

Supply Chain Management: Components

Section 3, Section 3.2

Mother Dairy

In bound Logistics

- One of the largest players in India engaged in branded milk distribution in New Delhi and other parts of the country.
- *Procures milk* from hundreds of cooperatives located in several North Indian states.
- The milk is *transported to the Patparganj plant* in East Delhi, where it is homogenized, pasteurized and then stored in special tanks.

Mother Dairy

In House Logistics

- *Processing capacity* - 650,000 liters per day
- Mother Dairy offers a large *variety of products*:
 - Skimmed, toned, double toned and full cream milk
 - In half and one liter polythene packs
 - Over 30 flavors of ice creams

Mother Dairy

Out bound Logistics

- Nearly a hundred of its tankers crisscross Delhi and supply milk to over 600 booths located in the city.
- Sells loose milk through 200 manually operated containers setup in shops in congested areas,
- Over 400 delivery agents, who home deliver milk in some localities and
- 850 retail shops sells in polythene packs

Mother Dairy

- If you visualize this example you will notice three distinctive set of activities.
 - Procurement of raw milk from milk cooperatives and transporting them to the processing plant.
 - Processing milk and producing a number of variants of products.
 - Distribution of these products to the end customer.

Mother Dairy

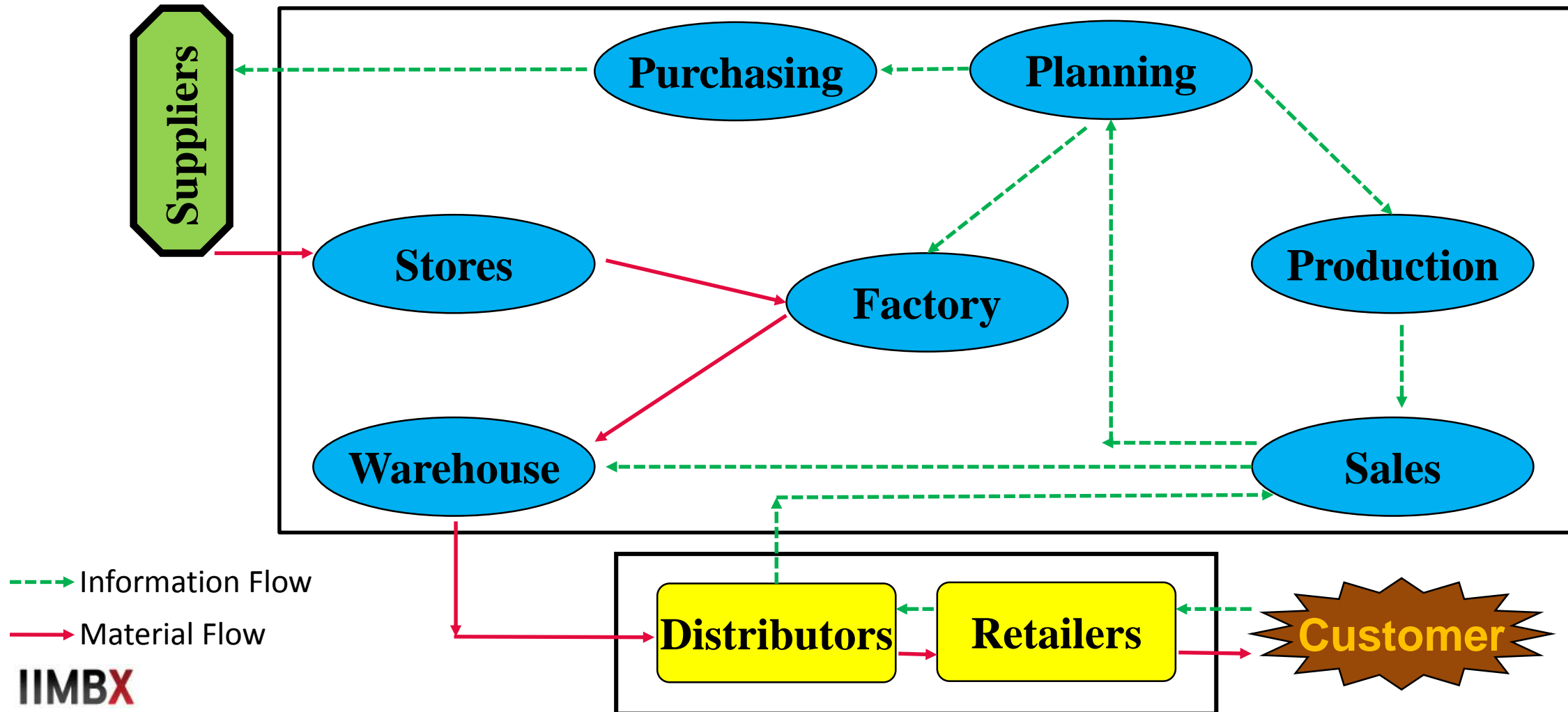
Supply Chain Components

The three major components of Mother Dairy supply chain may be designated as:

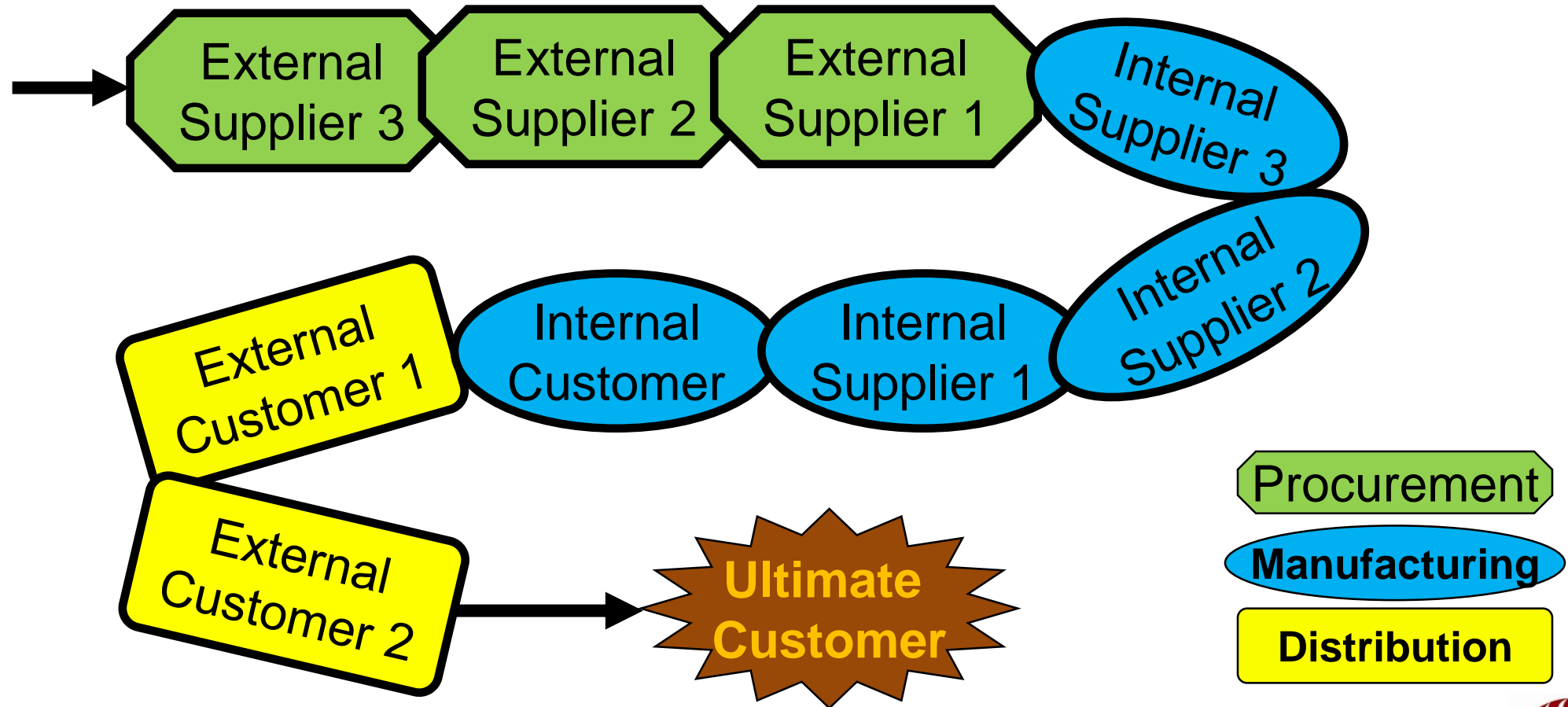
- In-bound supply chain
- In-house supply chain
- Out-bound supply chain

Supply Chain

Information & Material Flows



What is a Supply Chain?



Supply Chain Management

Issue to be addressed

- In-bound logistics management
 - Supplier Development, Strategic Sourcing
 - Supply Management
- In-house logistics management
 - Master Scheduling, MRP
 - Layout, materials handling
- Out-bound logistics management
 - Warehousing
 - Distribution & Channel Management

Design of an Appropriate Supply Chain

Role of SCM Structure

Section 3, Section 3.3

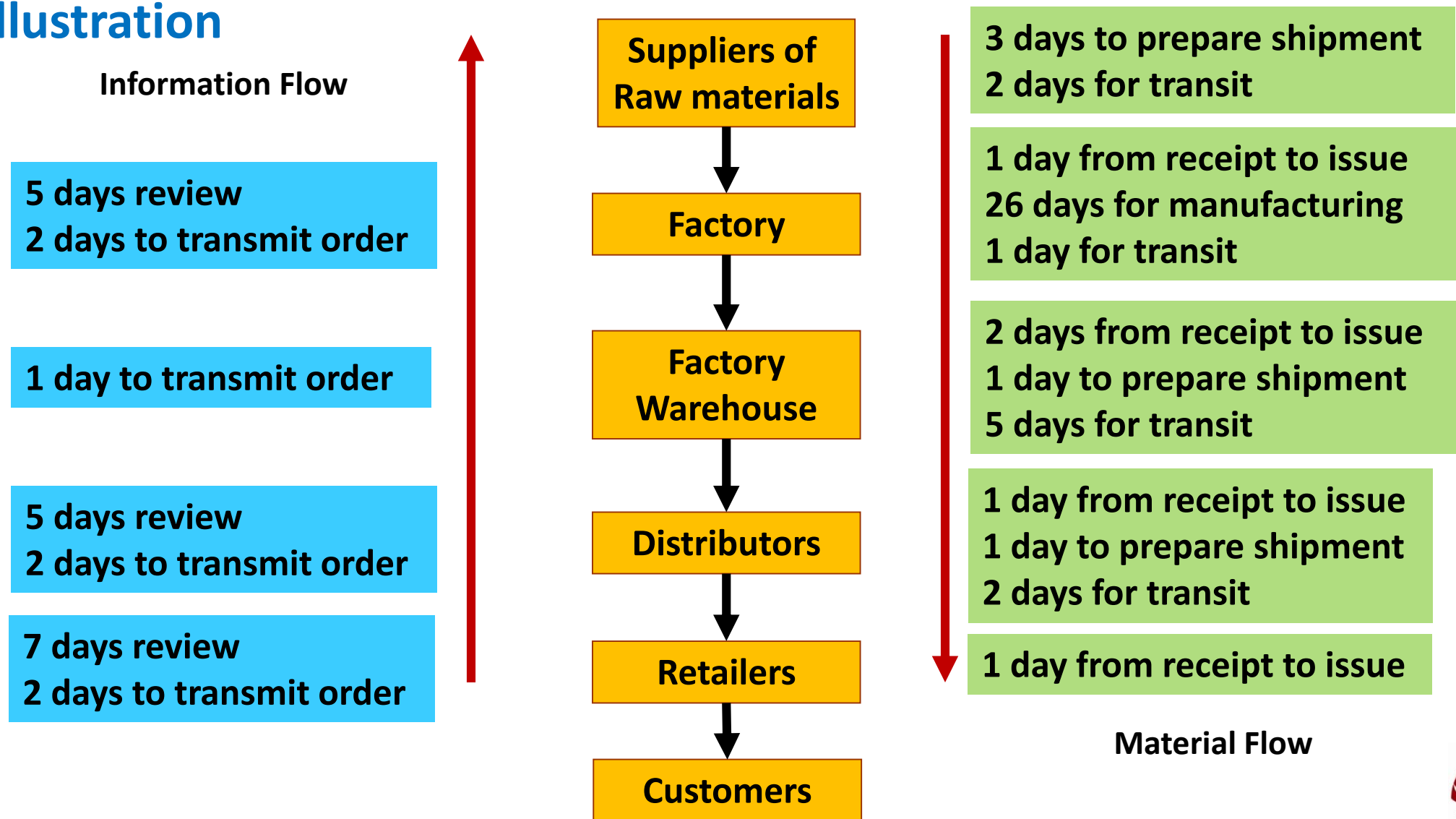
SCM Structure

Introduction

- Supply Chain Structure denotes:
 - The entities involved in delivering the goods and services to the ultimate customer and
 - Their relative positioning
 - Roles and responsibilities
- It also determines the nature and the quantum of information and material flows in the chain across various entities.

Supply Chain structure

An illustration



Supply Chain structure

Inferences

- There are five layers involved in this chain.
- Each layer influences the material and information flow in the chain.
- There is a certain lead time (delay) in fulfilling the customer orders.

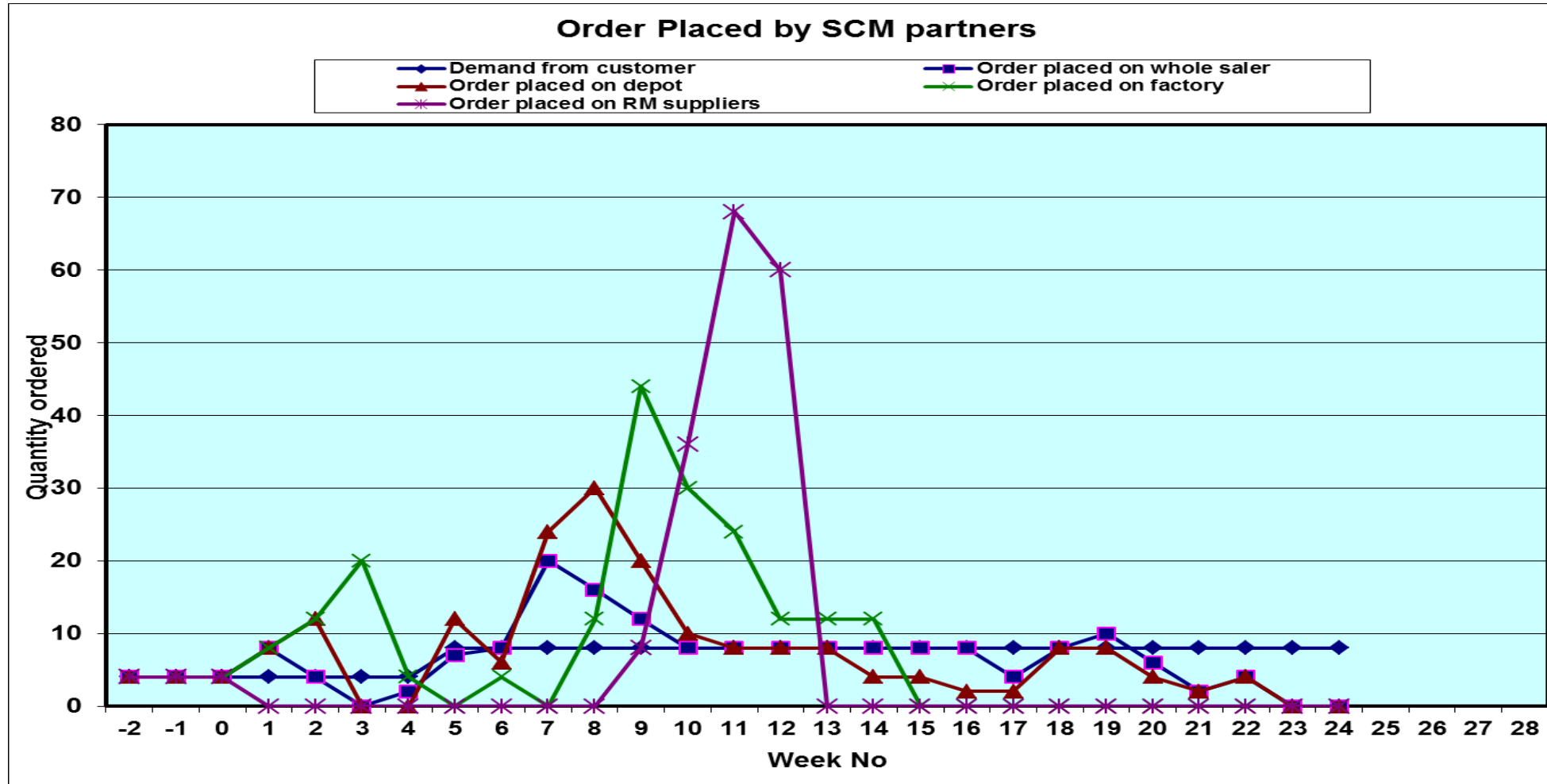
Supply Chain structure

Need for focusing on this issue

- With the coming of large electronic market places, the number of layers seems to be coming down significantly.
 - Is this beneficial, how exactly is this likely to affect the business?
- Many retail chains are complaining excess inventory in the pipeline and difficulties in demand management.
 - Has this anything to do with the supply chain structure?

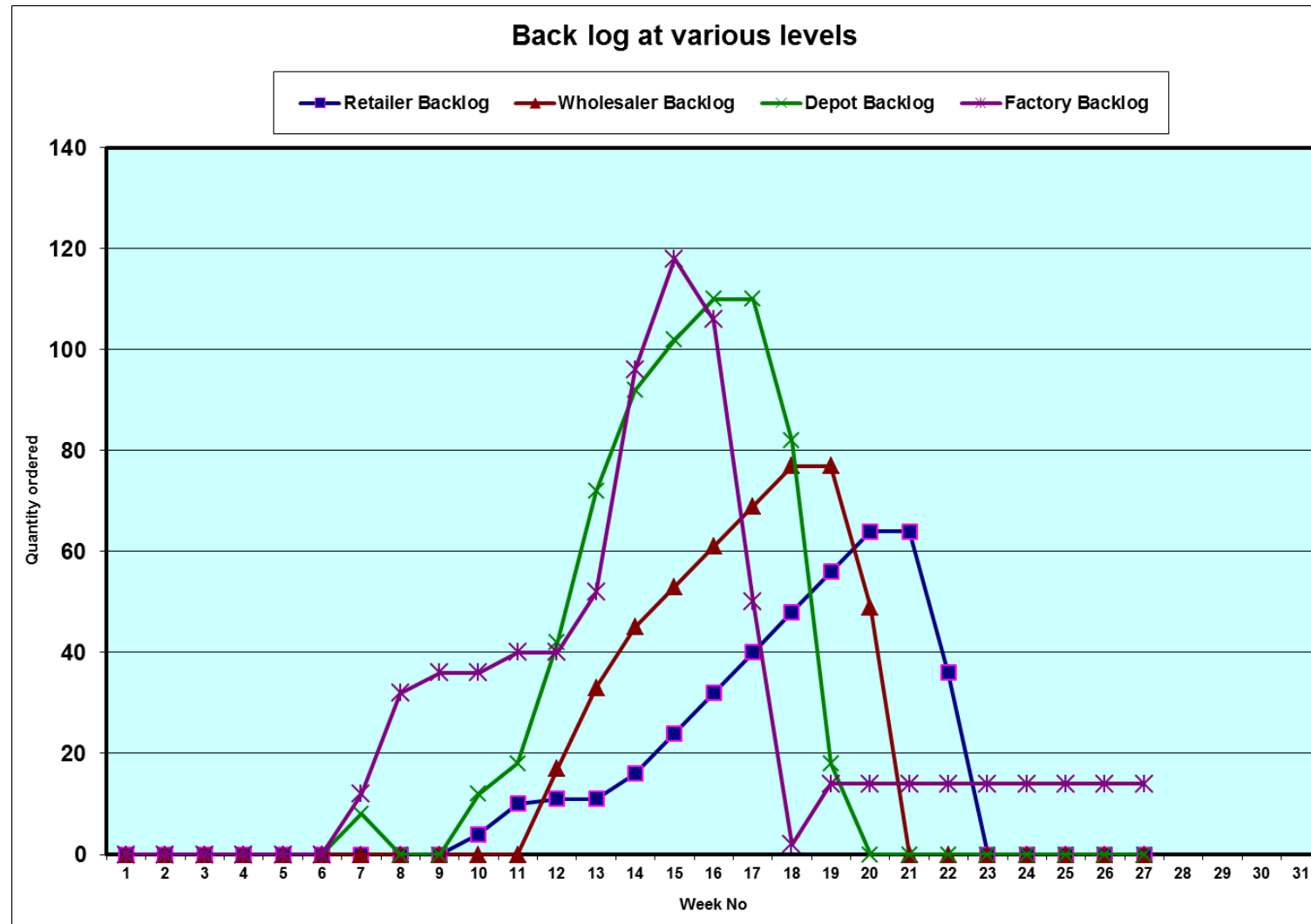
Bullwhip Effect in Supply Chains

Results from a simulated Beer Game

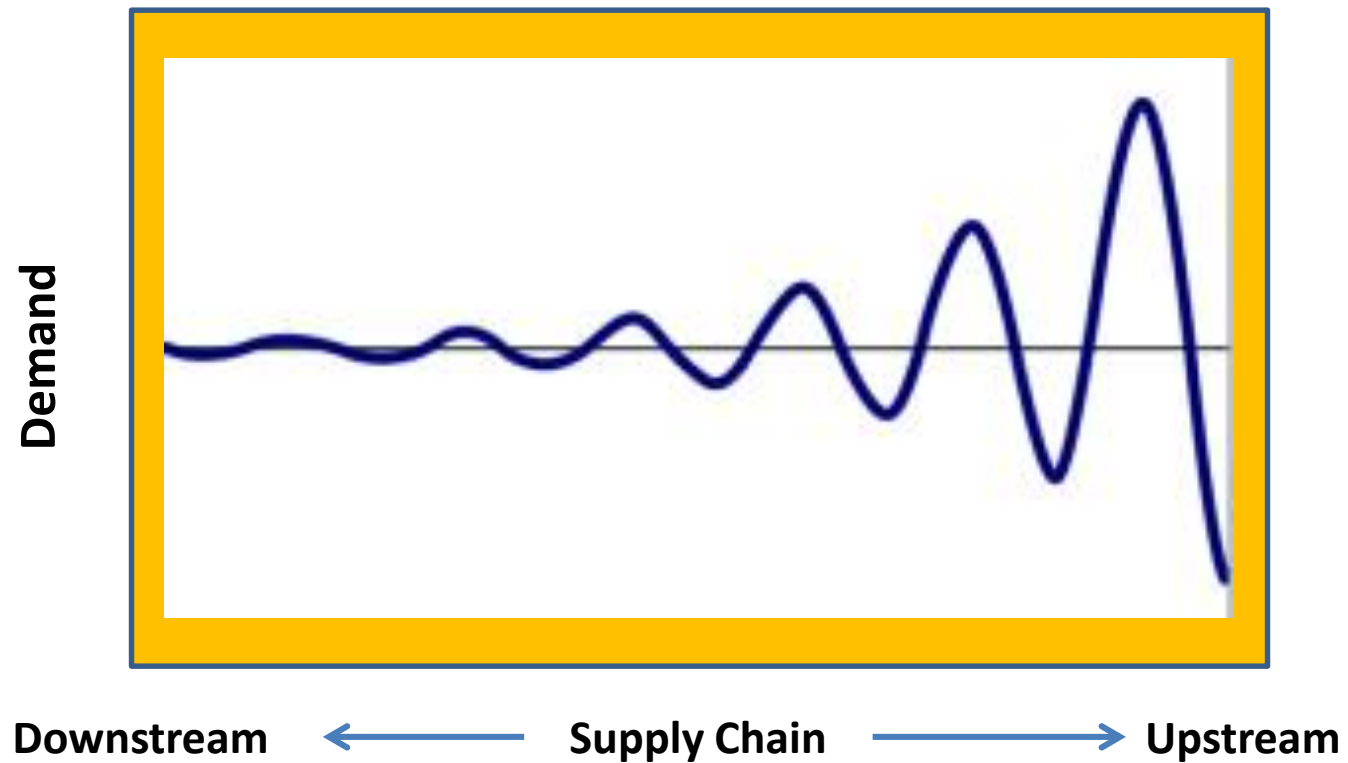


Bullwhip Effect in Supply Chains

Results from a simulated Beer Game (cont.)



Bullwhip Effect in Supply Chains



Bullwhip Effect

Key observations

- Downstream demand gets amplified by the time it reaches upstream.
- All levels go through the effect, albeit in varying magnitudes.
- The farther we are from the end point demand, the greater is the amplitude of this variation.
- There is a phase lag in the effect between the layers.
- Demand is mixed up with noise as it travels upstream in the chain.

What causes bullwhip effect?

- The more:
 - the number of layers
 - the delay
 - the rate of change, the greater the fluctuations
- Each layer:
 - updates its forecast in varying patterns
 - places order at different times
 - price fluctuations (promotions)
 - rationing of supply

Reducing the bullwhip effect

Some alternatives

- Devise new strategies for minimizing the number of layers.
 - 3PL and 4PL developments in logistics.
 - Use of Electronic Markets and Internet Based direct channels.
- Cut down delays in information exchanges.
 - Lead time reduction, reduction in fixed costs in ordering.
- Reduce the rate of change by improving demand intelligence.
- Improve quality of demand forecast update.
 - Use of point of sales data, EDI, Internet.
 - Share sales, capacity and inventory data across the supply chain partners.
- Improve Demand Planning methodologies.

Design of an Appropriate Supply Chain

Types of Supply Chains

Section 3, Section 3.3

Alternative Types of SCM

Role of Product Profile

- Product Profiles in reality are different.
 - **Example 1**: iPhone 6 which is the latest variant of cell phones from apple or the new generation gaming laptop from Dell.
 - **Example 2**: Groceries or some home maintenance tool kit such as Bosch Screw driver bit set.
- Will the type of supply chain be the same in both these cases?

Differences in product profile

Criteria for comparison

Criterion	Grocery or Home Maintenance Tools	iPhone or Laptop
Product life cycle	> 2 years	3 months to 1 year
Contribution margin	5% - 20%	20% - 60%
Product variety	low (up to 20 variants per category)	high (often thousands of variants)
Average forecast error	10%	40% - 100%
Average stock out	1% - 2%	10% - 40%
Forced end of season markdown	0%	10% - 25%
Available time window for "Produce – Deliver"	6 months - 1 year	1 day to 2 weeks

Alternative Types of SCM

The above example points us to certain issues pertaining to the profile of the product for which we want to configure a supply chain.

- First it is important for us to understand the profile of the product before you design a supply chain strategy.
- Some products are purely functional in nature – as we saw in the case of groceries, home maintenance tools etc. There are no fads, fashions, or extremely small time windows or opportunities for selling these.

One size does not fit all

- Understand the profile of the product before you design a supply chain strategy.
 - Primarily functional products
 - Primarily innovative products
- Choose between:
 - An efficient supply chain
 - A responsive supply chain

Elements of Efficient Supply Chain

- **Installing Point-of-Sale (POS) data system:**
 - Ensures that the demand data is captured accurately and immediately updating forecast.
 - Helps avoid bullwhip effect in supply chains and optimize inventory in the system.
- **Investing in SCM partnership programs** both on the “in-bound” & “out-bound” side:
 - Can help jointly work on a program to reduce supply chain costs.
- **Integrating material planning and control systems with ERP system** to benefit from improved data visibility.
- **Robust inventory control mechanisms:**
 - Will reduce the inventory in the system without compromising availability levels seriously.
- **Implementation of continuous replenishment programme using EDI links** for information sharing:
 - Will help improve efficiency of the supply chain.

IIMBX – Will help improve efficiency of the supply chain.



Responsive Supply Chain

Three strategies

- Find ways of handling the large variety that we may have to offer.
- Cut the lead times of business processes thereby one can react faster to the unfolding market development.
- Fundamentally rethink our approach towards managing the product portfolio offerings.

Elements of Responsive Supply Chains

Postponement Strategies

- Packaging postponement
 - Savings in transportation (bulk containers)
 - Handle multi-lingual requirements (HP printers)
- Assembly postponement
 - Low levels of investment in FG
 - Ability to handle a large variety through modular design (computer - the case of Dell)
- Manufacturing postponement
 - Final stages of manufacturing delayed until firm orders are received (Benetton dyeing of fabrics)

Efficient Product Portfolio Mgmt.

Tool for managing variety

- Standardization
 - Uses commonly available parts
 - Reduces costs & inventory
- Modular design
 - Combines standardized building blocks/modules into unique products

Design of an Appropriate Supply Chain

Issues in a Services Supply Chain

Section 3, Section 3.3

Services Supply Chain (SSC)

Unique?

- Is Services Supply Chain (SSC) any different?
 - Simultaneity: Often services are produced & consumed at the same time.
 - Perishability: Services cannot be inventoried as in the case of manufactured products.
- Services production involves collaboration of:
 - Service providers
 - Suppliers of other services or resources needed for the design and delivery of these services
 - The service clients
- All working together to co-produce value in complex value chains or networks.
- Therefore, Service Businesses could be People Oriented as well as People Intensive.

If services supply chains are different, it could be because of the above features of services.

Manufacturing Supply Chain (MSC) Vs Services Supply Chain (SSC)

MSC

- Material Flow Dominant
- Inventory can spatially separate consumption & production
- Inventory – A good measure of SCM performance
- Technology can play a role in improving effectiveness

SSC

- Information Flow Dominant
- Simultaneity of consumption & production demands responsiveness
- Lead time – A good measure of SCM performance
- People oriented & People intensive business

Critical aspects of services supply chain

No inventory in the chain

- Since we design a system for no inventory – 100% fulfillment (on time) is a necessity.
 - Capacity & Demand Management modules of SCM are critical elements.
 - Managing demand – supply matching issues are very critical to SCM performance.
 - Strategies for matching the supply with demand are done very differently in SSC.
 - Pricing is one of the main levers in this process.
 - Flow: Delivery reliability issues are paramount.
 - We need control systems for this.

Critical aspects of services supply chain

Simultaneity of production & consumption

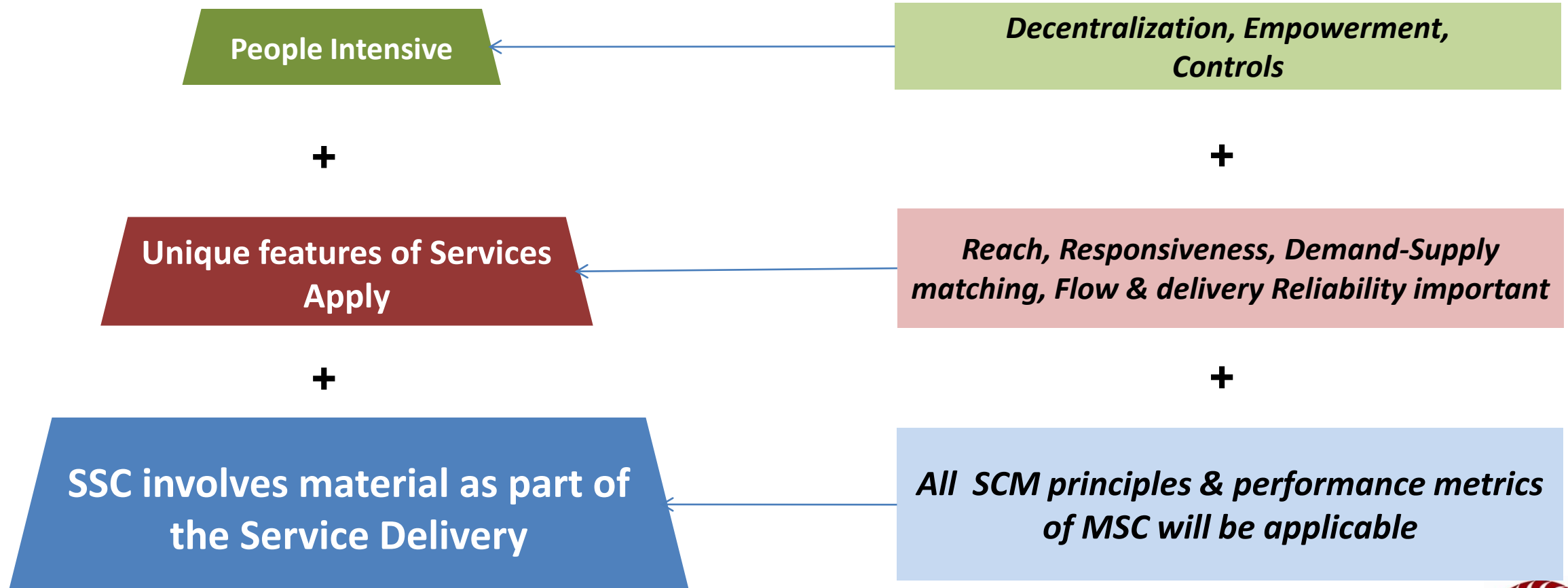
- Reach is an important parameter for SCM performance.
- Design of service delivery system is critical in SSC.
 - Choice of service networks
 - Logistics planning
 - Manning the supply chain
- How will we improve responsiveness?
 - Are the people empowered to take decisions immediately?
 - How much capacity – Effectiveness Vs Efficiency trade-offs?

Critical aspects of services supply chain

People Oriented & People intensive business

- Chain will be resource (manpower) intensive.
 - Implications for scalability & choices
 - Implications for quality & SSC performance
- Level of Decentralization is a critical aspect of SSC.
 - Service firms generally require more decentralization.
 - How to set up associated controls?
- Customer is mostly exposed to the **lowest level** in the hierarchy in an organization.
 - Service Quality Implications

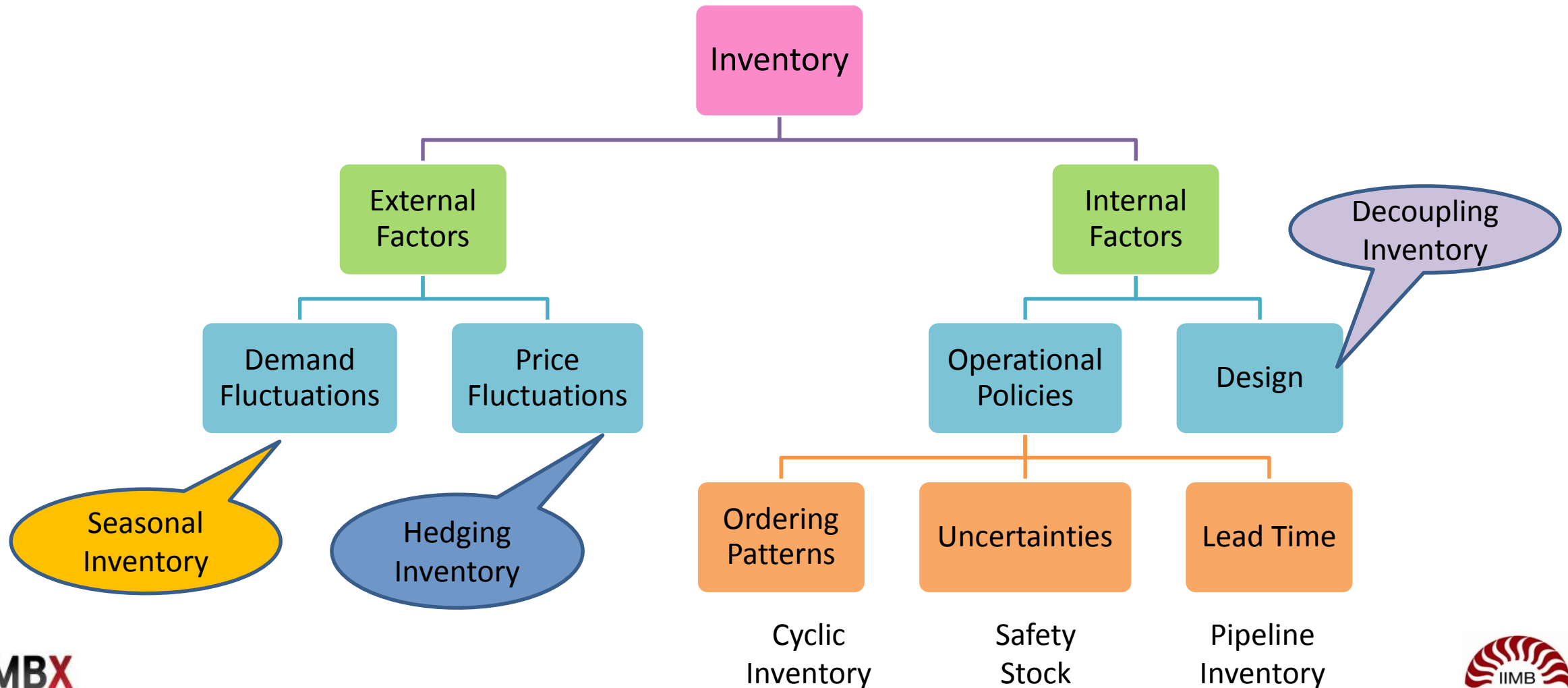
SSC is far more challenging!



Issues in Inventory Planning

Types of Inventory
Section 3, Section 3.4

Types of Inventory in Organizations



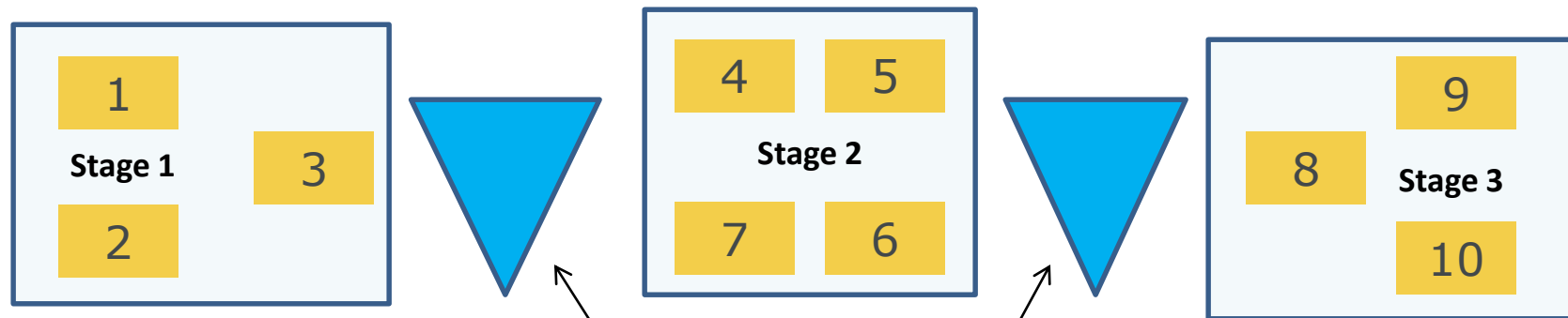
Types of Inventory

- Hedging Inventory: Used to hedge against price fluctuations in International markets and to ensure availability of the required material at reasonable prices over an extended time horizon.
- Seasonal Inventory: Seasonality in demand is absorbed using inventory.
- Decoupling Inventory: Complexity of production control is reduced by splitting manufacturing into stages and maintaining inventory between these stages.
- Cyclic Inventory: Periodic replenishment causes cyclic inventory.
- Pipeline Inventory: Exists due to lead time in business processes involved in getting the material.
- Safety Stock: Used to absorb fluctuations in demand due to uncertainty in demand, supply (Qty., Lead Time).

Decoupling Inventory

An illustration

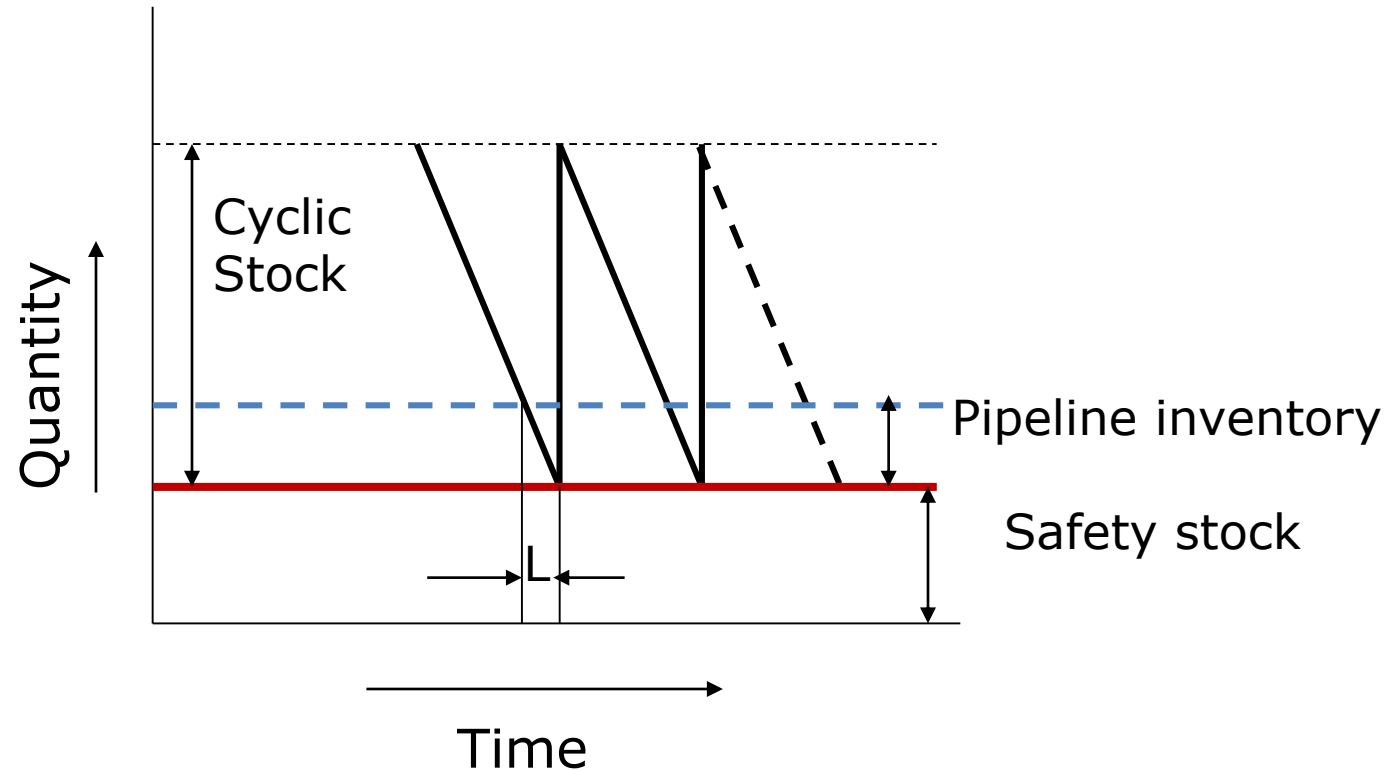
Production System without any decoupling inventory



Decoupling Inventory

Cyclic, Pipeline and Safety Stocks

A graphical illustration



Cyclic inventory, pipeline inventory and safety stocks are critically linked to “how much” and “when” decisions in inventory planning.

Issues in Inventory Planning

Costs & Decisions

Section 3, Section 3.4

Inventory Planning

Decisions

- All inventory planning problems seek to address two important decisions:
 - How Much should we order?
 - In inventory planning terminology we call it as **order quantity**.
 - When to order?
 - This is often referred to in inventory planning parlance as **reorder point**.

Inventory Planning

Cost (Ordering Cost)

Cost of ordering - This includes all administrative costs involved in ordering a batch of material for our use:

- Looking for appropriate set of suppliers
- Negotiating with them, selecting the supplier
- Arriving at price, payment and delivery terms
- Placing the order, monitoring the supply
- Receiving the items, certifying for quality & stocking up in the stores
- Manpower & other infrastructure costs related to all the above activities

Inventory Planning

Cost (Carrying Cost)

- **Cost of Carrying** the inventory in our stores. This includes:
 - Interest for the locked up capital
 - Storage related costs – Rent, insurance
 - Obsolescence, damage etc.
 - Manpower and other infrastructure costs related to all the above activities
- The more we carry inventory, more will be these costs and vice versa.

Inventory Planning

Cost (Shortage Cost)

- **Cost of shortage** - Shortages happen on account of uncertainties in the system related to demand, supply lead time, supply quantity etc.
 - Arises out of disruptions
 - Productivity losses
 - Loss of customer good will etc.
- While this is important, it is hard to measure them directly and easily as in the case of the other two costs.

Issues in Inventory Planning

The Economic Order Quantity (EOQ) Model

Section 3, Section 3.4

EOQ Model

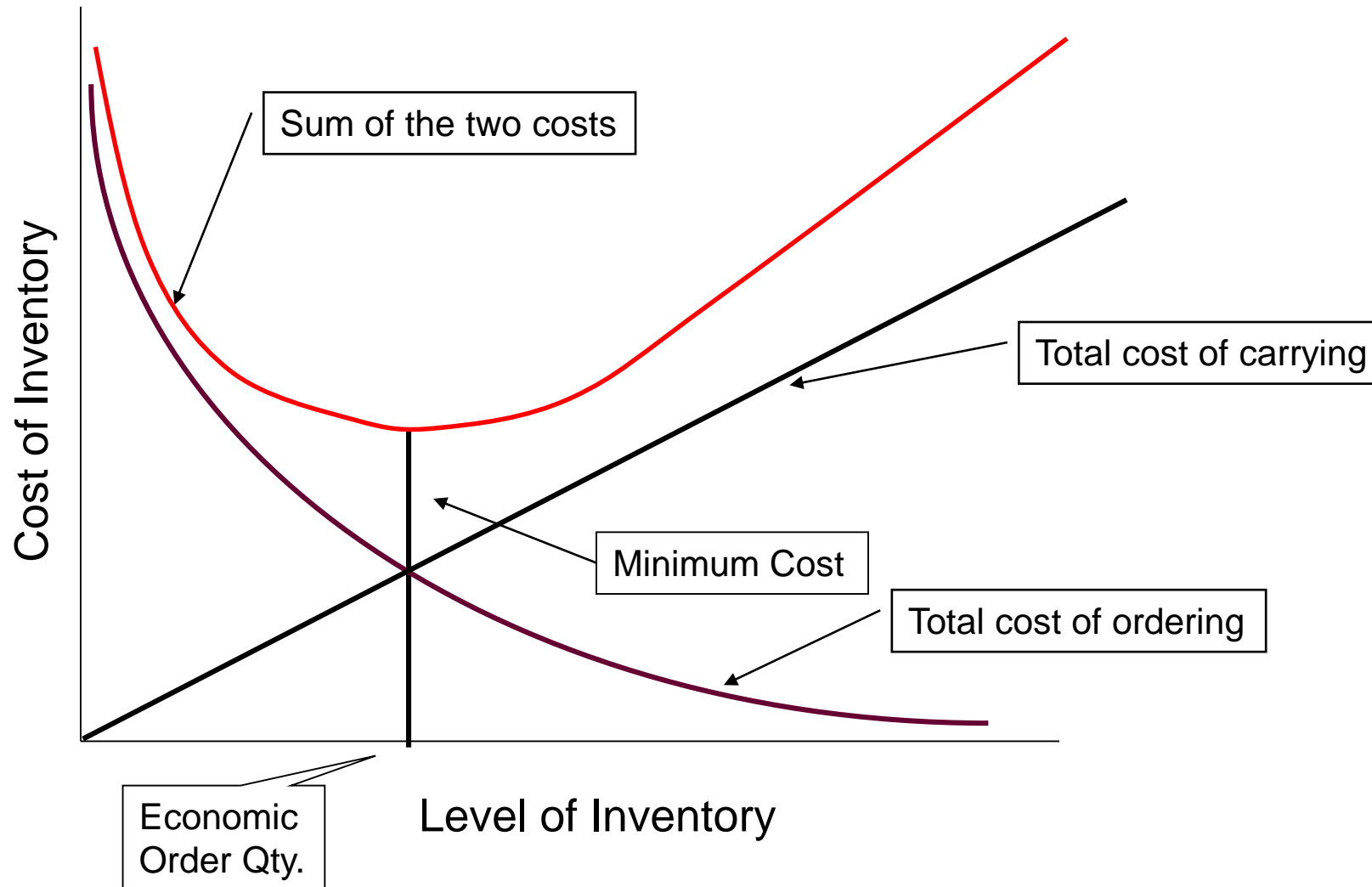
- Let us say we are planning for an annual demand of D (say $D = 1000$).
- Let us denote the order quantity as Q .

Impact of Varying Order Quantities

Demand (D)	Order Qty. (Q)	Number of Orders	Maximum Inventory	Minimum Inventory	Average Inventory
10,000	5000	2	5000	0	2500
10,000	1000	10	1000	0	500
10,000	500	20	500	0	250
10,000	250	40	250	0	125
10,000	100	100	100	0	50
10,000	50	200	50	0	25
10,000	20	500	20	0	10
10,000	10	1000	10	0	5

EOQ Model

A graphical representation



EOQ Model

- From the graphical representation of this problem, we notice that the total cost curve has a boat shape with a flat bottom.
- The quantity that results in least cost is the Economic Order Quantity (EOQ).
- EOQ can be calculated using the formula :

$$EOQ = \sqrt{\frac{2 * \text{Cost of Ordering} * \text{Demand}}{\text{Cost of Carrying}}}$$

EOQ Model

A numerical illustration

- Annual Demand = 10,000
- Cost of Ordering = \$ 200 per order
- Unit Cost = \$ 400
- Cost of Carrying = 16% of unit cost = \$ 64/unit/year
- $EOQ = \sqrt{\frac{2 * \text{Cost of Ordering} * \text{Demand}}{\text{Cost of Carrying}}} = \sqrt{\frac{2 * 200 * 10000}{64}} = 250$
- What does this policy mean to us:
- How much ? **250**
- How many orders in a year? $10,000/250 = 40$
- Suppose we work for 320 days in a year, this means we place an order once in 8 working days ($320/40 = 8$)
- Therefore when to order? **Once in 8 days**

EOQ Model

Numerical Illustration (Summary)

- **Cost of the plan:**
 - Cost of Ordering: $40 * 200 = \$ 8,000$
 - Average Inventory = $(250 + 0)/2 = 125$
 - Cost of Carrying Inventory = $125 * \$64 = \$ 8000$
 - **Total Cost = \$ 16,000**
- Summary of the results of our example:
 - Our decisions:
 - How much to Order? 250;
 - When to Order? Every 8 working days
 - Cost of the Plan: \$ 16,000

EOQ Model

Some Inferences...

- At EOQ both the **costs are equal**;
 - i.e the total cost of ordering is equal to total cost of carrying the inventory.
- The model is robust to model parameters because of the **flat bottom – boat structure**.
- In any real life situation in which there are two major mutually opposing cost structure, the **flat bottom boat type** of total cost curve will manifest:
 - Therefore we do not need too much effort to accurately estimate the model parameters.

Issues in Inventory Planning

Extensions of the EOQ Model

Section 3, Section 3.4

Issues in using EOQ Model

Model assumptions

1. Assumptions about order quantity.

- a) There are no restrictions in the quantity that we can order
- b) There are no preferred order quantities for the items
- c) No price discount is offered when the order size is large

2. Lead time is zero (ignored).

3. Assumptions about Demand.

- a) The demand is known with certainty
- b) Demand is continuous over time

Relaxing Assumptions in EOQ Model

Effect of Discount

- Suppose in our example the supplier offers a discount structure.
 - 1% discount on price if we order 500
 - 2% discount on price if we order 1,000
 - 4% discount on price if we order 4,000
- Let us see analyze the impact of $Q = 500$ first.

Effect of Discount (Q = 500)

	EOQ	Q = 500
Annual Demand	10,000	10,000
Price of item (\$)	400.00	396.00
Discount Offered	-	1%
Order Qty.	250	500
Cost of ordering/order	200	200
No. of orders	40	20
Total Cost of Ordering (\$)	8,000	4,000
Carrying cost	16%	16%
Unit Carrying Cost (\$)	64.00	63.36
Average Inventory	125	250
Total Cost of Carrying Inventory (\$)	8,000	15,840
Purchase Price (\$)	4,000,000	3,960,000
Total Cost of the Plan (\$)	4,016,000	3,979,840

Effect of Discount (Multiple Scenarios)

Annual Demand	10,000	10,000	10,000	10,000
Price of item (\$)	400.00	396.00	392.00	384.00
Discount Offered	-	1%	2%	4%
	EOQ	Q = 500	Q = 1000	Q = 4000
Order Qty.	250	500	1,000	4,000
Cost of ordering/order	200	200	200	200
No. of orders	40	20	10	2.50
Total Cost of Ordering (\$)	8,000	4,000	2,000	500
Carrying cost	16%	16%	16%	16%
Unit Carrying Cost (\$)	64.00	63.36	62.72	61.44
Average Inventory	125	250	500	2,000
Total Cost of Carrying Inventory (\$)	8,000.00	15,840.00	31,360.00	122,880.00
Purchase Price (\$)	4,000,000	3,960,000	3,920,000	3,840,000
Total Cost of the Plan (\$)	4,016,000	3,979,840	3,953,360	3,963,380

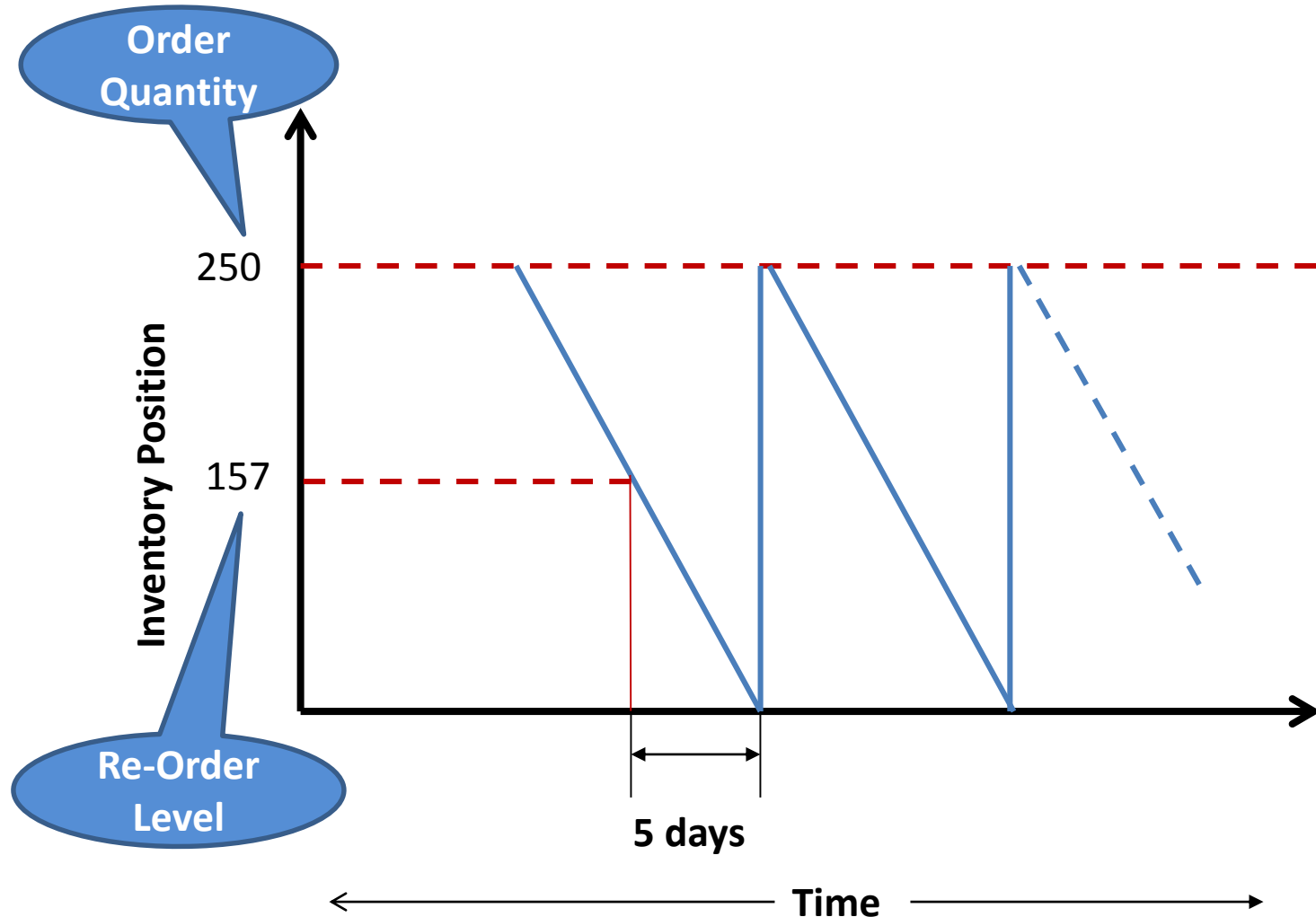
Relaxing Assumptions in EOQ Model

Incorporating Lead Time Information

- Suppose the lead time is 5 days:
 - Annual Demand = 10,000
 - No of working days = 320
 - Daily Demand = 31.25
 - Demand for 5 days = $156.25 \cong 157$
- Place an order for 250 items when the inventory position has reached 157.
- This is called **Re-order Level**.

Relaxing Assumptions in EOQ Model

Incorporating Lead Time Information



Relaxing Assumptions in EOQ Model

Effect of Demand Uncertainty

- Relaxing assumption about demand certainty will result in shortages due to difficulty in estimating demand.
- On account of uncertainty we need to introduce another type of inventory called **safety stock**.
- There are some known systems in practice that can handle this situation.
 - One Example: **Order-up to-Level** or Periodic Review Inventory System

Order-up to-Level Inventory System

- Review date: 1st and 16th of every month
- Review period: 15 days (R)
- Lead time to receive the material: “L”
- The two critical decisions for this model:
 - When to Order – Review Period (R)
 - How Much to Order – Determined by the order-up to-level (S)

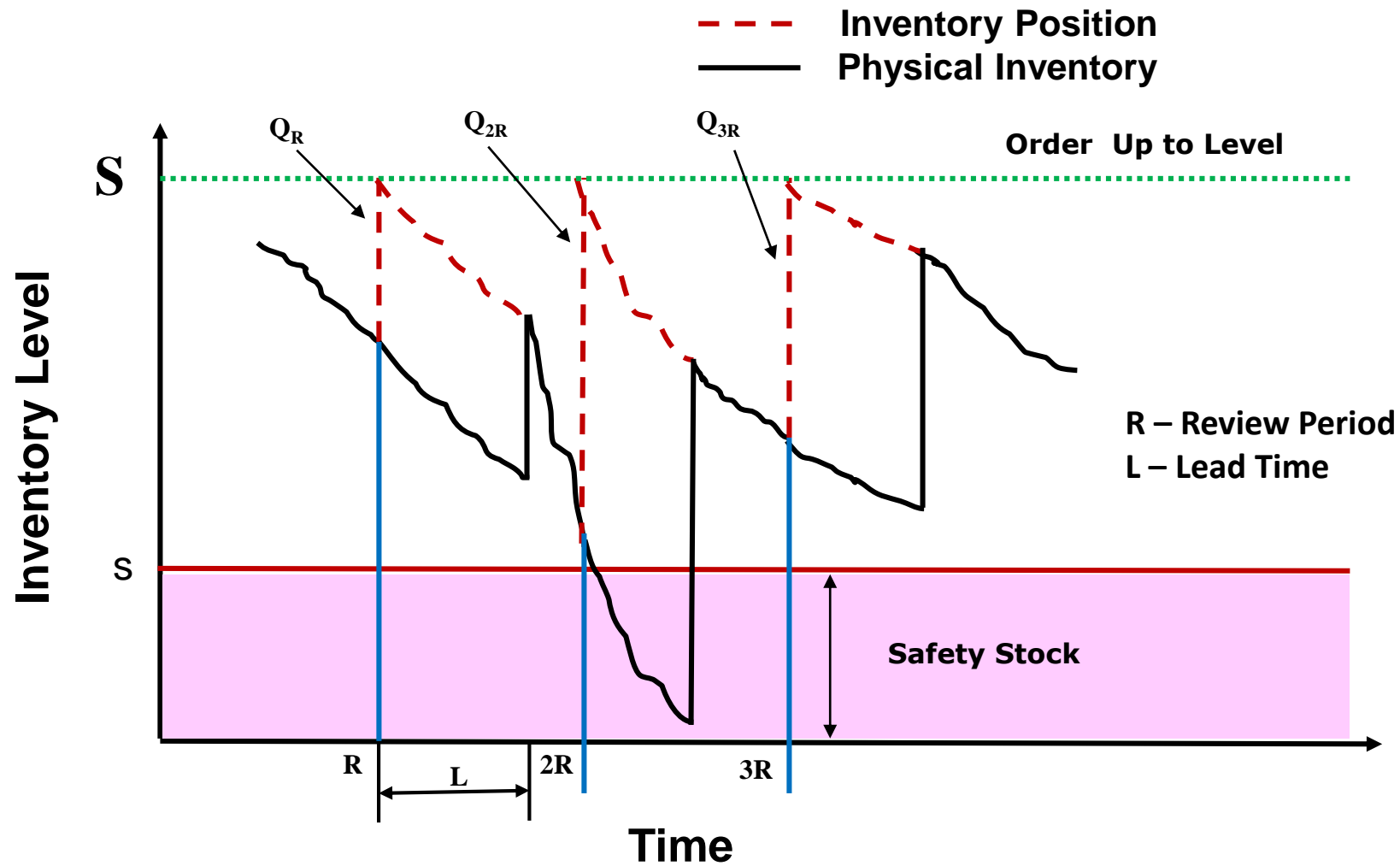
Fixing Review Period

Some considerations

- Review Period - Use a convenient, managerially sound time period for review based on the situation.
 - Type of Item - Value and Consumption Levels
 - High: Review Frequently – Once in a fortnight
 - Medium: Once in a Month
 - Low: Once in 2 months or a Quarter

Order-up to-Level Inventory System

A graphical illustration



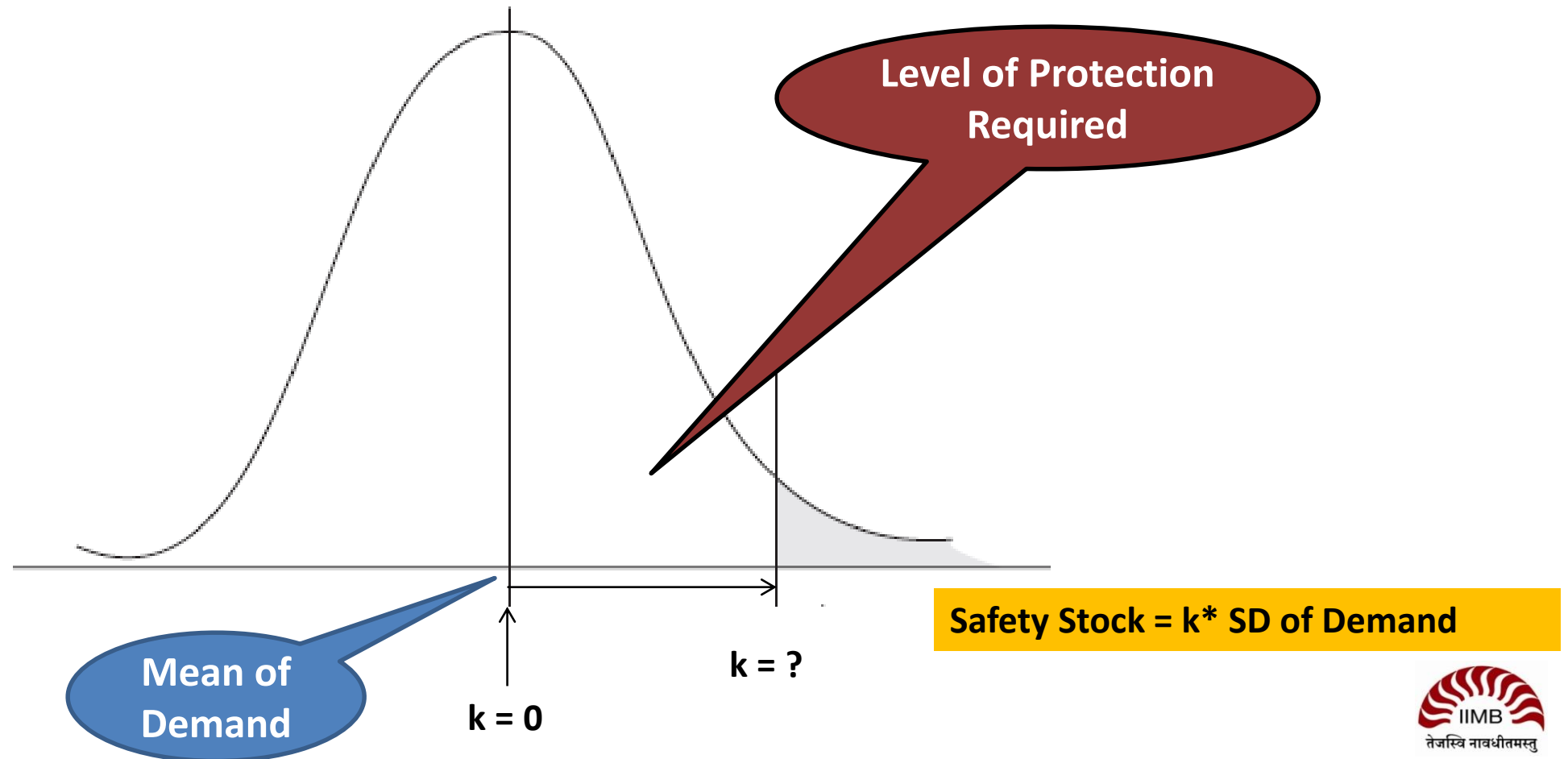
Order-Up to-Level Inventory System

Handling Demand Uncertainty

- In order to handle Demand Uncertainty:
 - Mean of the demand (μ) per unit time
 - Standard Deviation of the Demand (σ) per unit time
 - Desired Level of Protection ($\alpha =$ % of occasions of “no stock out”)
- Once we know these three, we can compute the required parameters for the model.

Fixing Safety Stock

Conceptual Basis



Fixing Order-Up to-Level

A step-by-step computational methodology

- **Step 0:**

- Decide on the desired level of protection (α)
- Estimate the current inventory position (IP)

(IP = Inventory on Hand + Inventory on Order)

- **Step 1:** Compute the Mean of Demand (MD) and Standard Deviation

(SD) of Demand during $(R + L)$ time periods:

- $MD = \mu * (R + L)$
- $SD = \sigma * \sqrt{(R + L)}$

Fixing Order-Up to-Level

A step-by-step computational methodology

- **Step 2**: Compute the Safety Stock (SS)
 - $k = \text{NORM.S.INV}(\alpha)$
 - $SS = \{k * SD\}$
 - $\text{NORM.S.INV}(\alpha)$ = Normal Variate for a desired level of protection (α)
- **Step 3**: Compute the Order up to Level (S)
 - $S = MD + SS$
- **Step 4**: How Much to Order?
 - $Q = S - IP$

Order-Up to-Level Inventory System

Numerical Illustration

- Mean Weekly Demand = 200
- Standard Deviation of Weekly Demand = 40
- Review Period = 2 Weeks
- Lead Time for Supply = 2 Weeks
- Desired Level of Protection = 95%
- Let us say that:
 - We are reviewing on 16th April
 - We need to decide **how much to order**

Order-Up to-Level Inventory System

Numerical Illustration (cont.)

Step 0:

- Desired level of protection (α) = 95%
- Current inventory position (IP) = (say) 475

Step 1:

- $MD = \mu * (R + L) = 200 * (2+2) = 800$
- $SD = \sigma * \sqrt{(R + L)} = 40 * \sqrt{(2 + 2)} = 40 * 2 = 80$

Step 2: Compute the Safety Stock (SS)

- $k = \text{NORM.S.INV}(0.95)^\# = 1.645$
- $SS = \{k * SD\} = 1.645 * 80 = 131.6 \cong 132$

Step 3: Compute the Order up to Level (S)

- $S = MD + SS = 800 + 132 = 932$

Step 4: How Much to Order?

- $Q = S - IP = 932 - 475 = 457$

Reverse Supply Chain

Concept & Issues

Section 3, Section 3.5

Reverse Supply Chain

A case in point

- The amount of e-waste generated in Bangalore alone is estimated to be 200,000 tons.
- Although highly toxic and dangerous, e-waste has precious metals such as gold and platinum.
 - A typical mobile phone may contain about 250 grams of silver, 24 mg of gold and 9 mg of palladium.
 - A Laptop contains in addition to gold and silver substantial amounts of copper.
- Cerebra Integrated Technologies, a Bangalore based company is building India's largest e-waste recycling plants to extract these precious metals.
- The plant when fully become operational will be able to process 90,000 tons of e-waste.

Reverse Supply Chain

Context

- Over the recent past there has been growing concern on the impact of business on environment.
 - Depletion of natural resources, waste generated from production and service systems and at the end-of-life of products.
- Increasingly, firms are under pressure to take responsibility for restoring, sustaining and expanding the planet's ecosystem instead of merely exploiting them.

Reverse Supply Chain

Legislative angle

In the last ten years we see a multifaceted approach to tackle the problem of environmental protection and sustenance.

- Policy makers have brought in new legislations that put regulatory pressures on businesses as a means to tackle the problem.
- The legislations based on 'extended producer responsibility' requires that business organizations need to take responsibility for 'take back of products at the end-of-life'.

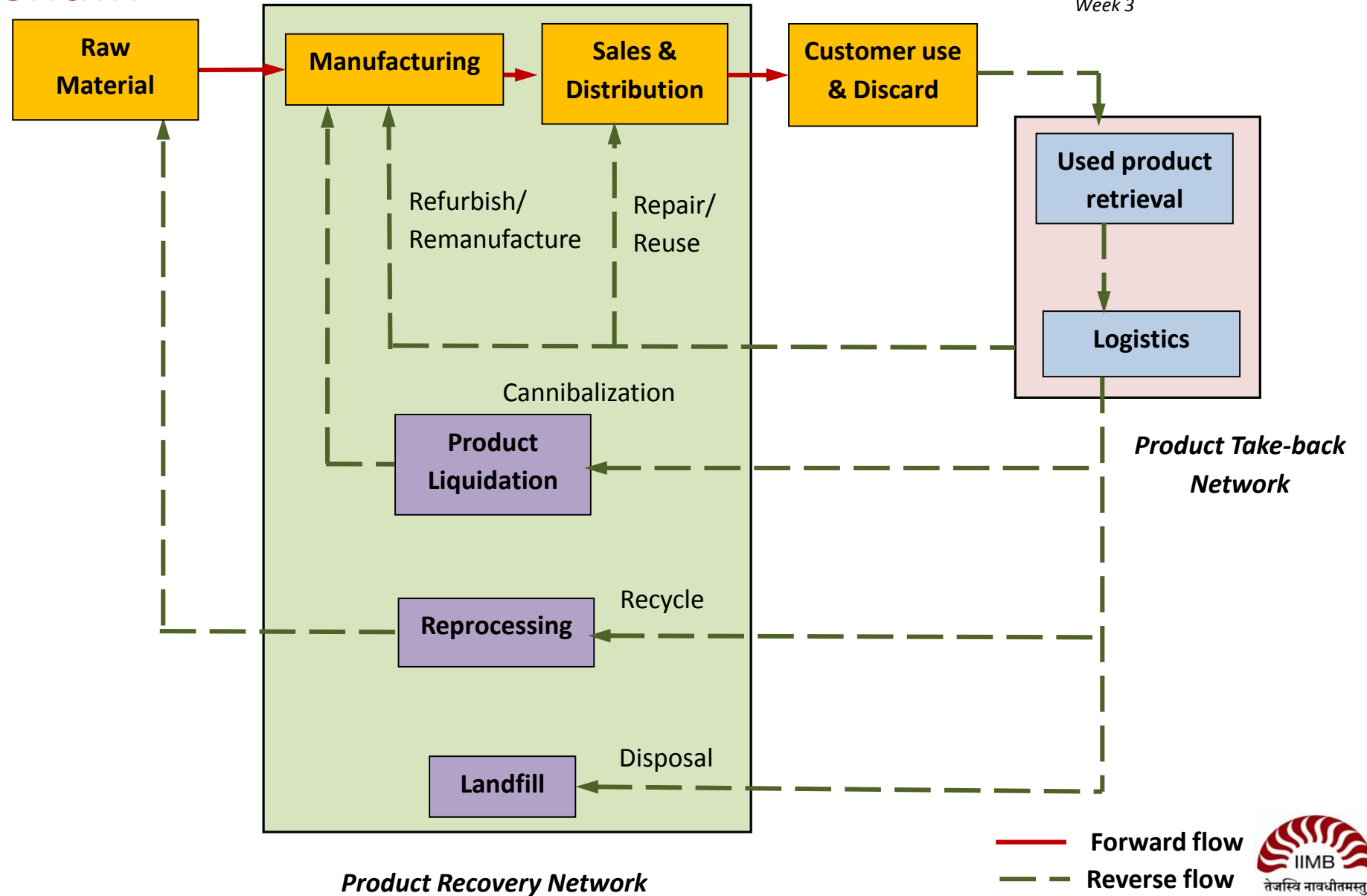
Reverse Supply Chain

Implications for Business

- What happens when we take back the used products?
- Steps will be required to discover economic value out of them.
- Dis-assembly of used products will be as important as assembly of new products in a manufacturing system.
- Remanufacturing, Refurbishing and Recycling will become important elements in an operations system.
- Importance of a Reverse Supply Chain.

Reverse Supply Chain

A schematic Representation



Reverse Supply Chain

Entities & Their Roles

Multiple entities are involved in a reverse logistics network and have multiple goals and motivation to participate.

- The customer and the regulatory agencies are important entities in reverse logistics.
- In the Product Recovery Network, players have different roles to play.
- The OEMs may take part in all of the product recovery activities such as repair, refurbish, remanufacture, and recycle.
- Alternatively, they may contract these activities to other players.
- If there are enough economic incentives, third-party agencies may collect and recover used products and sell them to secondary market.

On account of these, reverse supply chain planning is far more complex than the forward supply chain.

Reverse Supply Chain

Issues & Challenges

- Complexity in assessing the inflow of used products and the divergent spread of the end use customers.
 - How are organizations likely to handle this?
- Two streams for raw material – one the new component from the forward supply chain and the other used component recovered from a discarded final product.
 - How are we to handle the associated inventory control problems?
- Since there are multiple players and multiple arrangements among these players possible, how are the product recovery activities ultimately organized among various entities?

Supply Chain Management

Module Highlights

Supply Chain Module

Highlights

- Every organization will have a supply chain - simply because multiple entities get together to create value for the end customer.
- SCM pertains to the design and operational aspects of dealing with these multiple entities.

Supply Chain Module

Highlights

Design of a supply chain critically depends on the profile of the products and services that we offer to the customers.

- An innovative product or a service may need a responsive supply chain.
- A functional product on the other hand may need a functional supply chain.
- There are certain features each of these supply chain may need.

Supply Chain Module (cont.)

Highlights

- The number of layers in a supply chain is an important aspect of supply chain design.
 - This may lead to bullwhip effect and we may have to take counter-measures to tackle this.
- Several Services have three unique characteristics which may influence the supply chain design. This includes:
 - Simultaneity in Production & Consumption
 - Non-existence of inventory in the system
 - People Oriented and People Intensive nature of business
- These may call for newer dimensions in supply chain design & operation.

Supply Chain Module (cont.)

Highlights

- Inventory Planning & Control could be done using the EOQ model and other extensions for handling several real life situations.
- Reverse Supply Chain is a important issue for the future, given major concerns about sustainability of business operations.