, time of use and product & capacity availability to increase supply chain profits.

(1) → R.M. for multiple customer segments

- If the supplier serves multiple customers segments with a fixed asset, the supplier can improve revenue by setting different prices for each segment.
  → Must figure out customer segments.
- → Price must be set with barriers such that the segment willing to pay more is not able to pay the lower price
  Barriers:- Time, location, prestige, inconvenience, extra service

RM for Perishable assets:-

Any assets, that loses value over time is Perishable

Eg:- high-tech products. such as computers, and cell phones, high fashion apparel, underutilized capacity, fruits and vegetables., pharmaceuticals are Perishable.

Eg:- Dell uses RM → year is divided into Eight sales cycles of about two weeks. once the sales

Two basic approach:- 1.

Dynamic Pricing:- Vary price over time to maximize expected revenue limited capacity, Demand variability, seasonality in demand pattern, short planning horizon.

Overbooking : overbook sales of the assets to account for cancellations.

Overbooking or overselling of a supply chain asset is valuable if orders cancellations occurs and the asset is Perishable.

Level of over booking is trade off b/w the cost of wasting the assets if too many cancellations leads to unused assets (Spoilage) and the cost of arranging a backup (offload) if too few cancellations lead to committed orders being larger than the available capacity.

RM. for Seasonal demand:-

Seasonal peaks of demand are common in many sc's.

- Most retailers achieve a large portion of total annual demand in Decembers.
- off-Peak discounting can shift demand from Peak to non Peak periods.
- charge higher price during Peak periods and a low price during off-Peak periods.

RM for Bulk and Spot customers:

Most consumers of production, warehousing and transportation assets, in a supply chain face the problem of constructing a portfolio of long-term bulk contracts, and short term spot market contracts

- long-term contracts for low cost
  short " " flexibility

~~Based on~~

The Basic decision is the size of the bulk contract. The fundamental trade-off is b/w wasting a portion of the low cost bulk contract and paying more for the asset on the spot market.

~~X~~ (1) ~~<~~

All of these, RM strategies that use Differential pricing as a critical Level to Maximize Earnings.

RM may also be Defined as the use of Differential pricing Based on customer segmentation of use, and product & capacity availability to increase supply chain surplus.

22/2. 9, 19, 23, 45, 13, 53, 55,

UNIT - IV

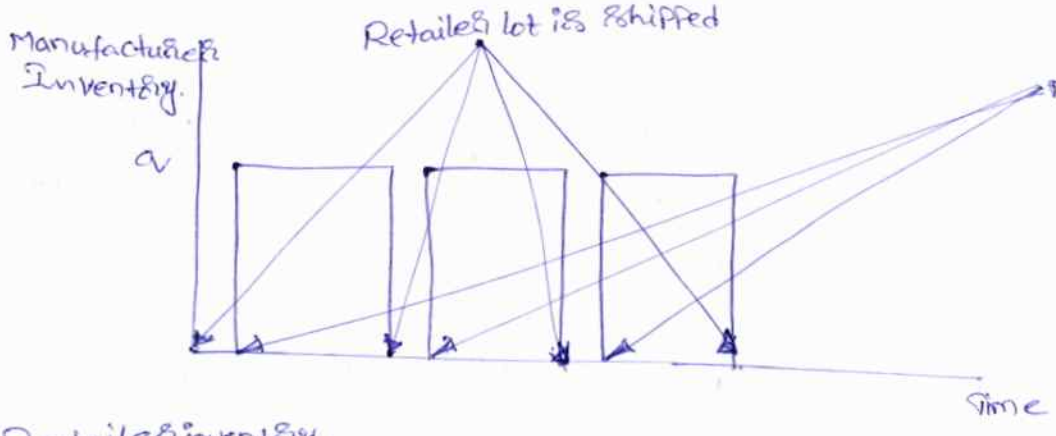
Planning and Manging Inventories in a Supply chain

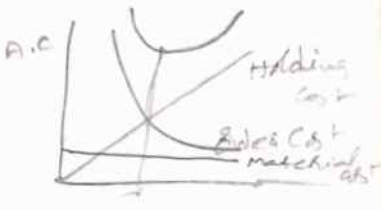
Managing Multi-echelon cycle inventory:

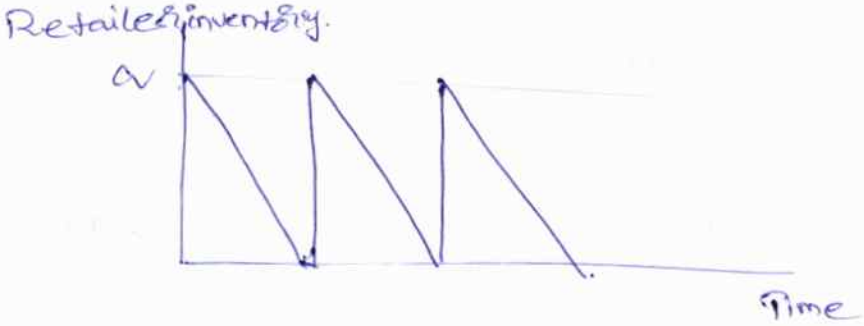
In multiechelon supplychain has muliples stages and Possibly many players at each stage. The lack of co-ordination in lot sizing decisions across the supplychain results in high cost and more cycle inventory than reauried.

"The goal in a multiechelon system is to decrease total costs by co-ordinating orders across the supplychain.

consider a simple multiechelon system with one manufacturer - supplying one retailer. Assume that production is instantaneous. So the manufacturer can produce a lot when needed. if the two stages are not synchronized. The manufacturer may produce a new lot of size Q right after shipping a lot of size Q to the retailer. In this case R Retailer carries an average inventory of Q/2 the manufacturer carries an average inventory of about Q.







For a simple multiechelon supply chain with only one player at each stage, ordering policy in which the lot size at each stage is an integer multiple of the lot sizes at it's immediate customer have been shown to be quite close to optimal. when lot sizes are integer multiples, co-ordination of orders across stages allows for a Potential Portion of the delivery to a stage to be cross-docked on to the next stage.

The extention of cross dock depends on the ratio of the fixed ordering 's' and holding cost 'i' at each stage. The closer this ratio is between two stages the higher is the optimal percentage of cross-docked product.

If one party (distributor) in a supply chain supplies multiple parties (retailers) at the next stage of the supply chain, it is important to distinguish retailers with high demand from those with low demand. If retailers are grouped such that all retailers in one group order together and for a retailer, either the ordering frequency is an integer multiple of the ordering frequency at the distributor. or (the ordering frequency at the distributor is an integer multiple of the frequency at the retailer)

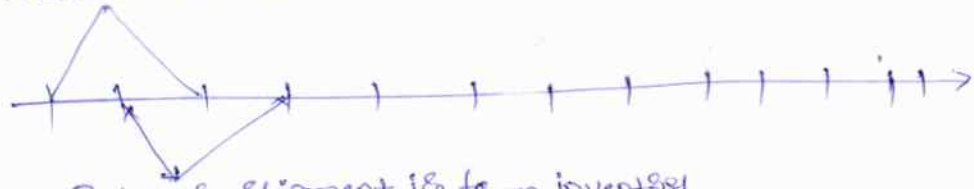
- An integer replenishment policy has every player ordering periodically, with the length of the reorder interval for each player an integer multiple of some base period.

Ex:- The distributor places a replenishment order at every two weeks

Distributor Replenishment order arrives.

Distributor replenishment every two weeks

Retailer shipment is cross-docked.



Retailer replenishment every week

Retailer shipment is from inventory.

Retailer shipment is cross docked

Retailer replenishment every two weeks

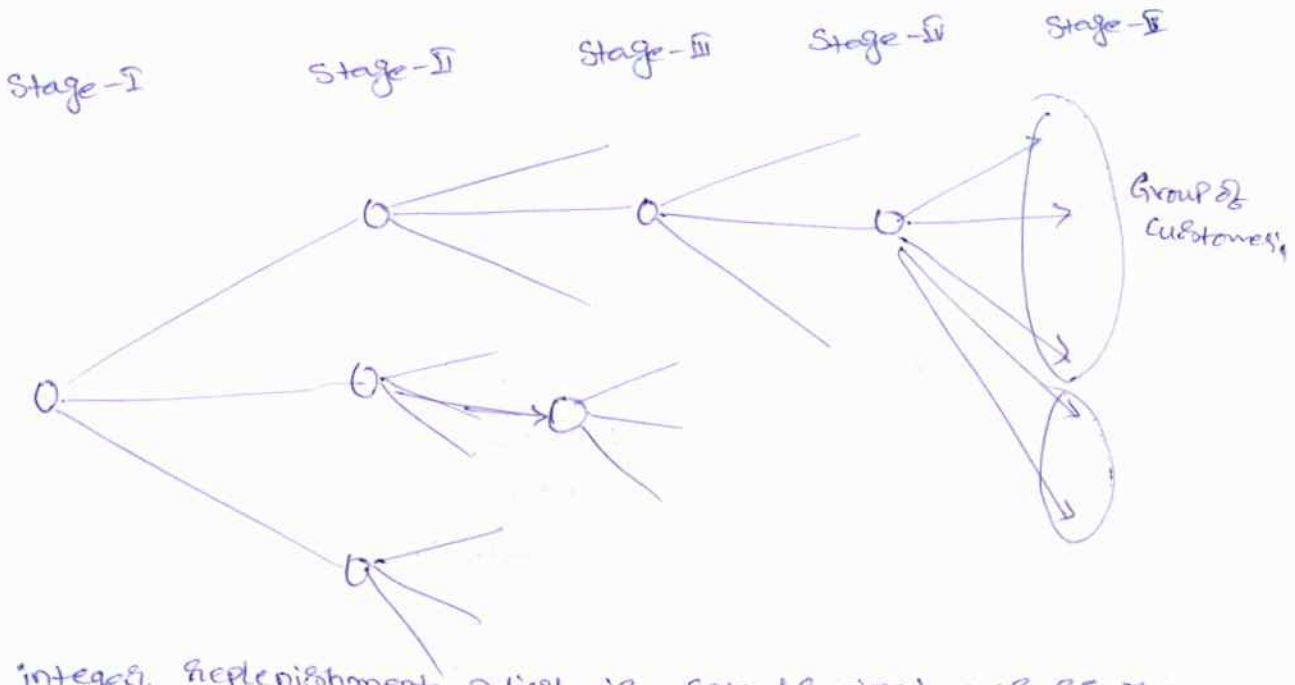
Retailer shipment is cross-docked.

Retailer replenishment every 4 week

Some retailers place replenishment orders every week and others two or four weeks. observe → That for retailers ordering more frequently ~~than~~ than the distributor, ~~the~~

→ The retailer's ordering frequency is an integer multiple of the distributor's frequency.

→ For retailer's ordering less frequently than the distributor, the distributor's ordering frequency is an integer multiple of the retailer frequency.



If an integer replenishment policy is synchronized across the two stages, the distributor can cross-dock part of it's supply on the next stage. All shipments to retailers ordering no more frequently than the distributor are cross-docked. For retailer ordering more frequently than distributor. half the orders are ~~cross~~ cross-docked, with the other half shipped from inventory.

→ Integer ~~multi~~. replenishment policies for the supply chain can be summarized as follows.

① Divide all parties within a stage into groups such that all parties within a group order from the same supplier and have the same reorder interval.

② Set reorder interval's across stages such that the receipt of a replenishment order at any stage is synchronized with the shipment of a replenishment order to at least one of its customer. The synchronized portion can be cross-docked.

(5) For customers with a longer reorder interval than the supplier. Make the customer's reorder interval an integer multiple of the supplier's interval and synchronize replenishment at the two stages to facilitate cross-docking. In other words, a supplier should cross-dock all orders from customers who reorder less frequently than the supplier himself.

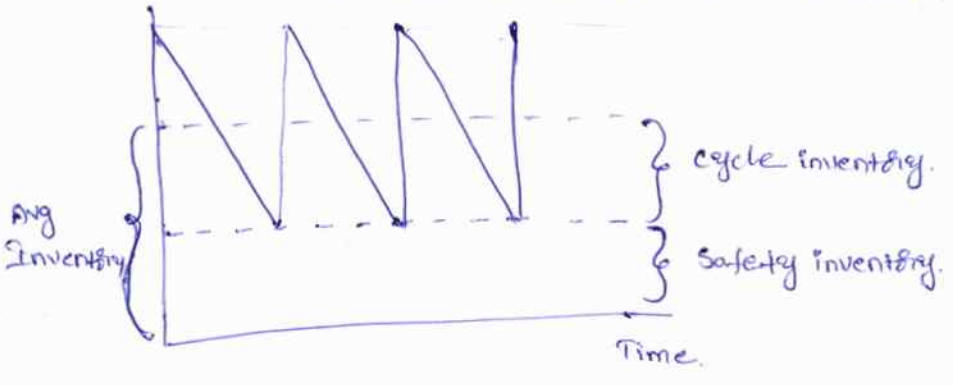
6. For customers with a shorter reorder interval than the supplier. Make the supplier's reorder interval an integer multiple of the customer's interval and synchronize replenishment at the two stages to facilitate cross docking

5. The relative frequency of reordering depends on the setup cost, holding cost, and demand at different parties.

Integer replenishment policies can be synchronized in multiechelong supply chain's to keep cycle inventory and order cost low. under such policies, the reorder interval at any stage is an integer multiple of a base reorder interval. Synchronized integer replenishment policies facilitate a high level cross-docking across the supply chain.

The Role of Safety inventory in supply chain:-

Safety inventory is inventory carried to satisfy demand that exceeds the amount forecasted for a given period. Safety inventory is carried because demand is uncertain and a product shortage may result if actual demand exceeds the forecast demand.



For any supply chain there are two key questions to consider. when planning a safety inventory.

→ Gucci, Prada.
→ Dell., compaq
→ Amazon,

1. What is the appropriate level of safety inventory to carry?
2. What actions can be taken to improve product availability while reducing safety inventory.

Determining Appropriate level of Safety inventory:

Appropriate level of safety inventory is determined by following two factors

1. uncertainity of both demand and supply.
2. desired level of Product availability.

A uncertainity of supply & demand grows the required level of safety inventory increases.

Ex:- Sale's of Palm Personal digital ~~Sta~~ assistants at B&M office Supplies.

1. ~~Manag~~Measuring demand uncertainity.
2. Measuring Product availability
   a) Product fill rate (f_r)
   b) Order fill rate (o_r)
   c) cycle Service level(CSL)
3. Replenishment Policies.
   a) continuous review
   b) Periodic review.
4. Evaluating cycle Service level(CSL) and Fill rate. Given Replenishment Policy.
   a) Evaluating Safety inventory Given by Replenishment Policy.
   b) evaluating cycle Service level ~~in~~ a given a Replenishment Policy
   c) Evaluating Fill rate given a Replenishment Policy.
5. Evaluating Safety inventory Given desired cycle service level & Fill rate
   (a) Evaluating Safety inventory Given desired ~~cycle s~~ CSL
   (b) " " " " Fill rate
6. Impact of desired Product availability and uncertainity on Safety inventory.

6(a) Reduce suppliers lead time

6(b) Reduce the underlying uncertainity of demand.

1) Measuring the demand uncertainity:-

demand has systematic as well as random component

⇒ The goal of forecasting is to predict the systematic component and estimate the random component.

The random component is usually estimated as the standard deviation of forecast error.

- ✓ D = Avg demand / period
- ✓ σ_D = Standard deviation of demand / period

✓ Lead time is the gap b/w when an order is placed and when it is recived. In this case uncertainity of demand during it's lead time 'L'

✓ → It is denoted the lead time by 'L'

Di. evaluating distribution of demand for K. period

✓ demand for each period i, $i = 1, \ldots L$ is normally distributed with mean D_i, Standard deviation σ_i

✓ ρ_{ij}: correlation co-efficient of demand b/w periods i & j

~~Standard deviation of~~

~~$P = D_L = \sum_{i=1}^{L} D_i$ Ω :~~

Total demand during 'L' periods is normally distributed with a mean 'P' and Standard deviation of Ω

$$P = D_L = \sum_{i=1}^{L} D_i$$

Standard deviation of Ω : $\sqrt{\sum_{i=1}^{K} \sigma_i^2 + 2 \sum_{i>j} \rho_{ij} \sigma_i \sigma_j}$

Demand for two periods:- +ve correlate : if $\rho_{ij} = 1$

-ve correlate $\rho_{ij} = -1$

independent $\rho_{ij} = 0$

Assume that demand during each of L periods is independent and normally distributed with a mean of D and standard deviation of σ_D

Total demand during L periods Normal distribution with Mean D_L Standard Deviation of σ_L

$$D_L = LD \qquad \sigma_L = \sqrt{L}\sigma_D \rightarrow (1)$$

→ Another Measure of uncertainity is coefficient of variation (CV)

$$CV = \sigma/\mu \quad \frac{\text{Standard deviation}}{\text{mean}}$$

Co-efficient of variation (cv) measures the size of the uncertainity relative to demand.

② Measuring Product availability. → ability to fill a customers order out of available inventory. A stockout occurs if a customer order arrives when product is not available.

Product fill rate: (f_r) is the fraction of product demand that is satisfied from product in inventory.

→ fill rate should be measured over a specified amount of demand rather than time.

→ it is measured fill rate over every million units of demand rather than every month.

* → Fill rate is equivalent the probability that product demand is supplied from available inventory.

② Order fill rate:- It is the fraction of orders that are filled from available inventory.

→ order fill rate should also be measured over a specified number of orders rather than time.

→ In a multiple product scenario an order is filled from inventory.

→ Order fill rate tends to be lower than (e.g.: Godrej, calicut) product fill rates because all products must be in stock for an order to be filled.

Product fill rate (f_r) and order fill rate. is usually not significant in a single product situation. when the firm is selling multiple no of products. There difference may be significant to products → shipped, an out-of-stock situation. one product is not being filled from stock. The firm in this case may have a poor order fill rate even it has good product fill rate.

(c) Cycle Service level (CSL):- It is the fraction of replenishment cycles that end with all the customer's demand being ~~not~~ met.

- A replenishment cycle is the interval between two successive replenishment deliveries.

* - The CSL is equal to the probability of not having a stock out in a replenishment cycle.

- CSL can be measured ~~with~~ over a specified numbers of replenishment cycles.

3. Replenishment Policies:-

A replenishment policy consists of decisions regarding when to reorder and how much to reorder.

These decisions determines the cycle and safety inventory along with the fr and CSL

→ 2 types

(a) continuous review
(b) Periodic review

(a) → Inventory is continuously tracked and an order of a lot size 'Q' is placed when the inventory declines to the reorder point (ROP)

- In this case size of order does not change ~~for~~ from one order to the next time b/w orders.

(b) Inventory ~~set~~ status is checked at regular periodic intervals and an order is placed to raise the inventory level at specified ~~threshol~~ periods.

→ In this case time b/w orders is fixed, the size is not fixed.

4. Evaluating cycle service level and Fill Rate Given a Replenishment Policy:

✓ In this we restrict our attention to continuous review policy.

→ The replenishment policy consists of a lot size 'a' ordered when the inventory on hand declines to the ROP. Assume that weekly demand is normally distributed with mean D and standard deviation σ_D & assume that lead time 'L' weeks

(a) Evaluating Safty inventory Given a Replenishment Policy:-

Safty invent. corresponds to the average number of product on hand when a replenishment order arrives.

Given lead time of L week's

mean weekly demand D.

✓ Expected demand during lead time = DL ✓

→ Store manager places a replenishment order when ROP products are on hand.

* Safety inventory, ss = ROP − DL. *

(b) Evaluate CSL Given Replenishment Policy:-

✓ our goal is to evaluate CSL, Probability of not stocking out in a replenishment cycle.

CSL = Prob(demand during lead time of L weeks ≤ ROP)

→ lead time L week's and weekly demand is normally distributed with a mean D and Standard deviation of σ_D)

→ observe that a stockout occurs in a cycle demand during lead time is larger than ROP.

Demand during lead time is normal distributed with mean of D_L and Standard deviation σ_L from eq. ①.

CSL = $F(ROP, D_L, \sigma_L)$

Evaluating Fill Rate Given a Replenishment Policy:-

~~Our discussion focuses on evaluating fill rate for a firm~~
Our discussion focuses on evaluating fill rate for a continuous review policy under which 'Q' units are ordered when the quantity on hand drops to the ROP.

→ ~~To evaluate the fill rate~~

→ A stockout occurs if the demand during the lead time exceeds the ROP. We need to evaluate the average amount of demand in excess of the ROP in each Replenishment cycle.

→ Expected Shortage / Replenishment cycle (ESC)

$$f_r = 1 - ESC/Q = \frac{(Q - ESC)}{Q}$$

Let $f(x)$ be the density function of the demand distribution during lead time

$$ESC = \int_{x=ROP}^{\infty} (x - ROP) f(x) dx$$

demand during lead time is normally distributed with mean D_L

Standard deviation σ_L, Safety Inventory = SS

$$ESC = -SS\left[1 - F_S\left(\frac{SS}{\sigma_L}\right) + \sigma_L f_S\left(\frac{SS}{\sigma_L}\right)\right]$$

F_S = Standard Normal cumulative distribution function

f_S = " " density function.

$$ESC = -SS\left[1 - NORM\,DIST\,(SS/\sigma_L, 0, 1, 1)\right] + \sigma_L\,NORM\,DIST\,(SS/\sigma_L; 0, 1; 0)$$

Excel equalti

Key Point :- Both fill Rate and cycle Service level increase as the Safety inventory is increased. For the Same safety inventory an increase in lot size increase the fill Rate but the cycle Serive level.

5. Evaluating Safety inventory Given desired cycle (CSL) Service level & Fill Rate:

Firm have a desired level of Product availability and want to design Replenishment Policies that achieve this level.

Ex:- Wal-Mart has a desired level of Product availability for each Product Sold in a Store. The Store Manager Must design a Replenishment policy with the appropriate level of Safety Inventory to meet this goal.

5(a) Evaluating Required Safety Inventory given desired cycle Service level.

our goal is to obtain the appropriate level of safety inventory given the desired CSL. we assume that continues Review Replace Ment Policy is followed.

Ex: Consider a Wall Mart Store Manager at Wall-Mart responsible for designing Replenishment policies for all Product's in the Stores.

→ The Store's Manager wants to identify a suitable ROP and safety Inventory to achive the desired CSL.

Desired Service level = CSL (Find)

Mean demand during lead time: D_L

Standard deviation of demand during lead time: σ_L

$$ROP = D_L + SS$$

SS: safety inventory

Probability (demand during lead time $\leq D_L + SS$) = CSL

$$F(D_L + SS, D_L, \sigma_L) = CSL$$

$$D_L + SS = F^{-1}(CSL; D_L, \sigma_L)$$

$$SS = F^{-1}(CSL, D_L, \sigma_L) - D_L$$

$SS = F_S^{-1}(CSL) \times \sigma_L$

5(b) Evaluating Required Safety inventory Given Desired Fill Rate :-

~~we now evaluate~~ the required safety inventory given a desired fill rate (f_r) and the fact that a continuous review replenishment ~~plan~~ policy is followed. ~~For~~ consider a ~~store~~ manager at wall mart targeting a fill rate of f_r ~~%~~

→ The current Replenishment lot size is ⊖ first step is to obtain the expected shortage per replenishment cycle (ESC)

Expected ~~shortages~~ / Replenishment cycle = ~~ESC~~

$$ESC = (1 - f_r)Q$$

Safety inventory. SS

$$ESC = SS\left[1 - F_S\left(\frac{SS}{\sigma_L}\right) + \sigma_L f_S\left(\frac{SS}{\sigma_L}\right)\right]$$

(6) Impact of Desired Product availability and Uncertainty on Safety inventory :-

As desired Product availability goes up, the required safety inventory also increases because the supply chain must ~~be~~ now be able to accommodate ~~time~~ uncommonly high demand & uncommonly low supply.

(5) The goal of supply chain Manager is to reduce the level of safety inventory required in a way that does not adversely affect ~~avail~~ Product availability.

(1) The required safety inventory grows rapidly with an increase in the desired Product availability.

(2) The required safety inventory increases with an increase in the lead time and the standard deviation of Periodic demand.

1. Reduce the Supplier Lead time L:

If lead time decreases by a factor of 'k' the required safety inventory decreases by a factor of $\sqrt{k}$

Reducing the supplier lead time requires significant effort from the supplier, where as ~~direct~~ Reduction in safety inventory occurs at the retailer.

⇒
- The benefit has manifested itself in the form of reduced safety inventory.

Eg: Seven-Eleven Japan, tremendous reliance of suppliers to reduce the lead time.

2. Reduce the underlying uncertainty of demand (σ_D) :-

if σ_D is reduced by a factor of k, the required safety inventory also decreases by a factor of 'k'

The reduction in σ_D may be achieved by better Market intelligence and the use of more sophisticated forecasting methods.

→ This Market intelligence allows the Stores Managers to make better forecasts, reducing uncertainity. In most supply chains

⇒ The key to reducing the uncertainity is to link all forecasts to the underlying forecast.

Throughout the supplychain to customers demand data. A lot of The demand uncertainity exist only because each stage of supply chain plans and forecasts independently.

This distorts demand throughout the supply chain, increasing uncertainty. Smoothed to Stabilization.

The importance of the level of Product availability:-

The level of product availability is measured using the cycle service level & the fill rate, which are metrics for the amount of customer demand satisfied from available inventory.

The level of product availability, also refered to as the customer service level, is one of the primary measure of a supplychain's responsiveness. A supplychain can use a high level of product availability to improve it's responsiveness and attract customers. Thus increasing revenue for the supply chain. However high level of product availability requires large inventories, which raises supply chain costs.

∴ The supplychain must achieve a balance between the level of availability and the cost of inventory. The optimal level of product availability is one that maximizes supplychain profitability.

Factors Affecting optimal level of product availability:-

Cost of overstocking the P

① Cost of overstocking the Product
② cost of understocking the Product.

The optimal level of product availability, consider L.L.Bean a large Main-Order company that sells apparel. one of the product's L.L.Bean sells is ski jackets. The selling season for ski-jackets is from November to February. The buyer at L.L.Bean currently purchases the entire season's supply of ski jackets from the manufacturer before the start of the selling season. Providing high level of product availability requires the purchase of a large number of jackets.

Although a high level of product availability is likely to satisfy all demand that arises, it is also likely to result in a large number of unsold jackets at the end of the season, with L.L.Bean losing money on unsold jackets.

In contrast. a low level of Product availability is likely to result in few unsold Jackets. However, it is quite likely That L.L. Bean will have to turn away customers willing to buy Jackets because they are sold out in this scenario. L.L. Bean loses potential profit by losing customers.

→ The buyer at L.L. Bean must balance the loss from having too many unsold Jackets and the lost profit from turning away customers. when deciding the level of product availability.

→ cost of overstocking = C_o

~~cost of understocking~~

cost of understocking = C_u

The two key factors that influence the optimal level of Product availability are

1. cost of overstocking the product
2. cost of understocking the product

L.L. Bean has a buying committee that decides on the quality of each product to be stocked. Based on demand over the past few years.

P_i is the probability that demand equals D_i

P_i is the probability that demand is less than or equal to D_i

Expected demand = $\sum D_i P_i$ = 1,026

Table 1

Demand distribution for Parkas at L.L. Bean

Demand Di (i)	Probability (Pi)	cumulative Probability of demand Being Di or less (Pi)	Probability of demand Being Greater than Di
4	0.01	0.01	0.99
5	0.02	0.03	0.97
6	0.04	0.07	0.93
7	0.08	0.15	0.85
8	0.09	0.24	0.76
9	0.11	0.35	0.65
10	0.16	0.51	0.49
11	0.20	0.71	0.29
12	0.11	0.82	0.18
13	0.10	0.92	0.08
14	0.04	0.96	0.04
15	0.02	0.98	0.02
16	0.01	0.99	0.01
17	0.01	1.00	0.00

under the old policy of ordering the expected value. The buyer would have ordered 1000 Parkas.

from table 51% probability that demand will be 1000 or less.

The policy of ordering is 1000 parkas results in cycle service level of 51% at L.L. Bean.

V → Buyer committee must decide an order size & CSL that Maximize the profits.

~~Each Parkas cost (c) = 45~~

each Parkas costs L.L. Bean (c) : $45 is priced in the catalog at P = $ 100.

any unsold Parkas at the end of the season are sold at the outlet store for Rs 50.

Holding the Parka in inventory and transporting it to the outlet store cost L.L. Bean Rs 10. Thus L.L. Bean recovers as salvage value of s = Rs 40.

Each Parka, it sells and incurs is unsold at the end of the season. L.L. Bean makes a profit of

P − C = R. 55 on each Parka it sells and incurs a loss of C − S = Rs 5 on each unsold Parka. That it send to outlet store

Expected profit from ordering a thousand Parkas.

$$= \sum_{i=4}^{10} \left[D_i (P-C) - (1000 - D_i)(C-S) \right] p_i + \sum_{i=11}^{17} 1000 (P-C) p_i.$$

$$= \text{Rs } 49,900$$

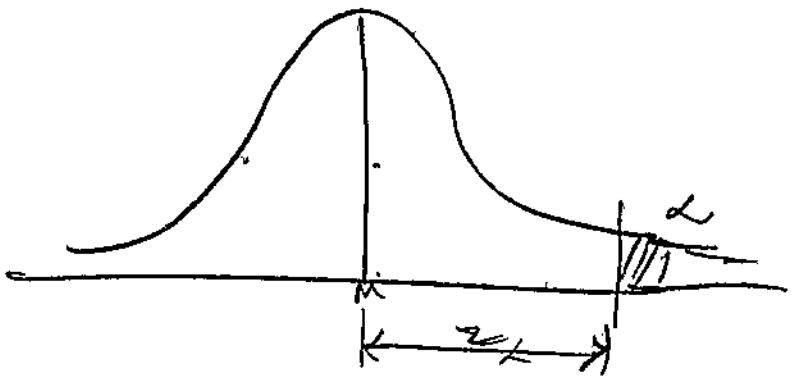
CSL = The Probability That There will be no stockout during a cycle

Item Fill Rate (Fr) The proportion of total demand. Met with available inventory

$CSL = 1 - \alpha$

α = Probability of stock out during a cycle

Eg: if $\alpha = 5\%$ $CSL = 95\%$



Product A

No of stock outs: 3, No of cycles = 12

CSL = Probability of no of stock out in cycle = $9/12 = 75\%$

total demand = 1900 units Total supply = 1820 units

Fill Rate = Proportion of total demand met = $\frac{1820}{1900} = 95.79\%$

To decide whether to order 1,100 Parkas, the buying committee must determine the impact of buying the extra 100 units

if 1,100 Parkas are ~~ordered~~ ordered, the extra 100 is sold. (for a profit of 5,500) if demand is 1,100 or higher. Otherwise the extra 100 units are sent to the outlet stores at loss of 500. from the table we see that there is a probability of 0.49 the demand is 1,100 or higher. and a 0.51 probability that demand is 1000 or less. We deduce the following.

Expected Profit from the extra 100 Parkas:

$$= 5,500 \times \text{Prob}(\text{demand} \geq 1,100) - 500 \times \text{Pro}(\text{demand} \leq 1,100)$$

$$= 5500 \times 0.49 - 500 \times 0.51$$

$$= 2,440$$

Total expected Profit from ordering 1,100 Parkas. is Thus 52,340.

Expected Marginal contribution of Each Additional 100 Parkas:-

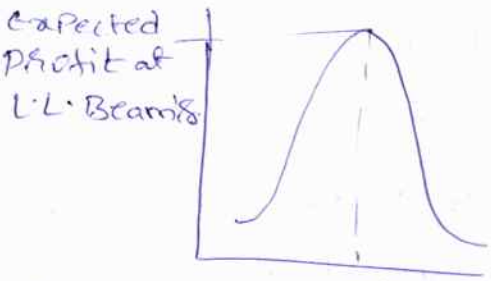
Additional ~~100's~~ Hundred's.	Expected Marginal Benefit	Expected Marginal cost	Expected marginal contribution
11.	5,500 × 0.49 = 2695	500 × 0.51 = 255	2695 − 255 = 244
12	5,500 × 0.29 = 1595	500 × 0.71 = 355	1595 − 355 = 1,240
13	5,500 × 0.18 = 990	500 × 0.82 = 410	990 − 410 = 580
14	5,500 × 0.08 = 440	500 × 0.92 = 460	440 − 460 = −20
15	5,500 × 0.04 = 220	500 × 0.96 = 480	220 − 480 = −2
16	5500 × 0.02 = 110	500 × 0.98 = 490	110 − 490 = −38
17.	5500 × 0.01 = 55	500 × 0.99 = 495	55 − 495 = −44

from the table
The expected marginal contribution is +ve up to 1,300 Parkas. but it is − ve from that point on Thus the optimal order size is 13000 Parkas.

Expected Profit from ordering 1300 Parkas = ~~49,900 + 2440~~

49,900 + 2,440 + 1,240 + 580 = 54,160.

The optimal order quantity is 1,300 packets, which provides, which provides a CSL of 92 percent.



~~L.L. Bean achieves fill rate of 100%~~
~~is much higher.~~

⇒ If demand is over 1,300, part of demand (D − 1300) is not satisfied.
in this case a fill rate of $1300/D$ is achieved.

$$f_2 = 1 \times \text{Prob}(\text{demand} \leq 1{,}300) + \sum_{D_i > 1300} (1{,}300/D_i)\, P_i$$

$$= 0.99.$$

Optimum Level of Product availability

1. Optimal cycle service level for seasonal items with a single order in a season
2. one-time orders in the presence of quantity discounts
3. Desired cycle service level for continuously ~~stocked~~ stocked items.
4. Demand during stockout is Backlogged.

1. Optimal cycle service level for seasonal items with a single order in a season :-

In this section we focus attention on seasonal products such as ski jackets. for which all left over items must be disposed of at the end of the season. The assumption is that the leftover items from the previous season are not used to satisfy demand for the current season.

P = Retail price / unit
c = cost / unit
S = Salvage value.

C_o = cost of overstocking by one unit = $c - s$

C_u = cost of understocking by one unit. = $p - c$

CSL^* = optimal cycle service level

O^* = corresponding optimal order size

→ CSL is the probability that demand during season will be at or below O^*

At the optimal cycle service level CSL^* the marginal contribution of purchasing an additional unit is zero.

if order quantity is raised from O^* to O^*+1 the additional unit sells if demand is larger than O^* this occurs with probability $1 - CSL^*$ and results in a contribution of $p-c$

Expected benefit of purchasing extra unit = $(1-CSL^*)(p-c)$

→ The additional unit remains unsold if demand is at or below O^*

this occurs with probability CSL^* and results in a cost of $c-s$

Expected cost of purchasing extra unit = $CSL^*(c-s)$

→ The expected marginal contribution of raising the order size from O^* to O^*+1 is given by

$$(1-CSL^*)(p-c) - CSL^*(c-s)$$

→ Expected marginal contribution must be '0' at the optimal cycle service level.

$$CSL^* = \text{Prob}(\text{Demand} \le O^*) = \frac{p-c}{p-s} = \frac{C_u}{C_u+C_o} = \frac{1}{1+(C_o/C_u)} \longrightarrow (1)$$

$$O^* = F^{-1}(CSL, \mu, \sigma) = \text{NORMINV}(CSL, \mu, \sigma) \longrightarrow (2)$$

The optimal order quantity maximizes Firm's profit. If demand during the season is normally distributed, with a mean of μ and a standard deviation of σ The optimal order quantity is given by.

(demand is normally distributed with Mean μ, Standard deviation of σ expected profit from ordering O units)

$$\text{Expected Profit} = (p-s)\mu \cdot F_s\left(\frac{O-\mu}{\sigma}\right) - (p-s)\sigma f_s\left(\frac{O-\mu}{\sigma}\right) - O(c-s)F(O,\mu,\sigma) + O(p-c)[1-F(O,\mu,\sigma)]$$

Expected profit's = $(p-s)\mu$ NORMDIST$((O-\mu)/\sigma, 0, 1, 1)$ −

$-(p-s)\sigma$ NORMDIST$((O-\mu)/\sigma, 0, 1, 0)$

$-O(c-s)$ NORMDIST$(O, \mu, \sigma, 1)$

$+O(p-c)[1-$ NORMDIST$(O, \mu, \sigma, 1)] \longrightarrow (3)$

Eg:- The manager at ~~the~~ Sportmart, a sporting goods Store, has to decide on the number of skis to purchase for the year, Management has ~~to~~ forecast demand to be normally distributed, with a mean of $\mu = 350$ and standard deviation of $\sigma = 100$. Each pair of skis costs $c = ~~\$~~ Rs 100$ and retails for $P = Rs 250$. Any unsold skis at the end of the season are disposed of for Rs 85. Assume that it costs Rs 5 to hold a pair of skis in inventory for the season. How many skis should the manager order to maximize expected profits?

Sol: Salvage value $s = 85 - 5 = Rs 80$.

Cost of understocking $: c_u = P - C = 250 - 100 = 150$.

cost of over stocking $: c_o = ~~C~~ S = 100 - 80 = 20$

$$CSL = \text{Prob}(\text{Demand} \leq O) = \frac{c_u}{c_u + c_o} = \frac{150}{150+20} = 0.88.$$

Optimal order size is

$$O^* = \text{NORMINV}(CSL, \mu, \sigma)$$
$$= \text{NORMINV}(0.88, 350, 100) = 468.$$

it is optimal for the Manager at sportmart to order 468 pairs of skis even through the expected number of sales is 350.

In this case ~~the~~.

The cost of understocking is much higher than the cost of overstocking; Manager is better ~~to~~ ordering more than the expected value to cover for the uncertainity of demand.

Expected Profit: $(P-S)\mu$ NORMDIST $((O-\mu)/\sigma, 0, 1, 1)$

$- (P-S)\sigma$ NORMDIST $((O-\mu)/\sigma, 0, 1, 0)$

$- O(C-S)$ NORMDIST $(O^*, \mu, \sigma, 1)$

$+ O(P-C)[1 - \text{NORMDIST}(O^*, \mu, \sigma, 1)]$

$= ~~59,500 \text{ NORMDIST}((O^*-\mu)/\sigma, 0, 1, 1) - (P-S)~~$

$= 59,500$ NORMDIST $(1.18, 0, 1, 1) - 17,000$ NORMDIST $(1.18, 0, 1, 0)$

$- 9,360$ NORMDIST ~~$(468, 0, 1, 0)$~~ $(468, 350, 100, 1) +$

$70,200 [1 - \text{NORMDIST}(468, 350, 100, 1)]$

$= Rs 49,146$

The expected profit of ordering 350 pairs of skis can be evaluated as $45,718. Thus, ordering 468 pairs results in an expected profit that is almost 8% higher than the profit obtained from ordering the expected value of 350 pairs

— x —

When 'o' units are ~~ordered~~ ordered, a firm is left with either too much or too little inventory, depending on demand. When the ~~demand~~ demand is normally distributed with expected value 'μ' and Standard deviation 'σ'.

$$\text{Expected overstock} = (o-\mu)\,F_S\left(\frac{o-\mu}{\sigma}\right) + \sigma f_S\left(\frac{o-\mu}{\sigma}\right)$$

The ~~following~~ formula can be evaluated using Excel as follows

Expected overstock = (o−μ) NORMDIST((o−μ)/σ, 0, 1, 1)
+ σ NORMDIST((o−μ)/σ, 0, 1, 0)

The expected quantity understocked at the end of the season.

$$\text{Expected understock} = (\mu-o)\left[1-F_S\left(\frac{o-\mu}{\sigma}\right)\right] + \sigma F_S\left[\frac{o-\mu}{\sigma}\right)$$

The formula can be valuated using Excel.

Expected understock = (μ−o)[1−NORMDIST((o−μ)/σ, 0, 1, 1)]
+ σ NORMDIST((o−μ)/σ, 0, 1, 0)

(9) One-time orders in the Presence of Quantity discounts:-

a buyer who has to make a single order when the seller offers a price discount based on the quantity Purchased. Such a situation may arise in the context of seasonal items such as apparel, for which the manufacturer offers a lower price per unit if order quantities exceed a given threshold. Such decisions also arise at the end of the life cycle for a product of spare parts. Future demand for the product of spare parts is uncertain, and the buyer has a single opportunity to order. The buyer must account for the discount when selecting the order size.

Consider a retailer of spare parts who has one last chance to order parts before manufacturer stops production. The part has a retail price per unit of P, a cost to the retailer (without discount) of 'c', and a salvage value of S. The manufacturer has offered a discounted price of c_d if the retailer orders at least K units.

The retailer can make its order size decision using following steps.

1. Using $C_o = C - S$ and $C_u = P - C$ evaluate the optimal cycle service level. ~~$C_u = P - C$~~ CSL* and order size O^* without discount. (previous model is suitable) eqn. (1) (2) (3)

2. $C_o = C_d - S$ and $C_u = P - C_d$ evaluate the optimal cycle service level CSL_d^* and order size O_d^* with a discount using (previous model eqn (1) (2)

   if $O_d^* \geq K$. evaluate the expected profit from ordering O_d^* units using eqn. (3).

   if $O_d^* < K$ evaluate the expected profit from ordering K units using eqn. (3)

3. Order O^* unit's if the profit in step-1 is higher. If the profit in step2 is higher. Order O_d^* unit's if $O_d^* \geq K$, or K units if $O_d^* < K$.

Ex:- Spares R Us, an auto parts retailer, must decide on the order size for a 20 year-old model of brakes. The manufacturer plans to discontinue production of these breaks after this last production run. Spares R Us has forecast remaining demand for the brakes to be normally distributed with a mean of 150 and standard deviation of 40. The brakes have a retail price of Rs 200 any unsold brakes are useless and have no salvage value. The manufacturer plans to sell each brake for Rs 50 if the order is for less than 200 brakes and Rs 45 if the order is for at least 200 brakes. How many brakes should Spares R Us order?

Sol:- First step is to calculate the optimal order quantity without discount.

cost of ~~understan~~ understocking $C_u = P - C$

$= 200 - 50 = 150.$

cost of overstocking $C_o = C - S = 50 - 0 = 50.$

$CSL^* = \text{Prob(demand} \leq R^*) = \frac{C_u}{C_u + C_o} = \frac{150}{150+50} = 0.75$

$O^* = \text{NORMINV}(CSL^*, \mu, \sigma) = \text{NORMINV}(0.75, 150, 40) = 177.$

Expected Profit from ordering 177 units = Rs 11,958 from ca (3)

Consider the discount

cost of understocking: $C_u = P - C_d = \text{Rs } 200 - 45 = 155$

cost of overstocking: $C_o = C_d - C = 45 - 0 = 45$

$CSL_d^* = \text{Prob(Demand} \leq R^*) = \frac{C_u}{C_u + C_o} = \frac{155}{155+45} = 0.775$

$O_d^* = \text{NORMINV}(CSL_d^*, \mu, \sigma) = \text{NORMINV}(0.775, 150, 40)$

$= 180$

$180 < 200$ The Retailer Must order at least 200 blankets to benefit from the discount.

calculate the expected Profit from ordering 200 units at 45 each

$=$ Rs 20,595

(3) Desired cycle service level for continuously stocked items:-

In this section we focus~~ed~~ on products such as detergents that are ordered repeatedly by a retail store such as Wall-Mart. Wall-Mart uses safety inventory to increase the level of availability and decrease the probability of stocking out between successive deliveries. If detergent is left over in a replenishment cycle. It can be sold in the next cycle. It doesn't have to be disposed of at a lower cost. Holding cost is increased. as the product is carried from one cycle to the next.

Two extream scenarios should be considered.

1. All demand that arises when the product is out of stock is backlogged and filled later, when inventories are replenished.

2. All demand arising when the product is out of stock is lost.

~~We~~ assume that demand / unit is normally distributed, along with the following inputs.

Q: Replenishment lot size

S: Fixed cost associated with each order

~~ROP : Reo~~

D: Average demand / unit time

σ : Standard deviation of demand / unit time

SS : $ROP - D_L$

c = unit cost

h = Holding cost as a fraction of product cost / unit time

H = cost of holding one unit for one unit of time.

H = hc

(4) Demand during Stockout is Backlogged :-

In this case all demand arising when the product is out of stock is backloged. Because no demand is lost, Minimizing cost ~~becaus~~ becomes equivalent to Maximizing profits.

~~Wall-Mart~~ store selling detergent. The store Manager offers a discount of c_u to each customer wanting to buy detergent when it is out of stock. This ensures that all these customers return when inventory is replenished. If the ~~the~~ Stores Manager increases the level of safety Inventory, more ~~ord~~ orders are satisfied from stock. This ensures that all the customers returning when inventory is replenished

$$CSL = 1 - \frac{HQ}{DCu}$$

σ_L = Standard deviation during lead time

Q = lot size.

The required safety inventory is given by: $SS = F_D^{-1}(CSL) \times \sigma_L$

Demand during stock out is lost:

In this case in which unfilled demand during the stockout period is lost, the optimal cycle service level.

$$CSL = 1 - \frac{HQ}{HQ + DCu}$$

Cu is the cost of losing one unit of demand during the stockout period.

~~Managerial~~

→ Managerial levers to improve supply chain profitability:

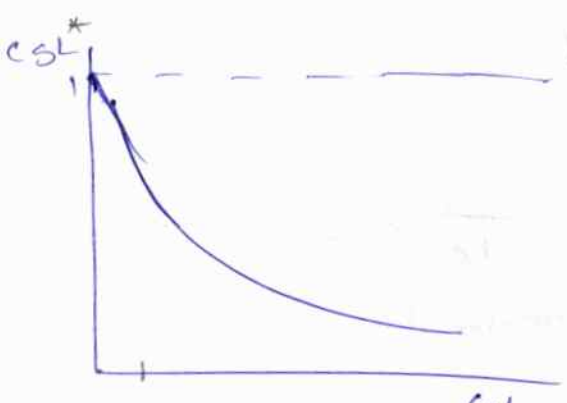
The cost of overstocking and understocking have a direct impact on both the optimal cycle service level and profitability.

Two obvious managerial levers to increase profitability

1. Increase the salvage value (overstocking) of each unit increases profitability (as well as the optimal cycle service level)
2. Decrease the margin lost from a stockout increases profitability (as well as the optimal cycle service level)

Optimum CSL is a function of the ratio of the cost of overstocking and the cost of understocking.

observe that as this ratio gets smaller, the optimal level of product availability increases. This fact explains the difference in the level of product availability b/w a high-end store.



→ Another significant managerial lever to improve supply chain profitability is the reduction of demand uncertainty. With reduced demand uncertainty a supply chain manager can better match supply and demand by reducing both over- and under stocking.

→ A manager can reduce demand uncertainty via the following means.

1. Improved forecasting: use better market intelligence and collaboration to reduce demand uncertainty.

2. Quick response: Reduce replenishment lead time so that multiple orders may be placed in the selling season.

3. Postponement: In a multiproduct setting, postpone product differentiation until closer to the point of sale.

4. Tailored sourcing: → allows the firm to increase its profits better matching with supply and demand. value of T. depends on the reduction in cost.
use a low lead time, but perhaps an expensive supplier as a backup for a low-cost but perhaps long-lead-time supplier.

Volume base tailored Product, } ① focusing on cost but unable to handle uncertainty well, and the other focusing on flexibility to handle uncertainty well but at a higher cost.

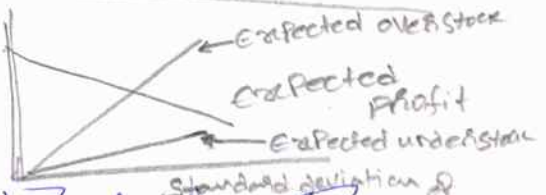
For tailored sourcing to be effective, having supply sources

Must focus on different capabilities. The low cost sourcing

① Improved forecasts:- Impact on profits and Inventories:-

companies have tried to better understand their customers and coordinate actions with in a supply chain to improve forecast accuracy. The use of demand planning information system, has also helped in this regard.

we show That the improved Forecast accuracy can help a firm. Significant increase its profitability while decreasing the excess inventory overstocked as well as the sales lost because of understocking.



② ~~Quick Response~~:-

Ex:- Consider a buyer at Bloomingdale's who is responsible for purchasing dinnerware with Christmas Party

② Quick Response:-

Quick Response is the set of actions a supply chain takes to reduce the replenishment lead time. Supply chain managers are able to improve their ~~lead time~~, forecast accuracy as lead times decreases, which allows them to better match supply with demand and increase supply chain profitability.

Before the start of the sales season, the buyer forecast weekly demand to be Normally distributed with a Mean ~~of~~ and standard deviation.

we compare the impact of the following two ordering Policies.

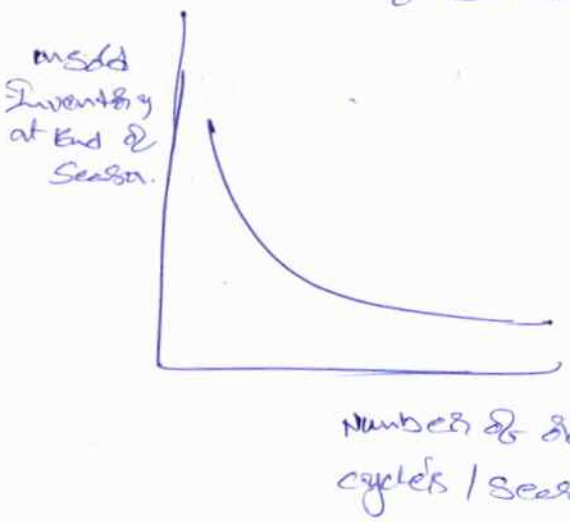
1. A single order must be placed at the beginning of the season to cover the entire season's demand

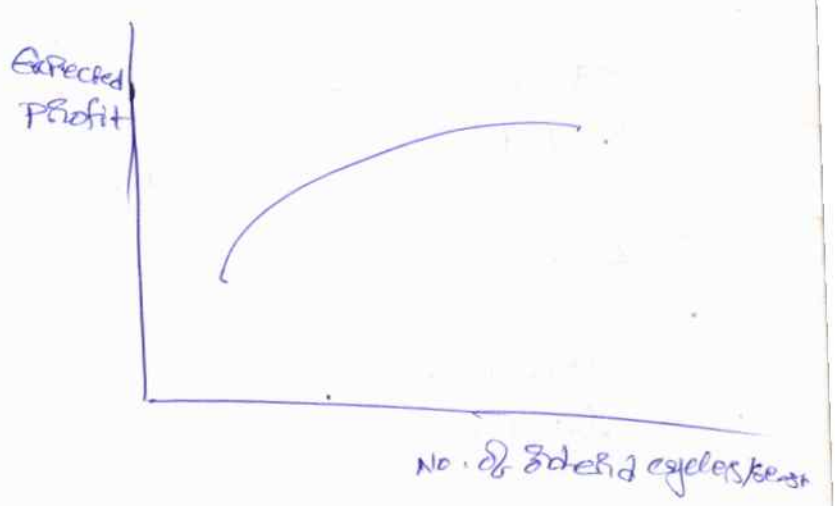
(18) 18/1/15 A/s

1, 4, 5, 8, 11, 13, 14, 16, 18, 19, 22, 26, 27, 29, 30, 37, 38, 42,

45, 46, 49, 50, 51, 52, 53, 55, 1, 7, 8 — 9

2. Two orders are placed for the season, one to be delivered at the beginning of the season and others to be delivered at the Middle of season.





It quick response allows multiple orders in the season, Profits increases and overstock quantity decreases.

Postponement:-

Postponement refers to the delay of Product differentiation until closer to the sale of the product. with postponement, all activities prior to Product differentiation require aggregate forecasts. That are more accurate than individual. Product forcast

* Individual Product forecasts are required close to the time of sale when demand is know with greater accuracy.

As a result, Postponement allows a supply chain to better Match supply with demand. Postponement can be a powerful managerial lever to increase the profitabili

UNIT-IV

Managing economies of scale in a S.C: cycle inventory.

cycle inventory exist because producing & purchasing in a large lots allows a stage of the supply chain to exploit economies of scale and thus lower cost.

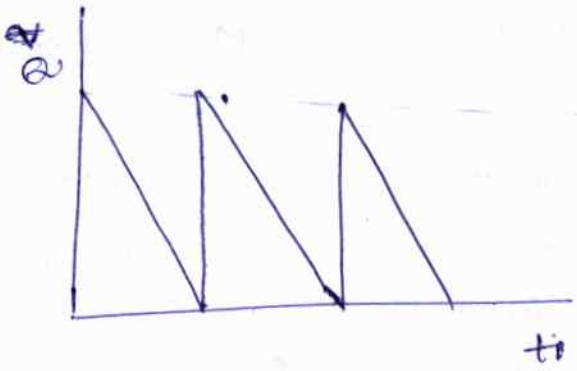
The presence of fixed costs associated with ordering and Transportation, quantity discounts in product pricing, and short-term discounts & trade promotions encourages different stages of a supply chain to exploit economies of scale. and ordering in large lots.

our goal is to identify managerial levers that reduce cycle inventory in a supply chain without raising cost.

The Role of cycle inventory in a supply chain:-

a lot & batch size: is the quantity that a stage of a supply chain either produces & purchases at a time. (Ex:- Printers)

cycle inventory is the average inventory in a supply chain due to either production & purchases in lot sizes that are larger than those demanded by the customer.



Q = quantity in a lot & batch size
D = Demand per unit time.

[Ex:- Inventory of Jean-Mart; a department store D = 100 Pairs/day
Store's Manager currently Purchases its lot size Q = 1000 Pairs.

⇒ Q = 1000 units, D = 100 Pairs/day ⇒ it takes 10 days for an entire lot to be sold.

⇒ Jean-Mart declines steadily for 1000 units to 0 units. This source of a lot

arriving and demand depleating inventory until another lot arrives & repeats it self every 10 days.]

⇒ When demand is steady; cycle inventory and lot size are related as follows.

$$\text{cycle inventory} = \frac{\text{lot size}}{2} = \frac{Q}{2} \quad \therefore \text{cycle inventory} \propto \text{lot size}$$

[ex:- $Q = 1000$ units, ⇒ cycle inventory: $\frac{1000}{2} = 500$ units]

⇒ lot size and cycle inventory also influence the flow time of material with in the supply chain. [∴ Littles law = $I = DT$]

$$\text{Avg flow time} = \frac{\text{average Inventory}}{\text{average flow rate. (Demand)}}$$

for any Inventory avg flow rate = Demand

⇒ Avg flow time resulting from cycle inventory = $\frac{\text{cycle inventory}}{\text{Demand}} = \frac{Q}{2D}$

ex:- lot size = 1000 Pairs, and demand 100, Pairs = $\frac{Q}{2D} = \frac{1000}{2 \times 100} = 5$ days

⇒ **avg price Paid/unit Purchased** is a key cost in the lot sizing decision.

A buyer may increase the lot size if this action results in a reduction in the price paid per unit purchased.

- The price Paid/unit is referred to as the **Material cost** and is denoted by 'c'.

⇒ The **fixed ordering cost** includes all costs that donot vary with the size of the order but are incurred each time an order is placed. There may be a fixed administrative cost to place an order, a trucking cost to transport the order, and a labour cost to receive the order.

- Fixed ordering cost/lot & batch is denoted by (S) is measured in ₹/lot

Ordering cost also displays economies of scale and ~~increases by~~ but Increasing the lot size decreases the fixed ordering cost/unit Purchased

Holding cost is the cost of carrying one unit in inventory for a specified period of time usually one year. It is a combination of the cost of capital, the cost of physical storage the inventory and the cost that results from the product becoming obsolete.

Holding cost is denoted by 'H' is measured in ₹/unit/year.

it is also denoted as a fraction 'h' of the unit cost of the product, Given a unit cost of 'c' the Holding cost 'H' is given by

$$H = hc$$

Total holding cost increases with an increase in lot size and cycle inventory.

⇒ Demand per unit time 'D' (or) R
⇒ Quantity in a lot or Batch size 'Q'
⇒ Average price/unit Purchased, ₹ c/unit.
⇒ Fixed ordering cost incurred / lot, ₹ S/lot (C_3)
⇒ Holding cost incurred/unit/year, ₹ H/unit/year = hc (C_1)

"Any stage of supply chain exploits economies of scale in its replenishment decisions" in the following three typical situations.

1. Fixed cost is incurred each time an order is placed or produced.
2. Supplier offers price discounts on the quantity purchased at lot.
3. The supplier offers short-term price discounts or holds trade promotions

⇒

① Lot Size for a single Product (EOQ)

D = Annual Demand for the product.
(C_3) S = Fixed cost incurred per order.
c = cost/unit
(C_1) h = Holding cost/year as a fraction of product cost.

* Purchasing Manager makes the lot sizing decision to minimize the total cost the store incurs. He must consider the three costs when deciding on the lot size.
  → Annual Material cost
  → Annual order cost
  → Annual holding cost.

⇒ Because Purchase Price is independent of lot size, we have

Annual Material cost = CD

⇒ The number of orders must suffice to meet the annual ~~demand~~ demand D

Given a lot size of Q

n: No. of orders/year: $\frac{D}{Q}$

⇒ Ordering cost S is incurred for each order placed.

Annual order cost: $\left(\frac{D}{Q}\right) S$ (or) C_3

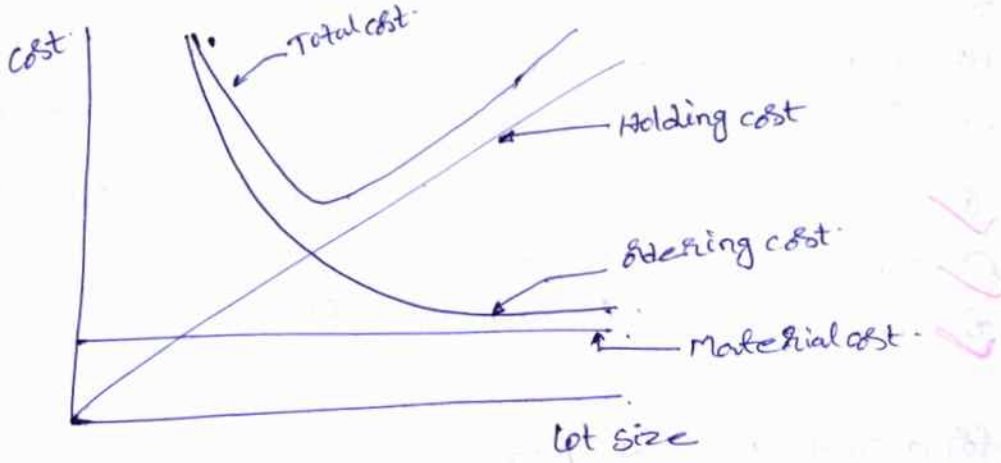
⇒ Given a lot size of Q., we have an average inventory of Q/2. The annual holding cost is thus the cost of holding Q/2 units in inventory for one year and is given as.

Annual Holding cost = $\left(\frac{Q}{2}\right) H$ (or) C_1

$= \left(\frac{Q}{2}\right) hc$

⇒ Total annual cost TC, is the sum of all three cost's.

Total annual cost: $TC = CD + \left(\frac{D}{Q}\right)^{(C_3)} S + \left(\frac{Q}{2}\right)^{(C_1)} hc.$



→ from the fig: annual holding cost ↑ with an ↑ in lot size.

→ The annual ~~order~~ ~~holding~~ ordering cost ↑ ↓ with an increase in lot size

⇒ The Material cost is independent of lot size

→ Total annual cost thus first declines and then increases with an increase in lot size.

Q which is denoted Q^*

$$Q^* = \sqrt{\frac{2DS}{hc}} \quad (or) \quad \sqrt{\frac{2RC_3}{C_1}}$$

$\therefore$ Cycle inventory in the system $= \frac{Q^*}{2}$

$\therefore$ Flow time spent by each unit in the system $= \frac{Q^*}{2D} \; (\text{or}) \; \frac{\text{Cycle inventory}}{D}$

$\Rightarrow$ Optimum order frequency $n^* = \frac{D}{Q^*} = \frac{D}{\sqrt{\frac{2DS}{hc}}} \Rightarrow \sqrt{\frac{Dhc}{2S}}$

$\frac{R}{\sqrt{2RC_3}} \Rightarrow \sqrt{\frac{RC_1}{2C_3}}$

Ex:- Demand for the DeskPro computers at Best Buy is 1,000 units/month. Best Buy incurs a fixed order placement, transportation, and receiving cost of ₹ 4,000 each time an order is placed. each computer costs Best buy ₹ 500 and the retailer has holding cost of 20%. evaluate the number of computers that the store manager should order in each replenishment lots

Sol:- Annual demand, $D = 1,000 \times 12 = 12,000$ units. $= (R)$

Order cost/lot, $S = ₹ 4,000 \quad = (C_3)$

unit cost/computer; $c = ₹ 500 \quad = c$

Holding cost/year as a fraction of inventory value, $h = 0.2$

$C_1 = h \times c$
$= 0.2 \times 500$
$= 100$

$$EOQ = Q^* = \sqrt{\frac{2 \times 12,000 \times 4000}{0.2 \times 500}} = 980$$

To minimize the total cost at Best Buy, the store Manager orders a lot size of 980 computers for each replenishment lot order.

$$\text{Cycle Inventory} = \frac{Q^*}{2} = \frac{980}{2} = 490.$$

$$\text{No. of orders/year} = \frac{D}{Q^*} \; (\text{or}) \; \frac{R}{Q^*} = \frac{12,000}{980} = 12.24$$

$$\text{Annual ordering and holding cost} = \frac{D}{Q^*} \cdot S + \left(\frac{Q^*}{2}\right) hc \quad (R)\ (C_3)$$

$$= \frac{12,000}{980} \times 4000 + \left(\frac{980}{2}\right) 0.2 \times 500$$

$$= ₹ 97,980.$$

$$\text{Avg flow time} = \frac{Q^*}{2D} \Rightarrow \frac{490}{12,000} \Rightarrow 0.041 \text{ year} = 0.49/\text{month}$$

② Aggregating Multiple Products in a single order.
③ Lot sizing with Multiple products & customers.

~~EOQ to exploit : Quantity discounts~~

② Economies of Scale to exploit quantity discounts:-

Two commonly used lot-size-based discount schedules.

1. All unit quantity discounts.
2. Marginal unit quantity discount & Multiblock tariffs.

In this ~~section~~ section we investigate the impact of such quantity discounts on the supply chain. We must answer the following Two & basic ~~quan~~ questions in this context.

a. Given a pricing schedule with quantity discounts, what is the optimal purchasing decision for a buyer. Seeking to Maximise profits? How does this decisions affect the supply chain in terms of lot sizes, cycle inventory and flow times.

b. under what conditions should a supplier offers quantity discounts?

① All-unit quantity discounts:

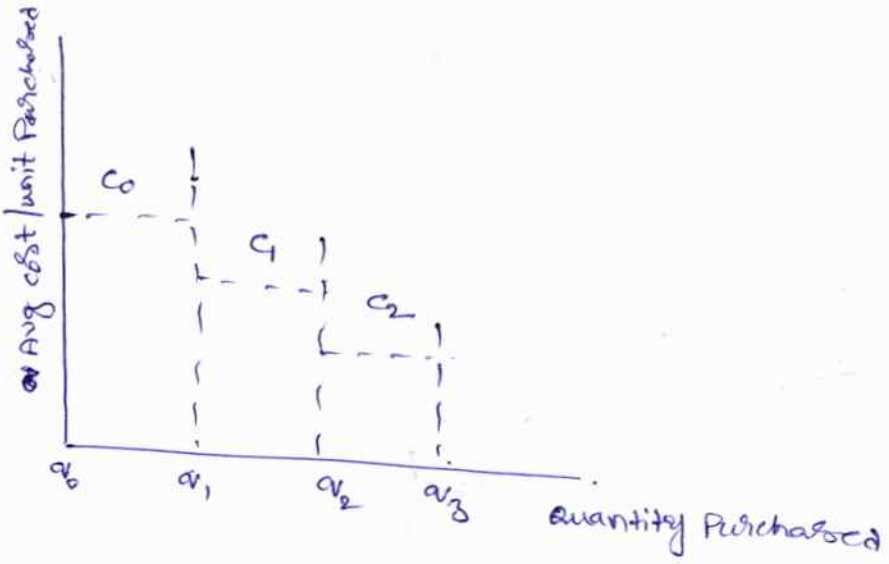
In all unit quantity discounts, the pricing schedule Contains specified break Points, $a_0, a_1 \dots a_r$ where $a_0 = 0$,

→ Where an order placed is at least as large as a_i but smaller than a_{i+1}, e.

→ each unit is obtained at a cost of c_i, in general, the unit cost decreases as the quantity ordered increases. ie $c_0 \geq c_1 \geq \dots \geq c_r$

→ The Retailer's objective is to ~~minimize profits~~, Maximize Profit & equivalently to minimize the sum of Material, order, holding costs.

$$Q_i = \sqrt{\frac{2DS}{hc_i}}$$



(i) $q_i \leq Q_i \leq q_{i+1}$

(ii) $Q_i < q_i$

(iii) $Q_i \geq q_{i+1}$

Case (i)

$q_i \leq Q_i < q_{i+1}$, Then a lot size Q_i units will results in the discounted price of C_i per unit.

Total anual cost $TC_i = \left(\frac{D}{Q_i}\right)S + \frac{Q_i}{2}hC_i + DC_i$

Case (ii)

$Q_i < q_i$, Then a lot size of Q_i does not result in a discount.

Raising the lot size to q_i units results in the discounted price C_i/unit

$$TC_i = \left(\frac{D}{q_i}\right)S + \frac{q_i}{2}hC_i + DC_i$$

② Marginal unit quantity discount:-

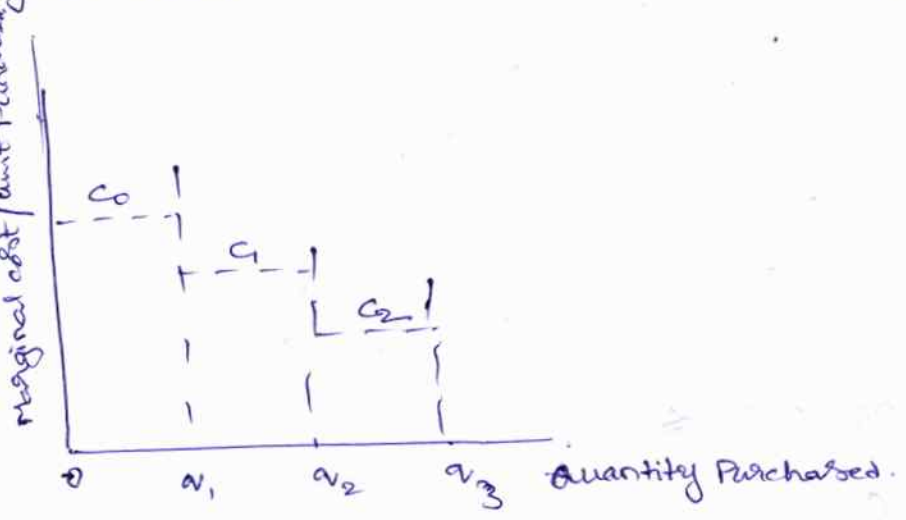
Marginal unit quantity discounts are also referred to as Multiblock tariffs

In this case, the pricing schedule contains specified Break Point's $q_0, q_1 - - - q_r$. It is not the average cost of a unit but the Marginal cost of a unit that decreases at the Break point.

=> If an order size is 'q' is Placed, the first $q_1 - q_0$ units are

priced at c_0 Then $q_2 - q_1$ are priced at c_1 - - -

→ The Marginal cost / unit varies with the quantity purchased.



The Retailer's objective is to decide on a lot size that Maximizes profits (or equivalently, Minimizes Material, Order and holding cost's.

③ Short - Term discounting Trade Promotion's (Forward buy)

The goal of trade promotions is to influence Retailers to act in a way that helps the manufacturer achieve its objectives.

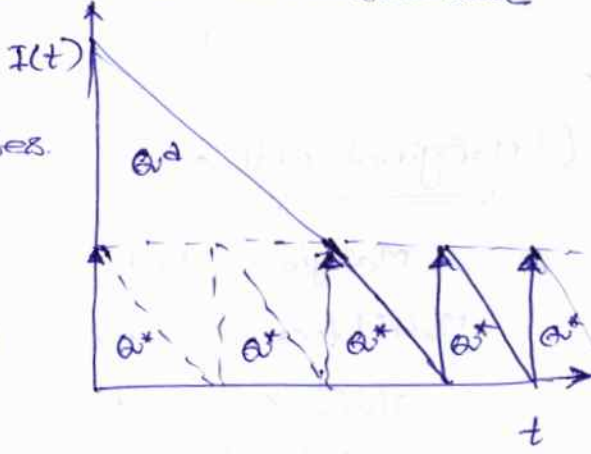
few key goal's:-

① Induce Retailers to use price discounts, displays, (or) advertising to spur sales.

② Shift inventory from the Manufacturer to the Retailer and Customer

③ Defend a brand against competition.

* our goal in this section is to investigate the Impact of a trade promotion on the behaviors of the Retailers and the performance of the entire supply chain.



Forward buying occurs when a Retailer Purchases in the promotional period for sales in future periods. A forward buy helps reduce the Retailers further cost of goods for product sold after promotion period. Although a forward buy is often a the Retailers appropriate response to a price promotion.

* it usually increase demand variability with resulting increase in inventory and flow time with in the supply chain. It can decreases Supply chain profits.

$$Q^* = \sqrt{\frac{2DS}{hc}} \; ; \quad Q^d = \frac{dD}{(c-d)h} + \frac{cQ^*}{c-d} \; ; \quad \text{ForBuy} = Q^d - Q$$

(d: d = discount cost/unit)