BA4055 **WAREHOUSE MANAGEMENT** **L T P C**
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COURSE OBJECTIVES:

- To help the students in explaining the significance of Warehousing.
- To provide timely customer service,
- To keep track of items so they can be found readily & correctly
- To minimize the total physical effort
- To minimize the cost of moving goods in & out of stage.

UNIT - I **INTRODUCTION WAREHOUSING** **9**

Introduction Warehousing – Basic Warehousing Decisions – Warehouse Operations – Types of Warehouses – Functions – Centralized & Decentralized – S rage Systems – Warehousing Cost Analysis – Warehouse Layout – Characteristics if Ideal Warehouse

UNIT - II **INVENTORY MANAGEMENT** **9**

Inventory: Basic Concepts – Role in Supply Chain – Role in Competitive Strategy – Independent Demand Systems – Dependent Demand Systems – Functions – Types _ Cost – Need for Inventory – Just in Time

UNIT - III **INVENTORY CONTROL** **9**

Inventory Control – ABC Inventory Control – Multi-Echelon Inventory Systems – Distribution Requirement Planning – Bull Whip Effect – Using WMS for Managing Warehousing Operations

UNIT – IV **MATERIALS HANDLING** **9**

Principles and Performance Measures Of Material Handling Systems – Fundamentals of Material Handling – Various Types of Material Handling Equipments – Types of Conveyors – Refrigerated Warehouses- Cold Chain- Agri SCM

UNIT – V **MODERN WAREHOUSING METHODS** **9**

Modern Warehousing – Au mated S rage & Retrieval Systems & their Operations – Bar Coding Technology & Applications in Logistics Industry – RFID Technology & Applications – Advantages of RFID

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to get complete insight in to warehouse concepts, various inventory control techniques and application of inventory management in supply chain.

TEXT BOOKS:

1. Vinod.V.Sople, Logistics Management, Pearson Education, 2004.
2. Arnold, Introduction Materials Management, Pearson Education, 2009.

REFERENCES:

1. Frazelle, World Class Warehousing & Material Handling, Tata McGraw-Hill, 2008
2. Satish K. Kapoor and PurvaKansal, Basics of Distribution Management - A Logistical Approach, Prentice Hall, 2003
3. Satish K. Kapoor and PurvaKansal Marketing, Logistics - A Supply Chain Approach , Pearson Education, 2003

Warehouse Management

UNIT - I
INTRODUCTION WAREHOUSING

Introduction Warehousing – Basic Warehousing Decisions – Warehouse Operations – Types of Warehouses – Functions – Centralized & Decentralized – S rage Systems – Warehousing Cost Analysis – Warehouse Layout – Characteristics if Ideal Warehouse

1. Introduction ware housing:

Warehousing is a critical component of supply chain management that involves the storage and management of goods and materials. It plays a pivotal role in ensuring the efficient flow of products from manufacturers to consumers. Warehouses are designed to store, organize, and protect goods, and they often serve as hubs for inventory management, order fulfillment, and distribution. Warehouses come in various types, including distribution centers, fulfillment centers, and cold storage facilities, each tailored to specific industry needs. Effective warehousing strategies help optimize inventory levels, reduce operational costs, and enhance customer satisfaction through timely and accurate order processing.

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2. Basic warehousing decisions:

Warehousing decisions are crucial for businesses to efficiently manage their inventory and logistics. These decisions include:

1. **Location:** Choosing the right location for a warehouse is vital. Factors like proximity to suppliers, customers, transportation hubs, and cost considerations should be evaluated.

2. **Layout and Design:** The warehouse layout should optimize storage space, accessibility, and workflow. Considerations include racking systems, shelving, and aisle design.

3. **Storage Systems:** Select appropriate storage systems based on the nature of the goods. Options include pallet racks, shelving, mezzanines, and automated systems.

4. **Inventory Management:** Implement efficient inventory control systems to track stock levels, orders, and reorder points. This reduces overstocking and stockouts.

5. **Material Handling:** Choose equipment like forklifts, conveyors, and automated systems to handle materials within the warehouse effectively.

6. **Technology:** Employ warehouse management systems (WMS) and barcoding for accurate tracking and management of inventory.

7. **Security:** Implement security measures to protect goods from theft and damage.

8. **Staffing:** Hire and train personnel for efficient warehouse operations, including order picking, packing, and shipping.

9. **Transportation:** Coordinate warehouse operations with transportation systems for seamless distribution.

10. **Cost Analysis:** Continuously assess operational costs, including rent, labor, utilities, and maintenance, to identify areas for cost reduction.

Optimizing these warehousing decisions is essential for businesses to maintain efficient operations and customer satisfaction.

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3. Warehouse operations:

Warehouse operations involve the management and control of various activities within a warehouse, including:

1. Receiving: Receiving, inspecting, and documenting incoming goods.
2. Storage: Properly storing items, often using shelving, racking, or bin systems.
3. Order Picking: Selecting items from storage to fulfill customer orders.
4. Packing: Packaging items for shipment, ensuring they are secure and protected.
5. Shipping: Arranging transportation and loading goods for delivery.
6. Inventory Management: Tracking and maintaining stock levels.

7. Quality Control: Ensuring product quality and integrity.
8. Security: Safeguarding against theft and damage.
9. Space Optimization: Maximizing warehouse space for efficiency.
10. Technology Integration: Using software and automation for better operations.

Efficient warehouse operations are essential for businesses to meet customer demands and control costs.

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4**. Types of warehouses**

There are several types of warehouses, each designed for specific purposes. Some common types include:

1. **Public Warehouses:** These are third-party facilities that offer storage and distribution services to multiple businesses.

2. **Private Warehouses:** Owned and operated by a single company to store their own goods and products.

3. **Cold Storage Warehouses:** Designed for storing perishable items like food, pharmaceuticals, and other temperature-sensitive products.

4. **Distribution Centers:** These facilities focus on efficiently distributing products to customers or retail locations.

5. **Automated Warehouses:** Utilize automation technology like robots and conveyor systems for tasks such as picking, packing, and stacking.

6. **Bulk Storage Warehouses:** Primarily used for storing large quantities of non-perishable goods, such as grains, minerals, or construction materials.

7. **Cross-Docking Warehouses:** Products are received and immediately shipped out to their destination without long-term storage.

8. **E-commerce Fulfillment Centers:** Specialized warehouses for online retailers to manage order processing and shipping.

9. **Retail Warehouses:** Used by retailers to store excess inventory and restock store shelves.

10. **Manufacturing Warehouses:** Store raw materials, components, and finished products for manufacturing processes.

The choice of warehouse type depends on the specific needs of a business and the nature of the products they handle.

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5. Warehouse functions

Warehouses play a crucial role in the supply chain and logistics process. Various functions are performed within a warehouse to ensure efficient storage, handling, and distribution of goods. Here are some key warehouse functions:

1. **Receiving:**
   - Unloading incoming shipments from suppliers.
   - Checking and verifying the quantity and quality of received goods.
   - Recording and documenting received inventory.
2. **Storage:**
   - Allocating space for different types of products.
   - Organizing goods based on factors like SKU (Stock Keeping Unit), size, or demand.
   - Implementing efficient storage systems, such as racking or shelving.
3. **Picking:**
   - Selecting items from storage locations to fulfill customer orders.
   - Utilizing various picking methods, such as batch picking, zone picking, or wave picking, to optimize efficiency.
4. **Packing:**
   - Preparing items for shipment by packaging them securely.
   - Labeling packages with appropriate shipping information.
   - Documenting and updating inventory levels after packing.
5. **Shipping:**
   - Coordinating the dispatch of goods to customers or other destinations.
   - Generating shipping documents and labels.
   - Choosing the most cost-effective and timely shipping methods.
6. **Order Processing:**
   - Managing and processing customer orders.
   - Verifying order accuracy before picking and packing.
   - Updating inventory levels in real-time as orders are processed.
7. **Inventory Control:**
   - Conducting regular stock counts and audits.

- Implementing inventory management systems to track stock levels.
- Identifying and addressing discrepancies or shrinkage.

8. **Quality Control:**
   - Inspecting incoming goods for damage or defects.
   - Implementing quality assurance processes to ensure the accuracy and condition of products.
9. **Returns Processing:**
   - Managing the return of defective or unwanted products.
   - Inspecting returned items for usability or potential restocking.
   - Updating inventory records accordingly.
10. **Cross-Docking:**
    - Transferring goods directly from inbound to outbound shipping points without storage.
    - Minimizing storage time to speed up the distribution process.
11. **Safety and Security:**
    - Implementing safety protocols to ensure a secure working environment.
    - Preventing theft, damage, or loss of inventory through security measures.
12. **Technology Integration:**
    - Implementing warehouse management systems (WMS) for real-time tracking and management.
    - Using technology such as barcode scanners, RFID (Radio-Frequency Identification), and automated systems to improve efficiency.

Efficient warehouse management is critical for businesses to meet customer demand, minimize costs, and streamline their overall supply chain operations. The specific functions performed can vary depending on the type of products stored, the industry, and the size of the warehouse.

6. Centralized & decentralized:

Centralized and decentralized are two contrasting approaches in various contexts, including governance, technology, and organizations.

1. **Centralized**:

- In a centralized system, authority and decision-making power are concentrated in a single or a few entities.
- It often leads to efficient control and coordination but can be less flexible and responsive.

- Examples include a traditional hierarchical organization structure and centralized government systems.

2. **Decentralized:**

- Decentralization involves distributing authority and decision-making across multiple levels or entities.
- It can promote adaptability and innovation but might lead to coordination challenges.
- Examples include decentralized blockchain networks and organizations that use flat or matrix management structures.

The choice between centralized and decentralized approaches depends on the specific context and goals, with some systems even using a combination of both (hybrid models).

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7. Warehousing cost:

Analyzing warehousing costs typically involves considering various factors, including:

1. **Fixed Costs:**

- **Facility Costs**:** Expenses related to leasing, owning, or maintaining the warehouse space.
- **Equipment Costs**:** Expenses for forklifts, shelving, conveyors, and other necessary machinery.
- **Insurance and Security**:** Costs for protecting the warehouse and its contents.

2. **Variable Costs:**

- **Labor**:** Costs associated with hiring, training, and compensating warehouse staff.
- **Utilities**:** Expenses for electricity, water, and heating/cooling.
- **Maintenance**:** Ongoing costs for repairing and servicing equipment.
- **Supplies**:** Expenses for pallets, packaging materials, and other consumables.
- **Transportation**:** Costs related to inbound and outbound shipments.

3. **Inventory Costs:**

- **Carrying Costs**: Expenses for storing inventory, including interest, insurance, and taxes.
- **Obsolescence and Shrinkage**: Costs associated with damaged or expired goods.
- **Handling Costs**: Expenses for moving and managing inventory.

4. **Technology Costs:**

- **Warehouse Management System (WMS)**: Expenses for WMS software and hardware.
- **Barcode/RFID Systems**: Costs for tracking and managing inventory.

5. **Regulatory and Compliance Costs:**

- Expenses related to adhering to safety, environmental, and other regulations.

6. **Space Utilization:**

- Analyzing how efficiently the warehouse space is utilized can reveal opportunities for cost savings.

7. **Demand Fluctuations:**

- Consider how seasonal or demand variations affect labor and inventory costs.

8. **Optimization:**

- Evaluate opportunities to streamline

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8. Warehousing layout:

Warehouse layout refers to the arrangement of storage, processing, and operational areas within a warehouse. It plays a crucial role in optimizing the efficiency and productivity of warehouse operations. There are several common warehouse layouts, including:

1. **Flow-Through Layout**: Goods enter at one end of the warehouse and exit at the other. It's efficient for high-throughput operations but may not be suitable for storage.

2. **Cross-Docking Layout**: Incoming goods are immediately loaded onto outbound trucks, with minimal storage. It's used for fast distribution.

3. **Bulk Storage Layout**: Ideal for large quantities of similar products, it involves stacking products on racks or shelves.

4. **Bin and Rack System**: Smaller items are stored in bins or on racks for easy picking and retrieval.

5. **Aisle-First Layout**: This design uses wide aisles, suitable for forklifts and other equipment to move easily. It allows for high-density storage and efficient order picking.

6. **Mezzanine Layout**: Utilizes a mezzanine level for additional storage or office space, effectively doubling the available space.

7. **Automated Layout**: Incorporates automated storage and retrieval systems (AS/RS) for efficient, high-density storage and retrieval.

The choice of layout depends on factors such as the type of products, the volume of goods, the order fulfillment process, and the available technology. An effective warehouse layout can significantly impact operational efficiency and reduce costs.

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9. Ideal warehousing:

An ideal warehouse is characterized by several key features that optimize its functionality and efficiency. Firstly, it should be strategically located to minimize transportation costs and provide easy access to suppliers and customers. The layout and design of the warehouse should be organized for efficient storage and retrieval of goods, with well-defined storage areas and clear aisleways.

Furthermore, an ideal warehouse should incorporate advanced technology and automation systems for inventory management and tracking, reducing errors and streamlining operations. Safety is paramount, with proper lighting, ventilation, and safety protocols in place to protect both workers and inventory. Climate control may be necessary for certain goods to prevent damage.

Scalability is also crucial, allowing the warehouse to adapt to changing business needs. Effective security measures, including surveillance and access controls, are essential to safeguard valuable inventory. Lastly, a well-trained and skilled workforce is necessary to operate the warehouse effectively, ensuring accurate order fulfillment and timely distribution.

UNIT - II

INVENTORY MANAGEMENT

Inventory: Basic Concepts – Role in Supply Chain – Role in Competitive Strategy – Independent Demand Systems – Dependent Demand Systems – Functions – Types _ Cost – Need for Inventory – Just in Time

Inventory:

Inventory refers to the stock of goods, materials, or products held by a business for various purposes. Here are some basic concepts related to inventory:

1. Types of Inventory:

- Raw Materials: Items used in manufacturing.
- Work in Progress (WIP): Partially finished products.
- Finished Goods: Completed products ready for sale.
- MRO (Maintenance, Repair, and Operations): Items for maintaining operations.
- Safety Stock: Extra inventory to prevent shortages.

2. Inventory Valuation Methods:

- FIFO (First-In-First-Out): Oldest items are sold first.
- LIFO (Last-In-First-Out): Newest items are sold first.
- Weighted Average: Cost is an average of all items.
- Specific Identification: Each item is individually priced.

3. Inventory Costs:

- Holding (Carrying) Costs: Expenses to store and manage inventory.
- Ordering Costs: Costs associated with placing and receiving orders.
- Shortage Costs: Costs incurred due to stockouts or low inventory.

4. Inventory Turnover: The rate at which inventory is used or sold. High turnover is generally more efficient.

5. Economic Order Quantity (EOQ): The optimal order quantity that minimizes total inventory costs.

6. Just-In-Time (JIT): A system that aims to reduce inventory levels by receiving goods just when they are needed.

7. ABC Analysis: Classifies items into categories (A, B, C) based on their importance, helping prioritize inventory management.

8. Stock Keeping Unit (SKU): A unique identifier for each inventory item, facilitating tracking and control.

9. Perpetual vs. Periodic Inventory Systems: Perpetual updates inventory continuously, while periodic counts and updates periodically.

10. Safety Stock: Extra inventory kept as a buffer against demand variability and lead time uncertainties.

Efficient inventory management is crucial for businesses to balance costs, ensure product availability, and meet customer demands.

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11. Inventory basic concepts:

In a supply chain, my role can vary depending on the context and the specific needs of the supply chain participants. Some potential roles I can play include:

1. Demand Forecasting: I can analyze data and trends to help forecast demand for products, allowing companies to plan their production and inventory management accordingly.

2. Inventory Management: I can assist in optimizing inventory levels, ensuring that businesses have the right amount of stock to meet customer demand while minimizing carrying costs.

3. Order Processing: I can automate order processing tasks, making it more efficient and reducing errors in the order-to-cash cycle.

4. Supplier Relationship Management: I can help monitor and manage relationships with suppliers, ensuring timely deliveries and quality control.

5. Data Analytics: I can analyze supply chain data to identify areas for improvement, cost savings, and efficiency enhancements.

6. Route Optimization: I can assist in optimizing transportation routes to reduce shipping costs and delivery times.

7. Risk Management: I can help identify and mitigate risks in the supply chain, such as disruptions due to natural disasters, geopolitical events, or other factors.

8. Customer Service: I can enhance customer service by providing information about order status and delivery times.

My role in the supply chain is adaptable and can involve various tasks to streamline and improve the overall supply chain process.

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12. Role in supply chain:

In competitive strategy, your role depends on whether you are a business leader, manager, or analyst. Here are a few key roles and concepts:

1. **Business Leader (CEO, Founder):** Your role is to set the overall direction and vision for the company. You make high-level strategic decisions, such as choosing the company's competitive positioning, identifying target markets, and deciding on broad strategic initiatives.

2. **General Manager/Division Head:** If you're responsible for a specific business unit or division, you play a critical role in implementing the company's competitive strategy within your domain. You oversee operational decisions, allocate resources, and ensure alignment with the broader strategy.

3. **Marketing and Sales:** These teams are responsible for understanding customer needs, market trends, and competitive positioning. They develop strategies to reach and engage customers effectively, emphasizing the company's unique value proposition.

4. **Operations and Supply Chain:** This department ensures efficient production and distribution of products or services. Their role is critical for cost

management and ensuring products reach customers as promised, contributing to the competitive advantage.

5. **Finance and Budgeting:** Finance teams play a crucial role in resource allocation, budgeting, and financial planning. They support competitive strategy by making sure investments align with the strategic objectives.

6. **Competitive Analysis:** Analysts or specialized teams monitor the competitive landscape, identifying strengths and weaknesses of competitors, market trends, and potential opportunities or threats. Their insights inform strategic decisions.

7. **Innovation and R&D:** Driving innovation is essential for maintaining a competitive edge. Research and development teams focus on creating new products or improving existing ones to stay ahead in the market.

8. **Human Resources:** HR ensures the company has the right talent, culture, and structure to execute the competitive strategy. They hire, develop, and retain employees who contribute to the company's competitive advantage.

9. **Technology and IT:** Information technology supports the execution of various competitive strategies, whether through data analysis, process automation, or digital transformation.

10. **Risk Management and Compliance:** Assessing and mitigating risks, including legal and regulatory compliance, is crucial in maintaining a sustainable competitive position.

Each role within an organization contributes to the development and execution of a competitive strategy, with the ultimate goal of achieving a sustainable advantage over rivals in the marketplace.

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13. Role in competitive strategy

Independent demand systems refer to a type of inventory management approach where the demand for a product is influenced by external factors and is not directly tied to the demand for other products. In other words, the demand for

these items is considered independent of other items in the inventory. Independent demand items are typically managed using techniques like Economic Order Quantity (EOQ) and reorder point analysis to determine optimal inventory levels and reorder points, taking into account factors such as lead times, demand variability, and service levels. This is in contrast to dependent demand systems, where the demand for an item is directly related to the demand for another item, such as components required for manufacturing a finished product.

14. Independent demand system:

A dependent demand system refers to a type of inventory management where the demand for an item is dependent on the demand for another item. It is in contrast to independent demand systems, where demand is driven by external factors such as customer orders. Dependent demand items are typically components or sub-assemblies that are used in the production of finished goods.

Key points about dependent demand systems:

1. Bill of Materials (BOM): In a dependent demand system, a Bill of Materials (BOM) is used to specify the components and their quantities required to manufacture a finished product. The BOM defines the hierarchical structure of the product and its components.

2. Material Requirements Planning (MRP): MRP is a common method used to manage dependent demand. It involves calculating the requirements for each component based on the production schedule for the finished product, lead times, and inventory levels.

3. Master Production Schedule (MPS): The MPS outlines the production schedule for finished goods, which drives the demand for the components listed in the BOM. This schedule helps in determining when and how much of each component is needed.

4. Just-in-Time (JIT): Some companies implement a Just-in-Time approach to minimize inventory costs in dependent demand systems. Components are ordered and received just in time for production, reducing the need for extensive warehousing.

5. Safety Stock: Safety stock is sometimes used for critical components to account for uncertainties in demand and lead times. It ensures that there are no production disruptions due to component shortages.

Overall, dependent demand systems are commonly used in manufacturing to efficiently manage the supply of components needed for production, reducing excess inventory and costs.

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16. Functions of cost

The functions of cost in economics can be categorized into three main types:

1. **Accounting Costs:** These are the actual, measurable expenses a firm incurs in its day-to-day operations. They include explicit costs, such as rent, wages, raw materials, and depreciation.

2. **Economic Costs:** Economic costs go beyond accounting costs by considering both explicit and implicit costs. Implicit costs represent the opportunity cost of using resources for a particular business endeavor. For example, if a business owner invests their own money and time into their business, the economic cost includes the earnings they could have made elsewhere.

3. **Cost Functions:** Cost functions describe the relationship between the level of production and the cost of producing that level. They can be expressed as mathematical equations to help businesses analyze and optimize their cost structures. Common cost functions include total cost, average cost, and marginal cost.

Understanding these cost functions is essential for businesses and economists to make informed decisions regarding production, pricing, and resource allocation.

Types of cost:

There are various types of costs in business and economics. Here are some common categories:

1. **Fixed Costs**: These are costs that remain constant regardless of the level of production. Rent, salaries, and insurance are examples.

2. **Variable Costs**: These costs change with the level of production. For instance, the cost of raw materials or labor directly tied to production.

3. **Total Costs**: The sum of fixed and variable costs.

4. **Marginal Costs**: The additional cost incurred by producing one more unit.

5. **Average Costs**: The cost per unit, calculated by dividing the total cost by the number of units produced.

6. **Explicit Costs**: Actual out-of-pocket expenses, like purchasing materials.

7. **Implicit Costs**: Opportunity costs, often related to using resources owned by the company, like the owner's time or equipment.

8. **Direct Costs**: Costs directly traceable to a particular product or project.

9. **Indirect Costs**: Costs not directly traceable to a specific product, often related to overhead.

10. **Sunk Costs**: Costs that have already been incurred and cannot be recovered.

11. **Variable and Fixed Costs**: Costs can also be classified into these two broad categories.

12. **Opportunity Costs**: The value of the next best alternative foregone when a decision is made.

Understanding these cost types is crucial for effective financial management and decision-making in business.

17. **Need for inventory:**

Inventory is essential for businesses to meet customer demand, maintain smooth operations, and capitalize on cost-efficiency. It helps ensure product availability,

buffer against supply chain disruptions, and allows for bulk purchasing, but excessive inventory ties up capital. Finding the right balance is crucial for profitability.

1. **Meeting Customer Demand:** Inventory ensures that a business has the products or materials on hand to meet customer demand in a timely manner. Without sufficient inventory, you risk running out of products, leading to lost sales and dissatisfied customers.
2. **Smoothing Production and Supply Chain:** Manufacturers need inventory to smooth out variations in production rates and supply chain disruptions. Maintaining buffer stock can help mitigate the impact of delays in raw material deliveries or unexpected spikes in demand.
3. **Cost Savings:** Buying inventory in bulk can lead to cost savings through economies of scale. Businesses can often negotiate better prices with suppliers when purchasing larger quantities.
4. **Seasonal and Cyclical Demand:** Many businesses experience seasonal or cyclical fluctuations in demand. Maintaining inventory allows them to stock up during slow periods and be prepared for high-demand seasons.
5. **Buffer Against Uncertainty**: Inventory acts as a buffer against uncertainty. This can include unexpected changes in demand, supply chain disruptions, or production issues. Having inventory on hand provides flexibility to adapt to these situations.
6. **Production Efficiency:** Manufacturers need raw materials and components readily available for production. A well-managed inventory system ensures that production lines can operate efficiently without frequent interruptions.
7. **Just-In-Time (JIT) Inventory:** Some businesses use JIT inventory systems to minimize carrying costs. However, even JIT systems rely on maintaining minimal levels of inventory to ensure that production is not disrupted.
8. **Safety Stock:** Safety stock is extra inventory kept on hand to mitigate the risk of stockouts due to unforeseen factors, such as unexpected demand spikes or supply chain disruptions.
9. **Economies of Transportation:** Economies of scale in transportation costs can be achieved by shipping larger quantities of goods at once. Maintaining inventory can help reduce transportation costs per unit.
10. **Strategic Product Positioning**: Businesses strategically position inventory to be closer to customers or retailers, reducing lead times and transportation costs.
11. **Trade-Off Between Holding Costs and Ordering Costs:** Inventory management involves finding the right balance between holding costs (the cost of storing inventory) and ordering costs (the cost of placing orders and receiving shipments). Efficient inventory management optimizes this trade-off.
12. **Data and Analytics:** Inventory data provides valuable insights into consumer behavior, product performance, and supply chain efficiency. It can be used to make informed decisions and improve overall business operations.

UNIT - III

INVENTORY

CONTROL

What is inventory control?

Inventory control, also called stock control, is the process of managing a company's inventory levels, whether that be in their own warehouse or spread over other locations. It comprises management of items from the time you have them in stock to their final destination (ideally to customers) or disposal (not ideal). An inventory control system also monitors their movement, usage, and storage.

Inventory control means managing your inventory levels to ensure that you are keeping the optimal amount of each product. Proper inventory control can keep track of your purchase orders and keep a functional supply chain. Systems can be put in place to help with forecasting and allow you to set reorder points, too.

Inventory control can include:

- Barcode scanner integration
- Complete inventory counts
- Keeping track of physical inventory with sales and purchase orders
- Product details, locations, and histories
- Reports and adjustments

The general goal is to maximize your profits while the least amount of inventory possible is sitting in your warehouse. Your business must do this without compromising customer satisfaction. While you can handle inventory control manually, there are automated systems that take the responsibility of managing your stock levels, and help eliminate costly human error.

Why is Inventory Control important?

Here are some ways inventory control is important for your business so you can gain an inherent understanding of the purpose of inventory control.

Quality control

Having an inventory management system allows you to implement greater quality control. If you can track and manage all aspects of your stock, you better control quality. The longer you hold inventory, the more likely it is to get damaged. You can avoid that by ensuring that stock gets rotated through your warehouse.

Inventory control techniques also allow you to track the quality of stock you receive from suppliers. How often do you have certain products returned? How often are those that are returned sent back because they break or have other defects? Seeing how products move through your inventory can point to any problems, and help you eliminate write-offs.

Organizational control

Inventory control means that you have organizational control in your business. A well-organizedstockroom lets you manage your merchandise and make the most of your investment in physical

inventory. This aspect of inventory control is vital for knowing where your stock is and the expediencywith which you can access it.

Inventory control in terms of the organization of your stock is vital for the proper running of your company. It will ensure that you have enough units to fulfill orders and have safety stock. Effective inventory control techniques will also help you avoid having any dead stock or overstock. Safety stock acts as a buffer to reduce the risk of an item being out of stock. Dead stock is inventory that doesn't sell. Which explains in a nutshell why inventory control is required.

Accounting accuracy

Keeping an accurate record of your inventory is vital for managing your assets. It will also help you in the event of an audit. Knowing what you have in assets allows you to know your overall spoilage and understand the value of your company.

Financial accounting rules and tax regulations may mandate your company to have a physical inventory account. All stock should have correct numbers and pricing in your inventory systems and your accounting software. This will ensure your company can go through audits without any questionto your business's accounting integrity.

How do you control inventory cost?

Inventory control software helps to record stock, packing, and shipping information in one place and, therefore, optimizes your business's procurement process. Real-time updates on stock movements can help you automate control of stock levels for accurate sales performance and inventory analytics. All of that helps you to control inventory costs.

Challenges of inventory control

Inventory control is vital for effective business operations. It can also come with challenges. It may seem difficult to find the time and resources, and developing a complete picture of your inventory can be difficult, especially if you have a larger company or multiple inventory locations.

However, these challenges can be overcome to ensure effective control over your inventory. The best way to manage all these challenges is to automate your inventory control process. Look into the bestinventory management software for your business.

Below are a few of the challenges you may

face. Finding the time and resources

Doing inventory management manually requires substantial resources. Money and staff hours are required for manual inventory control. However, if you do not prioritize inventory control, you will lose more time and money later on. Take the time to implement a regular schedule to dedicate to inventory control. Also, make sure to include inventory control in your budget.

Visibility

Companies with large stock, complex warehousing, or that are selling on multiple channels can have many moving parts to their inventories. This can create challenges with visibility. Businesses must have a complete picture of their business's inventory for replenishment,

to dead stock. This is why it's essential to learn how to control warehouse inventory.The reports you can obtain through inventory control software systems can help you improve visibility. For instance, you can get alerts when inventory level is low Having high visibility on how your inventory moves limits obsolete stock and helps determine how much inventory of each product you keep to meet customer demand.

Human error

Human errors are unavoidable when businesses have a constant flow of inventory in and out of their warehouses. For example, vendors need to send accurate invoices and they need to be matched with purchase orders and physical inventory. Any inaccuracies that occur at this stage can impact your inventory control.

You can mitigate human error by the optimization of your inventory control system and integrating your solutions. This will allow your software to alert you if there are any discrepancies between what was entered in the accounts payable and the physical inventory counts.

Inventory control systems

There are a number of types of inventory control systems and related techniques that businesses canutilize. So, what are the types of inventory control that your business needs?

Each has benefits and disadvantages based on your inventory size and company operations. Retailers may find that they have different needs to a wholesaler, for instance. Start by defining your business goals and metrics to get an idea of your current and future needs and pick an ideal inventory control method.

Then, determine if your business should

use a:Spreadsheet to control inventory

The use of a spreadsheet as a manual inventory control technique works best for smaller businesses that don't keep much stock or have a lot of different kinds of inventory. Keeping a spreadsheet is less expensive than the other two, but inventory control can be harder to maintain. Your team members will not, though, have to spend time learning to use an automated system for inventory control purposes.

While you may feel it gives you a better sense of control, manual inventory control through the use of a spreadsheet is far more prone to human error and is labor-intensive. Supply chain management may also be harder to maintain because it will require an employee to keep track of multiple moving parts. The replenishment of stock will also be harder to track in a manual system.

Periodic inventory system

A periodic inventory system usually relies on physical inventory counts. Inventory information is updated periodically when a physical count is conducted. This type of inventory control system is super time-consuming for businesses that deal with large amounts of inventory or frequent inventory moves. However, inventory control methods like this can work for companies that don't handle manyorders.

Periodic inventory generally uses the formula:

Cost of Goods Sold (COGS) = (Beginning Inventory + Purchases) – Closing Inventory.

This inventory control system is easy to implement and requires minimal information. However, your stock levels will rarely be up to date, leading to delays and increased write-offs. It also relies on inventory audits rather than an automated system that updates in real-time.

Perpetual inventory system

Perpetual inventory systems update your stock in real-time when a transaction happens or new stock is received through technology solutions. Around 72% of all retailers plan to adopt real-time visibility in their supply chain using automation, sensors, and analytics. It allows you to easily implement inventory management techniques like Economic Order Quantity (EOQ). EOQ makes sure inventory meets demands while minimizing holding and storage costs.

Perpetual systems give you better visibility on your inventory than periodic systems. These types of inventory control system functions lower the cost and time spent on physical inventory counts.

4 tips for inventory control best practice

Now that we have a foundation of what inventory control is and the inventory control systems you can utilize. Here are some tips when it comes to inventory control.

Use real-time inventory tracking

The value of automation cannot be understated. Real-time tracking gives you the most accurate, up- to-date information which guides your financial and business decisions. It can help increase your ROI and reduce your carrying costs. Automatic inventory tracking is extremely helpful when selling on multiple channels. Overselling can be damaging to the customer experience can be avoided when all the orders and inventory information is synced in real-time across all channels.

Be consistent with your labeling system

Modern warehouse management gives companies a wide range of options when it comes to labeling and identifying inventory. Find a system that works for your business and then be consistent with label strategies.

For example, SKUs make your inventory easy for your team to manage. Barcoding your inventory allows you easier multi-location inventory control, and multichannel inventory management.

Your company might also use Radio Frequency Identification (RFID) to identify individual products and components. RFID isn't just for raw materials, it can be used just as effectively with finished stock andcan track items throughout the supply chain.

ABC Analysis

One strategy you can use in a perpetual system is ABC analysis. This classifies inventory items based on the item's consumption value. That value is the total value of a piece of inventory consumed over a specific time frame. The letters stand for the different categories items can be placed into.

A items refer to goods with the highest consumption values. This will be a low number of items with a high consumption value.

B items are the category with less consumption value than A but higher than C items.

C items have the lowest consumption value. The risk on this stock is low, but so are the returns. Theyoften make up a good portion of your stock.

The table below is an example of how this system would be implemented in practice:

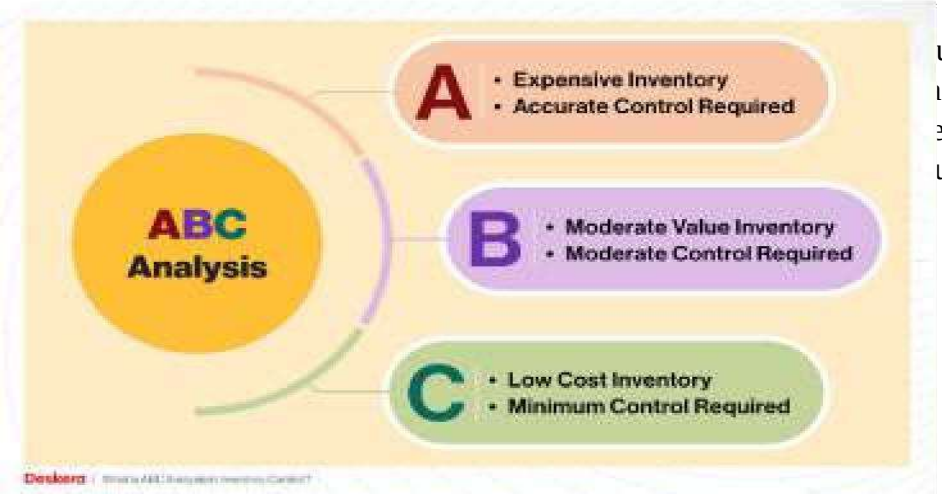
Class	Items	Cumulative	Consumption value	Cumulative
A	20%	20%	70%	70%
B	30%	50%	>20%	90%
C	50%	100%	10%	100%

Set reorder points

This may seem obvious, but reordering can be a tricky part of inventory control. You want your customers to have quick access to stock without having to deal with the carrying costs of dead stock. With inventory control software, you can set these levels to alert you when a product gets below a certain level. You can set individual products to reorder points using EOQ or ABC analysis.

It can also help you have better control over your lead time. Lead time is the time that passes between when an order is placed to replenish inventory and when it is received. This factor affects the amount of stock you need. Dead stock takes up valuable warehouse space. On average, space in warehouses and distribution centers in the US costs $5.08 per square foot. To enable a more accurate replenishment, you can also adopt a data-driven inventory planning system.

Perform regular audits



ular checks for theft, ıch department is in ems are accurately ur inventory.

What is ABC analysis?

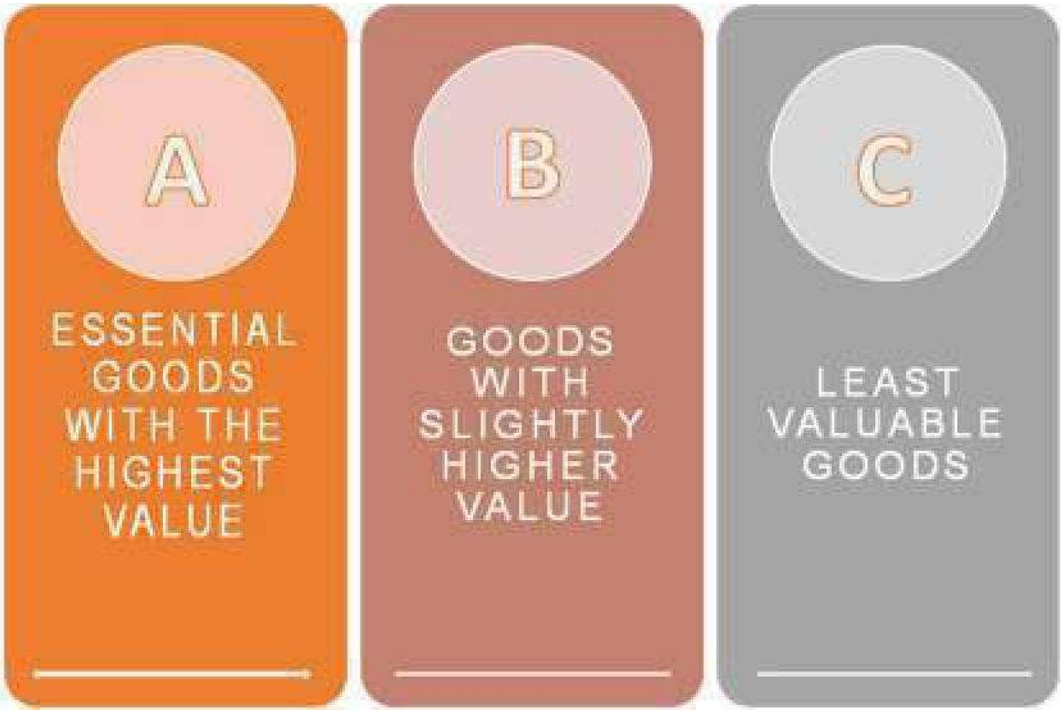
ABC analysis also referred to as ABC Classification, is a vital part of Inventory Management. It allows business owners to distinguish the products in their stock and focus on managing them based on their worth. The main objective of ABC analysis is to make maximum out of minimum investment without wasting any resources or inventory.

ABC analysis is an inventory classification strategy that categorizes the stocks into three categories, A, B, and C, based on their revenue.

Now let us find out what these three categories are.

3 Categories of ABC Analysis

The ABC analysis considers that all the goods cannot have equal value in the market. They are found in three different categories:



Segment A: Products included in category A are the most essential goods with the highest value. Segment A goods consist of approximately 20% of the total products with 80% of revenue generation for your business. It is considered as a small category with minimal goods, but maximum revenue.

Segment B: Products included in category B have a slightly higher value than segment B. It approximately regulates 30% of goods with 15% revenue generation. Not to mention, the goods included in this category are more in number but less in utility.

Segment C: Products included in category C are more in numbers but least valuable when it comes to generating revenue. As compared to category A & B, segment C has the maximum share of 50% of the stock, generating just 5% revenue.

To sum it up, A signifies the most important goods, B indicates moderately necessary goods, and C indicates the least essential inventory.

Now that you have understood the basis of segregating these goods, let us learn how to conduct an ABC analysis.

Conduct ABC analysis in 5 Steps

You can perform ABC calculations on individual products, groups of inventory, and a wide range of inventory and you can calculate in just 5 easy steps. Take a look.

Step 1: Use the formula mentioned below to calculate the annual consumption value of each product.

Annual number of units sold (per item) x cost per unit

Step 2: Enlist all the products in descending order based on their annual consumption value

Step 3: Total the number of units sold and the annual consumption value of the products.

Step 4: Calculate the cumulative percentage of the goods sold and the cumulative percentage of the annual consumption values.

Step 5: Divide the data into three categories. The split of the ABC categories will be unique to your company but approximately, 80%, 15%, & 5%.

Now that you have learned how to calculate the ABC analysis, let us look at the perks or benefits of ABC analysis.

Benefits of ABC analysis

Most of the organizations have a huge amount of stock-keeping units (SKUs), yet they have not been able to prosper or upscale their business significantly. There are many other challenges in inventory management that businesses have to handle. Challenges may include lack of information on stocks, a weak management process, difficulty in managing employees, space, and so on.

ABC analysis is a solution to this problem. It can assist companies to streamline and optimize their inventory management. Let's find out how.

analyze Customer Demand for a Product

Every product goes through four different stages after production- dispatch, growth, development, and declination later. Once the product hits it actual worth, its demand in the market starts sinking after a point. You can call it a life expectancy rate of a product. And the life expectancy of any product depends upon the client's requests.

ABC analysis helps companies identify customer demands. Often companies assume the demand for the goods and end up stocking up extras. To rule that dark room out of your business, ABC analysis makes sure that you know what your customer wants.

As a result of this, you will be able to manage your inventory efficiently and effectively. You will only order the products that your customers want, neither more than the requirement nor less than demand.

Note: A point to remember is if the market observes a sudden rise in demand for a particular product, the declination of that specific product gets further delayed.

Enables Negotiations with Suppliers

ABC analysis proves helpful in getting a fair deal on a product from a supplier. Let's see how.

For instance, if you are negotiating with a supplier for an A category product, you know you have to invest maximum since it generates the most revenue for your company. If the supplier is reluctant to make you the right offer or accept your offer, you can interest them with any extra benefits from your end. Maybe, a contract of sorts that you will take the next batch of goods from the same supplier.

As a result, you will not only crack a good deal as per your needs, you will additionally save more on A category products, procuring more benefits.

Improvement in Customer Service

When you don't know the accurate level of inventory that you should order, you end up stocking up on goods that might not even be beneficial to you. You stock up on unnecessary goods instead of stocking up on goods that your customers may want.

With the use of ABC analysis, you will know exactly what your customers are looking for or what they want. This as a result will help you satisfy your customer demands and extend your business. Not to mention, this will also cut down on the unnecessary from your budget and you will focus, invest only on the goods that earn you profit.

Along with that, you will also reduce inventory costs that you could be wasting on goods that do not interest your customer.

Manufacturing of Goods

ABC analysis enables manufacturers to improve their cycle of renewal of stocks. It allows them to manufacture goods based on their annual cost and not produce goods randomly. What often happens, as we have also discussed before, we often assume demand.

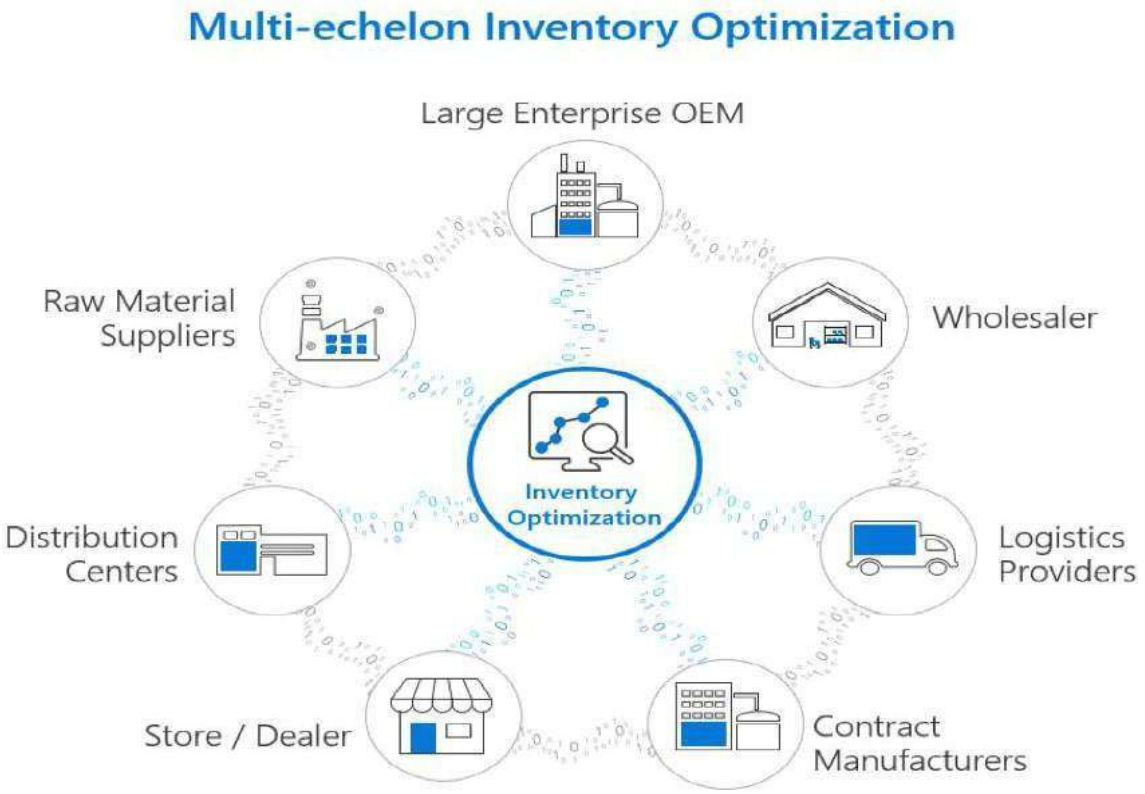
This assumption leads to production of goods that are not required, and then stocking them up in the warehouse where they sit for the longest. As a result of this you find yourself facing your worst nightmares as a business owner, your goods are damaged towards sitting in the warehouse.

With ABC analysis, manufacturer will be able to understand the worth of their products and only produce those goods high in demand and for those with low in demand, the quantity will be more controlled.

What Is Multi-Echelon Inventory Optimization?

The goal of inventory optimization is to have the right amount of stock at the right location at the right time, in order to successfully align supply with demand at all levels of the supply chain. To understand multi-echelon inventory optimization, we must first look at single-inventory optimization. Single-inventory optimization is a type of supply planning in which supply at each location is optimized independently of each other. This type of approach works for smaller companies that are composed of less complex supply chain networks with fewer points of distribution from the point-of-origin to the end-point, the consumer. In larger companies, the problem with using a single-echelon inventory optimization model is that in treating each distribution level independently of one another, you fail to recognize the impact that one level has on another. For instance, if you were to apply demand or replenishment strategies to different echelons of distribution, independently of each other, changes of stock levels at one distribution point could reduce availability of stock across the entire supply chain.

Multi-echelon inventory optimization helps companies optimize inventory levels throughout their distribution networks. This type of supply chain planning successfully combines inventory optimization (how much stock to keep at each distribution level) with multi-echelon planning (deciding where to keep inventory at each distribution level). In multi-echelon inventory optimization, companies can strategically manage their inventory across all echelons of their supply chain. It treats inventory optimization from a comprehensive or globalized perspective, helping successfully optimize inventory throughout the supply chain. Multi-echelon inventory planning mitigates such issues by helping to optimize levels of stock at your upstream distribution points, while failing to meet the needs of downstream locations or vice versa. Enterprises that have integrated this method of supply chain planning into their inventory optimization have enjoyed many benefits as a result.



how does this approach improve inventory planning?

MEIO enables manufacturers to strategically stock individual inventories across all echelons of the supply chain–increasing customer service levels while simultaneously decreasing costs.

For instance, the MEIO software might suggest the right "decoupling points" and adequate levels of materials, components, subassemblies and finished goods in any location of the entire supply chain.

It can optimize the balance of inventory across different locations for optimal "staging" and different Bill-of-Material (BOM) levels for optimal "postponement".

It also enables manufacturers to achieve the optimal replenishment frequency for individual products at each location.

The increased visibility that MEIO provides empowers centralized demand planning, reduces cost across the supply chain and streamlines operations.

Inventory optimization (IO) is a great first step to improving overall supply chain performance, but for companies with complex supply chains, MEIO goes further towards optimizing service levels while minimizing inventory costs.

For a large enterprise such as Nike and Oracle, managing inventory can be a challenging task with thousands of products located in thousands of locations all over the world. The challenge magnifies when locations are placed in different tiers or *echelons* of the enterprise's distribution channel. According to Forrester Research, the key differentiator these days between a highly successful company (e.g. Wal-Mart) and a company that has sub-optimal performance (e.g. Kmart) is an ability to increase the inventory turnover.
Broadly, there are two types of inventory systems: - the **single-echelon** (or, single-tier) inventory system and the **multi-echelon** (or, multi-tier) inventory system. We will look at them briefly here.

Single-Echelon Inventory System:
A *single-echelon* inventory system is one wherein a single Distribution Center (DC) acts as a central repository between the supplier of the inventory and the customer-facing outlets.
In a single-echelon network, an individual material-location combination is not affected by any other material or location. If a business was selling products from a single location, then it would be categorized as a single-echelon system. The DC is under the control of a single enterprise.

Multi-Echelon Inventory System:
A *multi-echelon* inventory system is one that relies heavily on layers of suppliers distributed across multiple distribution centers and that is based on outsourced manufacturing. In such a system, new inventory shipments are first stored at a central or regional distribution center (RDC). These central facilities are the internal suppliers to the customer-facing outlets, also called forward distribution centers (DCs). For example, Nike's distribution network consists of 7 RDCs and more than 300,000 DCs; and these DCs serve end customers. Here, the DC and RDC both are under the control of a single enterprise – Nike, Inc.

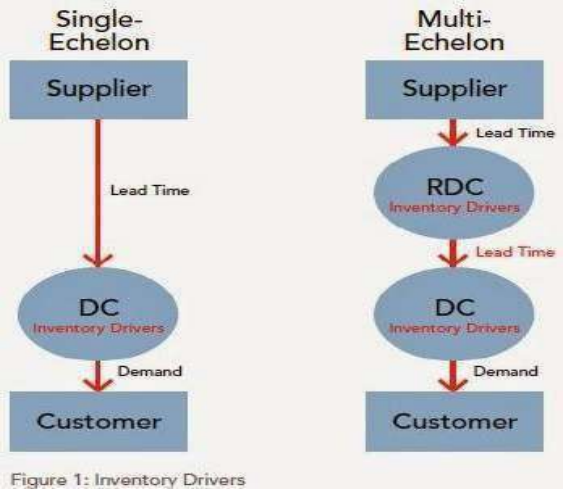


Figure 1: Inventory Drivers

However, there are some significant issues in optimizing a multi-echelon inventory system:-

- Demand variation measure for the RDC.
- Demand measure for the RDC, and how to forecast this demand.
- Defining optimal service level goals between the RDC and its "customers" - the DCs.
- Allocation of inventory down to the DCs when faced with a limited supply situation at the RDC.

Managing Inventory in Multi-Echelon Networks:

The objective of multi-echelon inventory management is to deliver the desired end customer service levels at minimum network inventory, with the inventory divided among the various echelons. With the primary focus on inventory, transportation and warehouse operations expenses also are taken care of, because their cost factors are part of the overall optimization.

The inventory drivers, denoted in red in Figure 1, are

- Replenishment review frequency
- Order supply strategy
- Service level goal

With a multi-echelon approach, the decisions regarding the inventory drivers are made at the enterprise level in a single optimization exercise rather than in a sequence of sub-exercises for each echelon.

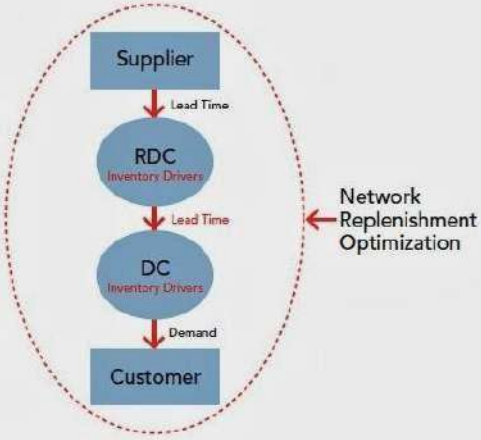


Figure 3: Multi-Echelon Approach

Figure 3 illustrates how all of the inventory drivers in both echelons are factored into the DC and RDC replenishment decisions to truly optimize the network's inventory.

A multi-echelon approach optimizes the networks inventory on various counts:-

- ***Avoid multiple independent forecast updates per echelon:*** The forecasts in all echelons are dependent on the primary customer demand signal at the DCs. A multi-echelon approach, however, is independent of demands from the immediate downstream customer.
- ***Account for all lead times and its variations:*** In each echelon, the replenishment decisions account for lead times and its variations of all upstream suppliers, not just the immediate suppliers.
- ***Monitor and manage the bullwhip effect:*** The enterprise measures the demand distortion and determines the respective root cause in order to take corrective measures.

- ***Enable visibility up and down the demand chain:*** Each echelon takes advantage of visibility into the other echelon's inventory positions—what is on hand, on order, committed and back ordered.
- ***Synchronizing order strategies:*** Synchronizing the ordering cycles at the DCs with RDC operations reduces lead times and lead time variation between the RDC and the DCs. Multi-echelon models can evaluate the impact on both echelons of different synchronization strategies.
- ***Offering differentiated service levels***, etc.: The RDC can provide different service levels (for the same product) to different DCs. A multi-echelon approach makes this possible, because the enterprise controls how and when a product enters and leaves the RDC.

Bullwhip Effect in Multi-Echelon Networks:

The bullwhip effect is an observed phenomenon in forecast-driven distribution channels. It refers to a trend of larger and larger swings in inventory in response to changes in customer demand, as one looks at firm's further back in the supply chain for a product.

In multi-echelon networks, the enterprise must consider and manage the bullwhip effect. The bullwhip effect is caused by independent rational decisions in demand signal processing, order batching, reactions to price variations and shortage gaming. Order batching in a lower echelon leads to excess demand fluctuations between echelons. Also, the lack of visibility up and down the demand chain can cause inventory stocks to pile up. A multi-echelon network can tackle the bullwhip effect by offering proper measurement, by identifying its root cause and by reducing or eliminating its impact on demand chain performance.

Two Paths to Multi-Echelon Performance in an Organization

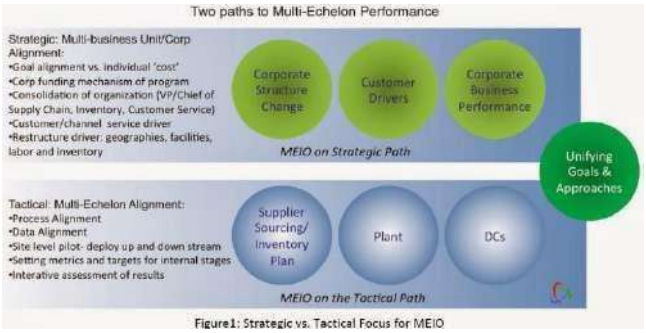


Figure1: Strategic vs. Tactical Focus for MEIO

What are the Benefits of Multi-Echelon Inventory Optimization?

1. Boost in Cost-Efficiency

Without a strong inventory optimization strategy, companies may keep more stock throughout their supply chain, so they are prepared to meet consumer demand with enough stock ready at any one distribution point. Sounds good, right? Well, unfortunately this approach is uneconomical, as well as unprofitable because it can lead to inventory excess, with too much capital tied up in stock that won't move quickly enough. Multi-echelon inventory optimization helps companies make better use of their capital, investing in optimal levels of stock that will move more fluidly throughout the supply chain.

2. Improvement in Customer Service

Without successfully optimizing their inventory levels, enterprises may end up forecasting too low, resulting in inventory deficits. This means that they could potentially be out of a certain product a customer wants or needs by the time inventory has moved downstream to the consumer. And, of course, this would hurt their customer service levels as they are not sufficiently meeting consumer demand. When companies utilize multi-echelon inventory optimization, they can successfully forecast optimal levels of stock throughout their supply network — meeting consumer needs and keeping customers happy.

3. Better Management of Supply or Market Volatility

If companies fail to optimize their inventory levels, they may not be prepared for sudden changes in market demand or supply. With multi-echelon inventory optimization, companies achieve optimal levels of stock throughout their supply chain. Having enough stock at any point throughout their distribution networks boosts an enterprise's agility, helping them more quickly and strategically respond to market and supply volatility.

4. Better Management of Lead Times

Without a strategic approach to inventory optimization, enterprises handicap their ability to manage fluctuating lead times. Since suppliers' estimates of lead times are not always accurate, sudden changes in lead times can arise, leading to stock shortages, excess stocks, etc. Multi-echelon inventory optimization helps companies maintain optimal levels of stock throughout the supply chain network, so they can quickly adapt and respond to lead changes as they come up.

5. lmproved Return on Investment

Without a successful inventory optimization strategy in place, enterprises may invest too much capital in stock that is not moving fast enough through their supply chain. Multi-echelon inventory optimization allows companies to manage optimal levels of inventory — so without too little or too much inventory, they can successfully meet consumer demand. This means better profits, and better returns on investments.

What is Distribution Requirements Planning (DRP)?

Distribution Requirement Planning (DRP) can be used for determining inventory required to be maintained at different stocking locations. It also makes sure that various supply sources are adequate for meeting the demand. This tool is essential for implementing Just-in-Time Production (JIT) and logistics system.

It is a meaningful expansion of Manufacturing Requirements Planning (MRP). It is helpful in the scheduling of production resources. It is also helpful in resolving various capacity related issues such as raw material constraints. MPS shows daily or weekly machine and production schedule. With the help of MPS, MRP can be used for coordinating the purchase and receipt of various components and materials for assisting manufacturing plan.

Distribution Requirement Planning is a planning approach that considers multiple distribution stages and the characteristics associated with each stage."

Terminologies related to DRP

A few related terms you need to know before proceeding are,

Production schedules

It is a business term used in operations management that refers to manufacturing or assembling products in a factory according to a specific timetable.

Supply chain

It is the network of organizations involved in creating and efficiently delivering a product or service.

Customer demand

It is how much of a product or service customers are requesting.

Distribution center

It is a facility that receives, stores, and distributes products to retailers or other businesses.

What is Distribution Requirements Planning (DRP)?

The distribution requirements planning process

We can summarize it into the following steps:

1. Establish delivery centers and supply locations
2. Identify market demand and distribution planning parameters
3. Plan for specific inventory control parameters
4. Determine allocation requirements and resource requirements
5. Generate a disbursement plan
6. Evaluate results and make necessary adjustments

How a distribution center work

DC is a facility that receives, stores, and distributes finished goods to retailers and other businesses. It is the backbone of the logistics network, and it is essential to have one or more delivery centers to serve consumers effectively.

Many factors go into choosing the optimal locations for centers. Some of the most important factors include:

- **The distribution network map** includes the distribution centers, suppliers, and buyers. Therefore, it should be easy to identify where each entity is located and connected.
- **The customer base** is essential to consider where most of your customers are located. This will help you determine how many locations for holding goods you need and how far apart they should be.
- **The distribution network topology** – This is how the locations are connected. There are three main topologies: radial, star, and mesh. It can also be a tree-like structure.
- **The distribution requirements** include the number of products, the weight and dimensions of products, and the delivery time.
- **The transportation network** includes the modes of transportation (road, rail, water, and air), the distance between warehouses, and the delivery time.
- **Labor availability** – It is vital to ensure enough workers are available at the allocation center when it opens.
- **Cost** – The warehouse should be located where the price is the lowest.

Distribution planning and distribution networks

DRP is crucial for making sure that companies can meet customer orders. Distribution resource planning includes ensuring enough resources for the distribution network, including distribution centers, transportation networks, and labor. It's also essential to maximize product availability at a lower cost.

A distribution network collects disbursement centers and other cooperations to serve buyers. Therefore, companies must carefully plan the disbursement network to ensure that they can deliver finished goods to b on time.

Supply chain planning and strategies for DRP success

Key supply chain planning and optimization strategies can help ensure DRP success.

One is to have accurate and timely data regarding market requirements. This information is used to create the distribution plan, so it must be as precise as possible.

An effective distribution center (DC) network is also essential for getting products to customers quickly and efficiently.

Finally, having a well-run inventory management system is critical for ensuring that products are available when customers need them while minimizing shortages.

Six must-consider ideas while making supply chain optimization strategies are,

1. Adjusting the warehouse locations
2. Planning production schedule
3. Allocating resources to meet disbursement demands
4. Minimizing shortages and maximizing customer satisfaction
5. Set safety stock levels.
6. Considering disbursement requirements in inventory control

The supply chain strategies should try to achieve the following.

- distribute products quickly and efficiently
- minimize shortages
- follow key tips for success

Key Parameters for distribution requirements plans

Some of the key parameters for supply chain distribution requirements plans include:

- customer orders
- safety stock
- inventory management
- Central planning
- central facility
- distribution planning
- supplying location
- actual demand signals
- minimize shortages
- regional facilities

Software tools for distribution requirements planning

Few software solutions that enable DRP are,

- Microsoft Dynamics AX
- Oracle EBS distribution
- Infor Distribution Planning
- JDA Distributed Order Management
- SAP Distributed Order Management
- Manhattan SCALE

Each software tool has its strengths and weaknesses, so it's important to choose the one that will work best for your organization.

Some of the benefits of using this software include:

- Increased accuracy and timeliness of data
- Improved network design
- More effective inventory control
- Easier compliance with government regulation

Benefits of Distribution Requirement Planning

DRP system offers many benefits as it helps with logistics and marketing. Following are the major marketing related benefits of this system:

- DRP helps in offering timely delivery of goods to its customers by integrating distribution centres.
- The on-time delivery helps in reducing the amount of customer issues.
- This system is useful for predicting future requirements to avoid over or under stocking.
- It facilitates better coordination with other functions including MRP.

Main logistics benefits of DRP system are as follows :

- By coordinating shipments, this system has helped in reducing distribution costs.
- By correctly predicting the requirement of inventory, the system helps in maintaining optimal level of items.
- It helps in saving space at the warehouse as over stocking is avoided.
- It helps in better coordination between manufacturing and logistics departments as they need to work in close coordination in an integrated system.
- The system can be used for simulating transportation and inventory requirements, thus improving budgeting process.

Constraints of DRP System

This system requires accurate numbers for proper functioning. The forecast done should be correct so that there is flow of goods through distribution. It also requires the forecast for each SKU (Stock Keeping Unit) and distribution centre. **Following kinds of errors may occur in the process :**

- The forecast may be incorrect.
- The performance cycle should be stable and consistent.
- If there are uncertainties in the system, then DRP may not prove to be very efficient. Such uncertainties may relate to vendors or supply chain. Because DRP cannot be treated as universal solution for the inventory management. So many companies are seen with substantial improvement in the performance by its use.

Difference between DRP and MRP

No.	DRP	MRP
1.	The customer demand on which the organisation has no control helps in estimating DRP.	MRP is estimated by production schedule which is managed by the enterprise.
2.	DRP works in an independent demand situation.	MRP works in a dependent demand situation.
3.	DRP integrates after finished goods are present in the warehouse.	MRP regulates inventory till manufacturing or assembling is completed.

Understanding the Supply Chain Bullwhip Effect

The different players in the supply chain — including customers, suppliers, manufacturers, and retailers — have limited control over the whole process, but their actions influence everyone else. As these different parties try to respond to demand fluctuations, they create ripple effects throughout the chain. One of these is the bullwhip effect. This phenomenon is named after the movement of a bullwhip, where a small movement of the wrist becomes a much larger, uncontrolled movement at the end of the whip.

In a supply chain, the bullwhip effect occurs when each party gradually escalates an initially small spike in demand. Each member of the supply chain overcompensates for this demand with excess product, leading to increased production, inaccurate demand forecasting, and inconsistent inventories.

Fortunately, you can mitigate or prevent the supply chain bullwhip effect with the right resources and planning. Let's look at the impact of the bullwhip effect on supply chain management and what you can do about it.

What Is the Bullwhip Effect in Supply Chain Management?

The bullwhip effect is the distortion of demand and increased volatility that occurs as forecasts and orders move from the retailer up to the manufacturer.

When a spike in demand occurs, each party in the supply chain adds additional products to their orders to act as a buffer. When one party does this, it serves the necessary function of ensuring in-stock products. However, when everyone does it, the result is inaccurate forecasting, stock hoarding, overstock inefficiencies, and out-of-stock products later.

Example of the Bullwhip Effect in Action

1. Say a retailer sells personal heaters and normally sells an average of five units a day. As the temperatures start dropping in winter, sales spike to 15 units a day. The retailer adjusts

their forecasting and orders enough stock to sell 20 units a day from their wholesaler to meet the demand.

2. The wholesaler, receiving the order for 20 items, then orders 30 units from the manufacturer.

3. The manufacturer receives the order for 30 items and increases their manufacturing run to 40 items.

A spike in demand for 15 units a day has ballooned up to 40 units, many of which won't reach the retailer until after the demand spike is done. Manufacturing products takes time, so what happens if, while those items are being made, an early Spring appears? For the retailer, sales of personal heaters would immediately drop. The retailer's forecasts are then affected, and they won't order more units, even though production has increased.

Example of the bullwhip effect

For instance, imagine a retailer selling hot chocolate that typically sells 100 cups a day in the winter. On a particularly cold day in that area, that retailer sells 120 cups instead. Mistaking the immediate increase in sales for a broader trend, the retailer requests ingredients for 150 cups from the distributor. The distributor sees the increase and expands its purchase order with the manufacturer to anticipate increased requests from other retailers as well. The manufacturer increases its manufacturing run in anticipation of greater product requests in the future.

At each stage above, demand forecasts have been increasingly distorted. If the retailer sees a return to normal hot chocolate sales when the weather returns to normal, it will suddenly find itself with more supplies than needed. The distributor and manufacturer will have even more excess inventory.

Another reason for the lack of information is that larger logistics operations at the wholesale level take longer to change, meaning that the conditions that caused a change in demand at the retail level may have passed by the time a wholesaler has reacted. As changing manufacturing output takes longer still and information from retailers is even more delayed in getting to manufacturers, the difficulty of reacting correctly to changes in demand increases even more so.

Even if the retailer had accurately assessed demand, for example, due to the start of a local hot chocolate festival, the bullwhip effect can still occur. The distributor, not being fully aware of local conditions, may assume this is due to a broad increase in the demand for hot chocolate, rather than specific conditions for that retailer. The manufacturer, being even more removed from the situation, would be even less likely to understand and correctly react to the change in demand.

Asset manager and famed "Big Short" investor Michael Burry made headlines in June of 2022 when he warned investors about the bullwhip effect for big-box retailers and others.

Impacts of the Bullwhip Effect

In the example above, the manufacturer may be stuck with a significant surplus of product. This can lead to disruptions to the supply chain and to that manufacturer's business—increased costs associated with storage, transportation, spoilage, losses of revenue, delays to shipments, and more. The distributor and the retailer in this example may also see similar problems.

What Does a Bullwhip Effect Indicate?

A bullwhip effect indicates that a small error in assessing consumer demand has been amplified through a supply chain. This means communication between firms in a supply chain is imperfect leading to firms up the supply chain missing important information.

How Do You Identify a Bullwhip Effect?

The bullwhip effect can be difficult to identify in real time, in part because it is caused by a lack of communication throughout a supply chain. Frequently, it is a phenomenon that is observed after the fact, when inefficiencies have already been created.

How Do You Prevent a Bullwhip Effect?

There are many things firms in a supply chain can do to prevent, or at least reduce the likelihood and severity of, a bullwhip effect. First and foremost they can ensure clear and consistent communications between companies up and down the supply chain. This will help avoid temporary or localized shifts in supply from being misinterpreted as broader than they are. Firms can also make sure to take a wider viewpoint when making forecasts for demand to reduce the effect of any temporary or limited shifts. Finally, companies can work to increase the speed at which they are able to respond to shifts in demand, meaning that they can readjust more easily if they incorrectly assess demand. This also reduces the need to overproduce or overorder to have a buffer in case of demand shifts.

Causes of Bullwhip Effect

There are a number of causes of the bullwhip effect in the supply chain. A lack of proper forecasting for customer demand shifts, delivery time, and inventory tracking are often major factors.

Here are the most common causes of the bullwhip effect:

Issues with Lead Time

Lead time is one of the most important aspects of inventory control and directly impacts your ability to meet customer demand. Calculating lead time and planning accordingly ensures you avoid losses and can fulfill orders. However, if there is an issue anywhere along the supply chain, lead time increases for each remaining step. This makes it difficult to meet customer demand and causes greater inventory level fluctuations.

Lack of Communication

One of the most common causes of the bullwhip effect is a lack of communication both internally and along the supply chain. Sharing information regarding shifts in demand, issues with production, and upcoming sales are key in avoiding issues. This is particularly important if you're interested in what is 3pl or dropshipping for eCommerce fulfillment (see order fulfillment meaning). There, your ability to fill orders relies entirely on maintaining a good flow of information.

Incorrect Demand Forecasts

Demand forecasting is complicated and requires setting and analyzing a wide range of Inventory KPI and eCommerce KPIs. Any mistakes along the way can lead to an inaccurate forecast. This in turn leads to an inability to meet demand or too much sitting inventory. There are also many external factors that can cause your forecast to be incorrect. Regularly conducting an inventory audit and reviewing and updating your forecast is key.

Too Many Discounts and Promotions

Another issue that commonly causes the bullwhip effect is running too many promotions or overusing discounts. This is because they disrupt larger demand trends and cause trouble with forecasting. Suppliers become accustomed to fulfilling orders at a high rate and this can quickly become a problem when the sales end and seasonal trends return.

If you regularly run into issues with excess inventory try kitting instead. It allows you to sell underperforming products by bundling them with better products. The markup is higher and you won't impact the supply chain.

How to Avoid Bullwhip Effect

Since the bullwhip effect can cause so many problems with inventory control, learning how to minimize the bullwhip effect is key. Though there are some causes that can't be helped, you can limit the chance your business is the cause.

Here are five steps you can take to minimize the bullwhip effect:

Use Warehouse Inventory Management Software

Proper inventory and order management go a long way to avoiding problems with the bullwhip effect. This is best done using software that can track inventory levels, product flows, and orders in real-time. They give you actionable data and provide detailed insight into your ability to meet demand. Even better, they can help you set par level, calculate optimal reorder points, and avoid wasting money on storing excess inventory.

Limit Your Promotions and Sales

Many businesses think that they should run promotions often to increase demand. This method of sales is dangerous in many ways and can easily cause losses for both the business and every step along the supply chain. Try to utilize sales periods only as necessary to meet customer expectations. Instead, focus on upselling and cross selling to increase your average order value and grow your sales in a sustainable way.

Streamline the Supply Chain

When your supply chain becomes congested with too many suppliers and moving parts, it becomes easier to make a mistake. Try to reduce your supply chain and streamline your order processes to ensure limit this risk. It also makes it much easier to maintain relationships and share information quickly.

Improve Order Planning

The unsung hero of inventory management is order planning. Accumulate as much data regarding inventory levels and demand trends to order the optimal amount of each product. You should also factor in any safety stock needed and any upcoming sales or seasonal demand shifts for inventory reduction. Using an ERP accounting system or demand planning software are great ways to optimize your order planning. SKU rationalization can also provide insight about which orders to prioritize.

Optimize Your Minimum Order Quantity (MOQ)

Setting a minimum order quantity is a good way to avoid shipping products at a loss. However, try to avoid complementing your MOQ with bulk discounts as this can attract customers who order more than you can handle. It can cause a lot of strife for your order fulfillment team and cause dramatic shifts in your inventory levels.

Bullwhip Your Inventory Into Shape

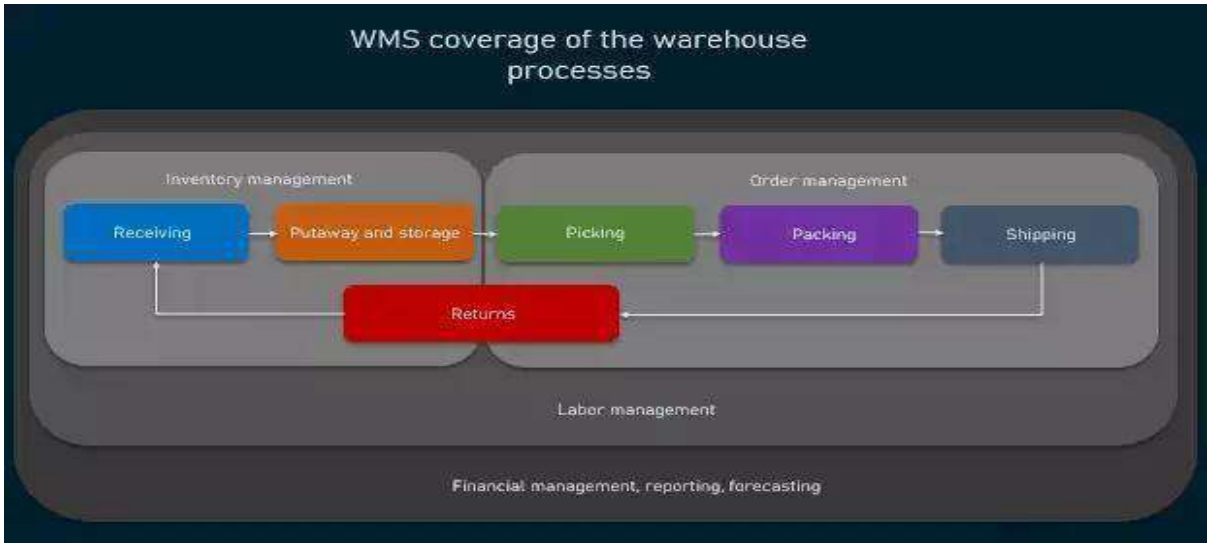
The bullwhip effect is an unfortunate effect of poor supply chain management and demand forecasting. By following our tips above and staying on top of trends, you can avoid causing trouble.

Using WMS for Managing Warehousing Operations

What is a warehouse management system?

Traditional order management systems (OMS) or enterprise resource planning (ERP) systems have basic warehousing functionality, but many companies soon find that they have outgrown their capabilities. So, the main advantage of the WMS is that it covers other aspects of the supply chain besides inventory and order management – such as labor management, financial management, reporting, and more.

Obviously, every business is unique and will have different software requirements. Let's take a look at the main modules most WMS platforms have and the most common problems they help to deal with.



Inventory management

Creating purchase orders. WMS stores all your suppliers' information in one place and syncs it to actual inventory levels making it easy to manage procurements. The product can also be added to the order by simply scanning the barcode. The orders are then emailed to the supplier right from the system.

Receiving and Putaway. Scanning devices integrated with WMS optimize receipt and direct workers to the best location to shelve the product. WMS may also suggest multiple strategies for slotting and best usage of the storage space depending on the type and characteristics of goods you deal with. For example, fast-selling products have to be put in the most accessible areas; fragile, in those areas where potential for damage will be minimized; perishables, according to their storage requirements and expiration date; and so on. Location recommendations are also connected to the forecasting module and are based on trends and product demand.

Storage. Location control is the core of warehousing, especially if you work with completely different types of goods or have to handle stock for multiple clients. Being able to track the exact location of every single SKU prevents pilferage and helps optimize further order processing. Also, storage conditions are vital for some product categories like perishable food – WMS keeps track of expiration dates and shelf life and prioritizes products accordingly.

Stock level control. WMS helps monitor the amount of product in multiple warehouses, notifying users if the level is too low and needs replenishing. Automatic reordering can be set up as well to prevent total stock depletion and overselling. Cycle counting is another great tool for inventory control and is offered by most WMSs.

Order management

Processing customers' orders is the key function of any sales-oriented business. Accuracy and speed are crucial to achieving customer satisfaction. There are many ways how implementing WMSs can help improve efficiency and reduce errors on every stage of this complex process.

Receiving/creating sales orders. If you work with various eCommerce platforms like Magento or Shopify and marketplaces like Amazon or eBay, integrating them with your WMS will allow you to manage all the orders from different channels in one system. Also, since most of the WMS are cloud-based, orders can be created on the go right from the mobile device, i.e., at trade shows or sales meetings.

Picking. Picking lists can be a pain to create. WMS will let you sort and print lists conveniently, e.i., by bin location, order date, SKU, etc. Mobile devices or voice systems can then guide workers to the exact place where the product is stored. If multiple items have to be picked, the optimal route together with the necessary equipment will be suggested to reduce travel time. Barcode or RFID scanners ensure the accuracy of getting the right items. Today, big players like Amazon or Alibaba also use robots in their warehouses and implement other AI technologies.

Packing. The type and amount of packaging are calculated automatically for every order and optimal packing procedure is suggested (e.i., gift wrapping). The shipping labels for UPS, FedEx, and USPS (as well as price tags, logos, BOLs, and other necessary paperwork) can be printed directly from the system so there is no need to manually enter addresses or retype tracking numbers. Quality control is also simplified as employees have the exact information and standards for every item.

Shipping. Rate calculation and real-time parcel tracking are available in most WMSs. If multiple orders are shipped to the same address, they can be merged to reduce shipping costs. Features of cross-docking and drop shipping are also offered by some providers.

Returns. WMS can help streamline this unpleasant process by automating every step: creating the return, recording the reason, updating stock, issuing full or partial refunds, and generating reports.

Invoicing. Invoices are created and sent automatically, including individual discounts and payment options for every customer. Normally multiple formats are supported, whether it is email, CSV, or EDI.

Overall, organizing your orders in one central system provides full visibility of the complete history for every order – payment information, shipping status, staff involved, total time spent, etc. Moreover, giving your customers access to view and manage their own orders increases their engagement and trust and encourages future cooperation.

Labor management

When the company is still small and you just have a handful of employees, managing is easy. Scheduling, payrolls, and performance control can be done manually and don't take long. However, it becomes more complicated as the company grows and the staff becomes more numerous. Most WMSs offer some kind of a labor management module that can be handy for:

Scheduling. For example, sometimes more people are needed at the docks to unload the incoming shipping quickly and not let the product overstock dock areas, and at other times a big order needs to be collected and packed promptly. Seasonal peaks and valleys also strongly affect labor demand and allocation. Automated schedulers help plan and forecast the exact number of people needed by day, zone, and job type according to your procurement and shipping schedule.

Increasing performance. Tracking KPIs (i.e., the number of items picked, number of orders packed, travel time, etc.) keeps managers informed, rewards stronger workers and identifies those not meeting their requirements or needing additional training. Moreover, workers' engagement increases due to visibility and access to operational results and peer comparisons.

Safety control. Unfortunately, since theft is a common problem, installing cameras and sensors and implementing video surveillance has become a widespread solution. Integrating a security system with your WMS helps monitor what exactly is happening in the warehouse by tracking staff location, identifying license plates of the incoming trucks, limiting access to certain areas, etc.

Overall cost estimation. Breakdown by process, employee, shift, supervisor, department, or customer provides full cost visibility and points out which customers are unprofitable to work with.

Financial management and reporting

Monitoring business performance and sales trends across locations, customers, and products is mandatory for making informed, data-driven decisions about future actions and developments. WMS offers numerous opportunities to track and generate reports concerning every side of your business:

- Customizable metrics let you assess all the data and know your most profitable customer, top-selling product, best-performing sales channel, most efficient worker, peak sales season, etc.
- Automatic balance sheet accounts for revenue, taxes, and the cost of products sold based on real-time data saves time and minimizes miscalculations. Many WMSs support multi-currency pricing, different tax systems, and landed cost management, which is crucial if you operate in multiple locations.
- Integration with accounting platforms like QuickBooks or Xero is also a common feature to have all accounting in one place.

Risk Management and Forecasting

Risk analysis and comprehensive planning are key to successful company development. Modern software offers solutions to analyze operational data and create forecasts, taking into account possible risks or actually disruptions in progress. A demand planning feature ensures that there is no overstocking and no products are going to waste as well as preventing stockouts. Products that are seasonal or selling fast can be tracked and prioritized. Full visibility and structuring of data helps better understanding and predicting customer behavior and needs.

Top providers of WMS

Most WMS software providers will offer a basic set of features such as:

- barcode and RFID scanners compatibility,
- providing real-time data streaming,
- inventory location recommendations,
- picking and packing options,
- product tracking,
- warehouse layout planning,
- kitting,
- creating reports,
- billing and invoicing,
- integration with ERP and other software,
- customization opportunities,
- on-Cloud basis, etc.

However, when you do deeper exploration, it turns out that all software options have specific weaknesses and strengths, no WMS on the market is absolutely perfect, and different WMS suit different purposes. Providers can focus on a certain business sector (wholesale, retail, or manufacturing) or company size (small, medium, or large). Below are descriptions of some of the top-rated WMS providers.

WMS top providers

	Trial availability	Price	Deployment type	Industry focus	Size focus
Fishbowl	14-day free trial	Starts from $4395	On-premise	Manufacturing, distribution	Small to medium
Manhattan	Demo by request	customized quotation	On-premise, cloud	3PL	Medium to enterprise
Netsuite	Free product tour available	Starts from $499/month	Cloud	Manufacturing, distribution	Medium to enterprise
QuickBooks Commerce	14-day free trial	Starts from $39/month	Cloud	eCommerce	Small to medium
3PL Manager	Free product tour available	customized quotation	Cloud	3PL	Any size

Benefits of a modern, cloud-based warehouse management system

With the internet and digital technology having transformed how customers make purchases—disrupting supply markets, changing customer buying patterns, and adding complexity to the supply chain—fulfillment operations need to meet the changes with a digitally connected solution of their own.

In moving to the cloud, warehouse management systems can meet the connected consumer with a connected fulfillment solution that offers real time visibility, scalability, and market reactivity.

Fulfillment process—Rapid implementation

To stay competitive in the new fulfillment economy, you need to adapt quickly. With a cloud-based system, you can ramp up your supply chain system fast. Powerful logistics capabilities are available in weeks, instead of months. Oracle Warehouse Management Cloud comes ready to integrate with multiple systems to support complex, multichannel fulfillment processes.

It delivers the same level of warehouse management functionality as an on-premises system, but without the IT overhead. Cloud technology eliminates the need to pay for hardware, software, and IT specialists to maintain the system. You're up and running quickly—at a more affordable cost.

Cloud-based WMS—No upgrades required

You're always on the latest software version with a cloud-based solution. Software-as-a-service (SaaS) pricing includes regularly scheduled updates and no IT infrastructure costs.

Everything exists in the cloud. Updates work similarly to apps in mobile phones, meaning that customers always have the latest codebase at work.

Connect logistics—Lower upfront costs

Multitenant, cloud-based solutions have an almost immediate return on investment and a lower total cost of ownership. With the cloud, there's no need for hardware, software, and IT specialists. It comes ready to integrate with multiple systems to connect all your logistics processes from end-to-end.

In contrast, a company with an on-premises WMS could easily have paid for several customizations and modifications over a five-year period. When it is time to upgrade, that company is looking at a total reinstallation and configuration.

With a cloud-based WMS solution, there are never any upgrade or maintenance fees. There are no IT infrastructure costs or costs for hardware, system, or database administrators. Everything is installed, managed, and maintained at Oracle data centers by Oracle experts. What used to be a significant expenditure is now a predictable—and more affordable—operating cost, enabling you to preserve your profit margins.

Scalability and flexibility of supply chain operations

Today's global market demands speed. Oracle's cloud-based solution gives you the scalability to quickly expand your supply chain operations to meet changing market conditions. Scale as needed to handle peak seasons and manage other changes. When new opportunities come along, you'll be ready. This business agility is yours without paying an on-premises price. Capital expenditures for in-house hardware, software, and labor are eliminated. So you can invest scare resources in your business—not your IT.

Seamless Integration—Warehouse management and ERP

Oracle Warehouse Management Cloud Service is built for integration. The solution supports integration with host enterprise resource planning (ERP), merchandising (MMS), and supply chain solutions (SCM).

Oracle WMS Cloud was built for integration, not isolation. Data can be sent and received using industry best practice RESTful web services and XML. These integration points can easily be leveraged by material handling equipment vendors to build integrations for automated warehouses.

Future of Warehouse Management

Oracle WMS Cloud represents a new paradigm in SCM software—a robust, next-generation, warehouse solution available at an outstanding value. New supply chain management functionality delivers innovative product features, mobile solutions, and a user-friendly interface.

Companies invest in warehouse management software to streamline and automate inventory fulfillment processes, while also controlling costs. Dynamic and easily configurable, a robust WMS system can leverage the cloud for a rapid, cost-effective implementation that realizes the following benefits:

- Increased operational efficiency—with warehouse management software managing fulfillment operations in the cloud, supply chains have real-time visibility into their inventory and operations—meeting how their customers engage in purchasing with relevant technology.
- A lower Total Cost of Ownership—implementing a cloud-based warehouse management system helps control costs as businesses no longer have to fear paying for costly maintenance and upgrades.
- Improved customer experience—faster fulfillment times means a better customer experience and better business. Customers can make purchases from anywhere at anytime. Warehouse management systems that are based in the cloud help businesses meet the demand that market realities dictate.

UNIT – IV
MATERIALS HANDLING

Principles and Performance Measures Of Material Handling Systems – Fundamentals of Material Handling – Various Types of Material Handling Equipments – Types of Conveyors – Refrigerated Warehouses- Cold Chain- Agri SCM

Principles of Materials Handling Systems

Materials handling systems involve the movement, storage, and control of materials within a facility or between locations. Some key principles include:

1. **Planning and Integration:** Design systems that seamlessly integrate with other processes, considering factors like workflow, space utilization, and equipment compatibility.

2. **Flexibility:** Build systems that can adapt to changes in demand, product types, and production processes, promoting efficiency and responsiveness.

3. **Safety:** Prioritize safety in the design and operation of materials handling systems to protect workers, products, and equipment.

4. **Efficiency:** Aim for optimal use of resources, minimizing waste, and maximizing productivity through streamlined processes and technology.

5. **Automation and Technology:** Leverage automation and technology to enhance accuracy, speed, and overall efficiency in material handling operations.

6. **Space Utilization:** Efficiently utilize available space to minimize storage costs and facilitate smooth material flow.

7. **Standardization:** Standardize processes and equipment where possible to simplify training, maintenance, and operations.

8. **Ergonomics:** Consider ergonomic factors in the design to ensure a safe and comfortable working environment for personnel involved in material handling.

9. **Cost-effectiveness:** Balance the initial investment with long-term operational costs to ensure a cost-effective and sustainable materials handling system.

10. **Environmental Sustainability:** Consider environmentally friendly practices, such as recycling, waste reduction, and energy efficiency, to align with sustainable principles.

These principles help guide the design and operation of materials handling systems to meet the specific needs of a given industry or facility.

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Performance measures for materials handling systems typically include

1. **Throughput:** The rate at which materials are moved through the system, often measured in units per hour.

2. **Utilization:** The percentage of time equipment or resources are actively used versus idle.

3. **Downtime:** The amount of time equipment is not operational, affecting overall efficiency.

4. **Accuracy:** The precision with which materials are handled and delivered to their intended destination.

5. **Cycle time:** The time it takes for a complete cycle of material handling operations.

6. **Labor productivity:** The efficiency of human resources involved in material handling processes.

7. **Inventory accuracy:** Ensuring that the physical inventory matches the recorded inventory to minimize errors.

8. **Space utilization:** Efficient use of storage space to minimize the footprint required for materials.

9. **Energy efficiency:** Measuring the energy consumption of the materials handling system.

10. **Safety performance:** Evaluating the system's adherence to safety standards and the occurrence of accidents or incidents.

These measures help assess the overall effectiveness, efficiency, and safety of materials handling systems in various industries.

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II. Fundamentals of Materials Handling Systems

Materials handling systems involve the movement, storage, and control of materials and products throughout the manufacturing, distribution, and consumption processes. Key fundamentals include:

1. **Material Flow:** Efficiently moving materials from one point to another, optimizing the flow to minimize bottlenecks and delays.

2. **Storage Systems:** Proper storage methods and systems, considering factors like accessibility, space utilization, and inventory management.

3. **Material Handling Equipment:** Selection and use of equipment such as conveyors, forklifts, and automated systems to facilitate material movement.

4. **Packaging:** Designing packaging that ensures product protection, ease of handling, and compatibility with handling equipment.

5. **Information Systems:** Implementing technology for real-time tracking, monitoring, and control of materials within the supply chain.

6. **Safety:** Ensuring a safe working environment for personnel and preventing damage to materials through proper handling procedures.

7. **Ergonomics:** Designing workstations and processes with consideration for human factors to enhance efficiency and reduce the risk of injury.

8. **Automation:** Integration of automated systems for tasks like sorting, picking, and packaging to improve efficiency and reduce labor requirements.

9. **Cost Efficiency:** Balancing the costs associated with material handling against the benefits of improved efficiency, reduced errors, and enhanced customer satisfaction.

10. **Environmental Considerations:** Implementing sustainable practices in material handling to minimize environmental impact.

Understanding these fundamentals helps businesses design and implement effective materials handling systems tailored to their specific needs and industry requirements.

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III. Various types of materials handling equipments

There are several types of materials handling equipment used in different industries:

1. **Forklifts:** Used for lifting and moving heavy pallets or materials.

2. **Conveyors:** Transport materials from one location to another, commonly used in manufacturing and distribution.

3. **Cranes:** Lift and move heavy materials vertically and horizontally, often used in construction and shipyards.

4. **Pallet Jacks:** Manual or electric equipment for lifting and moving pallets within a warehouse.

5. **Hoists:** Lift and lower heavy loads vertically, commonly used in construction and manufacturing.

6. **Automated Guided Vehicles (AGVs):** Autonomous vehicles used for material transportation in warehouses and manufacturing facilities.

7. **Robotic Systems:** Advanced robots designed for various material handling tasks, such as sorting and packaging.

8. **Stackers:** Lift and stack materials, often used in warehouses and distribution centers.

9. **Shelving and Racking Systems:** Provide storage solutions for organizing and accessing materials efficiently.

10. **Carts and Dollies:** Manual or powered devices for transporting materials within a facility.

These are just a few examples, and the choice of equipment depends on the specific needs and requirements of the industry or application.

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IV- Types of conveyors

There are various types of conveyors used for transporting materials in different industries. Some common types include:

1. **Belt Conveyors:** Utilize belts to move items along a path.

2. **Roller Conveyors:** Use rollers to move objects, often in a gravity-driven system.

3. **Screw Conveyors:** Employ a rotating helical screw blade to move granular or liquid materials.

4. **Bucket Conveyors:** Move bulk material using buckets attached to a rotating belt or chain.

5. **Chain Conveyors:** Utilize chains to move materials, often in a continuous loop.

6. **Gravity Conveyors:** Rely on the force of gravity to move items along an inclined or horizontal path.

7. **Pneumatic Conveyors:** Transport materials through a pipeline using air pressure.

8. **Vibrating Conveyors:** Move materials using vibrations, often for delicate or friable items.

9. **Flexible Conveyors:** Can be bent and adjusted to various shapes, offering versatility in material handling.

10. **Overhead Conveyors:** Suspended from above, these conveyors move materials horizontally or vertically.

The choice of conveyor type depends on factors such as the nature of the materials being transported, the distance, and the required speed and precision.

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V- Refrigerated warehouses

Know What is Refrigerated Warehouse? Also known as Cold Storage

A warehouse is used to store goods; a refrigerated warehouse is used to store those goods which can only be stored at certain temperatures to keep them fresh.

Refrigerated storage helps in eliminating sprouting, rotting and insect damage.

In general, there are three groups of products, foods that are alive (e.g. fruits and vegetables), foods that are no longer alive and have been processed in some form (e.g. meat and fish products), and commodities that benefit from storage at controlled temperature (e.g. beer, tobacco).

Cold storage helps stabilize market prices and evenly distribute goods both on demand basis and time basis

There are two main types of refrigeration system used in cold storage warehouses, a **Vapour absorption system (VAS)** and **Vapour compression system (VCS)**.

VAS, although comparatively costlier, is quite economical in operation and adequately compensates the higher initial investment.

Refrigerated Warehouses are connected with the following logistics modes:-

Reefer Container

A reefer is the term used to refer to a truck, trailer, or shipping container that is equipped with a refrigeration unit for the transportation of temperature sensitive cargo.

For LTL shipments, the common options available are to keep the freight in a "cool" or "fresh" temperature range, or a frozen temperature range. The "cool" range is typically used for freight such as fresh produce or other perishable items. If shipping a Truckload in a reefer unit, a more specific range can be requested.

Reefer Ship

A **reefer ship** is a refrigerated cargo ship; a type of ship typically used to transport perishable commodities which require temperature-controlled transportation, such as fruit, meat, fish, vegetables, dairy products and other foods.

Reefer Truck

A **refrigerator truck** is a van or truck designed to carry perishable freight at specific temperatures. Like refrigerator cars, refrigerated trucks differ from simple insulated and ventilated vans (commonly used for transporting fruit), neither of which are fitted with cooling apparatus.

Refrigerator trucks can be ice-cooled, equipped with any one of a variety of mechanical refrigeration systems powered by small displacement diesel engines, or utilize carbon dioxide (either as dry ice or in liquid form) as a cooling agent.

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VI- Cold Chain Management

The Cold Chain and its Logistics

Authors: Dr. Jean-Paul Rodrigue and Dr. Theo Notteboom

The cold chain involves the transportation of temperature-sensitive products along a supply chain through thermal and refrigerated packaging methods and the logistical planning to protect the integrity of these shipments.

1. The Cold Chain

While globalization has made the relative distance between regions of the world much smaller, the physical separation of these same regions is still a very important reality. The greater the physical separation, the more likely freight can be damaged in one of the complex transport operations involved. Some goods can be damaged by shocks, while undue temperature variations can damage others. For a range of goods labeled as perishables, particularly food (produces), their quality degrades with time since they maintain chemical reactions, which rate can be mostly mitigated with lower temperatures. It takes time and coordination to move a shipment efficiently, and every delay can have negative consequences, notably if this cargo is perishable. To ensure that cargo does not become damaged or compromised throughout this process, businesses in the pharmaceutical, medical and food industries are increasingly relying on the cold chain.

The **cold chain** involves the transportation of temperature-sensitive products along a supply chain through thermal and refrigerated packaging methods and the logistical planning to protect the integrity of these shipments. There are several means in which cold chain products can be transported, including refrigerated trucks and railcars, refrigerated cargo ships, reefers, and air cargo.

The cold chain is thus a science, a technology, and a process. It is a science since it requires an understanding of the chemical and biological processes linked with perishability. It is a **technology** since it relies on physical means to ensure appropriate temperature conditions along the supply chain. It is a **process** since a series of tasks must be performed to prepare, store, transport, and monitor temperature-sensitive products. The main elements of a cold chain involve:

- **Cooling systems**. Bringing commodities such as food to the appropriate temperature for processing, storage, and transportation.

- **Cold storage**. Providing facilities for the storage of goods over a period of time, either waiting to be ship to a distant market, at an intermediary location for processing and distribution, and close to the market for distribution.

- **Cold transport**. Having conveyances available to move goods while maintaining stable temperature and humidity conditions as well as protecting their integrity.

- **Cold processing and distribution**. Providing facilities for the transformation and processing of goods as well as ensuring sanitary conditions. Consolidating and deconsolidating loads (crates, boxes, pallets) for distribution.

From an economic development perspective, the cold chain enables many developing economies to take part in the global perishable products market either as producers or as consumers. The growth in income is associated with a higher propensity to consume fruits, vegetables, fish, and meat products. Increasing income levels are associated with a change in diet with, among others, growing demand for fresh fruit and higher value foodstuffs such as meat and fish. People with higher socioeconomic status are more likely to consume vegetables and fruit, particularly fresh, not only in higher quantities but also in greater variety. Consumers with increasing purchase power have become preoccupied with healthy eating. Therefore producers and retailers have responded with an array of exotic fresh fruits originating from around the world

From a geographical perspective, the cold chain has the following impacts:

- **Global**. Specialization of agricultural functions permitting the transport of temperature-sensitive food products to distant markets. It enables the distribution of vaccines and other pharmaceutical or biological products from single large facilities to any market around the world.

- **Regional**. It can support the specialization of production and economies of scale in distribution. This could involve large cold storage facilities servicing regional grocery markets or specialized laboratories exchanging temperature sensitive components.

- **Local**. Timely distribution to the final consumer of perishables, namely grocery stores, and restaurants.

Some domestic or transnational supply chains may only require one transportation mode, but many times ground shipments are only one link in a combination of transport modes. This makes intermodal transfers critical for the cold chain. Intermodal shipments typically use 40-foot refrigerated containers that are capable of holding up to 26 tons of food. The container makes loading and unloading periods shorter and less susceptible to damage both on the container and its cargo. The environments in these containers are controlled electronically by either plugging into a generator or power source on the ship or truck as well as terminals and distribution centers. The efficiency of cold chain logistics permitted the consolidation of cold storage facilities to service large market areas.

2. The Emergence of Cold Chain Logistics

Since the 1950s, third-party logistics providers began to emerge and institute new methods for transporting global cold chain commodities. Before their emergence, cold chain processes were mostly managed in house by the manufacturer or the distributor. In the United States, Food and Drug Administration restrictions and accountability measures over the stability of the cold chain incited many of these companies to rely on specialty couriers rather than completely overhauling their supply chain facilities.

Specialization has led many companies to not only rely on major shipping service providers such as the United Parcel Service (UPS) and FedEx but also to a more focused industry that has developed a niche logistical expertise around the shipping of temperature-sensitive products. The potential to understand local rules, customs, and environmental conditions, as well as an estimation of the length and time of a distribution route, making them an important factor in global trade. As a result, the logistics industry is experiencing a growing level of specialization and segmentation of cold chain shipping in several potential niche markets within global supply chains. Whole new segments of the distribution industry have been very active in taking advantage of the dual development of the spatial extension of supply chains supported by globalization and the significant variety of goods in circulation.

The reliance on the cold chain continues to gain importance. Within the pharmaceutical industry, for instance, the testing, production, and movement of drugs rely heavily on controlled and uncompromised transfer of shipments. A large portion of the pharmaceutical products that move along the cold chain is in the experiment or developmental phase. Clinical research and trials are a major part of

the industry that costs millions of dollars, but one that also experiences a failure rate of around 80%. About 10% of medical drugs are temperature sensitive. If these shipments should experience any unanticipated exposure to variant temperature levels, they run the risk of becoming ineffective or even harmful to patients.

In all the supply chains it is concerned with, cold chain logistics favor higher levels of integration since maintaining temperature integrity requires a higher **level of control of all the processes involved**. It may even incite third-party logistics providers to acquire elements of the supply chain where time and other performance factors are the most important, even farming. This may involve the acquisition of produce farms (e.g. orange groves) to ensure supply reliability. Temperature control in the shipment of foodstuffs is a component of the industry that has continued to rise in relation to international trade. As a growing number of countries focus their export economy around food and produce production, the need to keep these products fresh for extended periods of time has gained in importance for commercial and health reasons. The cold chain is also a **public health issue** since the proper transport of food products will reduce the likeliness of bacterial, microbial, and fungal contamination of the shipment. Also, the ability to transport medical goods over long distances enables more effective responses to healthcare issues (e.g. distribution of vaccines).

3. Providing Temperature Controlled Environments

The success of industries that rely on the cold chain comes down to knowing how to ship a product with temperature control adapted to the shipping circumstances. Cold chain operations have substantially improved in recent decades, and the industry can answer the requirement of a wide range of products. Different products require the maintenance of different temperature levels to ensure their integrity throughout the transport chain. The industry has responded with the setting of temperature standards that accommodate the majority of products. The most common temperature standards are "banana" (13 °C), "chill" (2 °C), "frozen" (-18 °C) and "deep-frozen" (-29 °C), each related to specific product groups. Staying within this temperature range is vital to the integrity of a shipment along the supply chain, and for perishables, it enables to ensure optimal shelf life. Any divergence can result in irrevocable and expensive damage; a product can lose any market value or utility.

Being able to ensure that a shipment will remain within a temperature range for an extended period of time comes down largely to the type of container that is used and the refrigeration method. About 20% of all the energy consumed in cold chain logistics involves cargo refrigeration. Factors such as duration of transit, the size of the shipment, and the ambient or outside temperatures experienced are important in deciding what type of packaging is required, and the related level of energy consumption. They can range from small insulated boxes that require dry ice or gel packs, rolling containers, to a 53 footer reefer, which has its own powered refrigeration unit. The major cold chain technologies in providing a temperature-controlled environment during transport involve:

- **Dry ice**. Solid carbon dioxide is about -80°C and is capable of keeping a shipment frozen for an extended period of time. It is particularly used for the shipping of pharmaceuticals, dangerous goods, and foodstuffs and in refrigerated unit load devices for air cargo. Dry ice does not melt. Instead, it sublimates when it comes in contact with air.

- **Gel packs**. Large shares of pharmaceutical and medicinal shipments are classified as chilled products, which means they must be stored in a temperature range between 2 and 8°C. The standard method to provide this temperature is to use gel packs or packages that contain phase changing substances that can go from solid to liquid and vice versa to control an environment. Depending on the shipping requirements, these packs can either start off in a frozen or refrigerated state. Along the transit process, they melt to liquids, while at the same time capturing escaping energy and maintaining an internal temperature.

- **Eutectic plates**. They are also known as "cold plates". The principle is similar to gel packs. Instead, plates are filled with a liquid and can be reused many times. Eutectic plates have a wide range of applications, such as maintaining cold temperatures for rolling refrigerated units. They can also be used in delivery vehicles to keep the temperature constant for short periods of time, a process that can be suitable for deliveries in noise-sensitive areas or for night deliveries.

- **Liquid nitrogen**. An especially cold substance, of about -196°C, used to keep packages frozen over a long period of time and mainly used to transport biological cargo such as tissues and organs. It is considered as a hazardous substance for the purpose of transportation.

- **Quilts**. Insulated pieces that are placed over or around freight to act as a buffer in temperature variations and to maintain the temperature relatively constant. Thus, frozen freight will remain frozen for a longer time period, often long enough not to justify the usage of more expensive refrigeration devices. Quilts can also be used to keep temperature-sensitive freight at room temperature while outside conditions can substantially vary (e.g. during the summer or the winter).

- **Reefers**. The generic name for a temperature-controlled transport unit, which can be a van, small truck, a semi-trailer, or a standard ISO container. These units, which are insulated, are specially designed to allow temperature-controlled air circulation maintained by an attached and independent refrigeration plant. A reefer is, therefore, able to keep the cargo temperature cool and even warm. The term reefer increasingly applies to refrigerated forty-foot ISO containers, with the dominant size being 40 high-cube footers (45R1 being the size and type code).
- The cold storage facility is the most commonly used in cold chain logistics. It can range from a single temperature-controlled room servicing a single user and function to a large dedicated distribution center servicing multiple users and functions. There are also punctual examples, such as converting mines into cold storage facilities.

4. Cold Chains Operations

- Moving a shipment across the supply chain without suffering any setbacks or temperature anomalies requires the establishment of a comprehensive logistical process to maintain **shipment integrity**. This process concerns several phases ranging from the preparation of the shipments to final verification of the integrity of the shipment at the delivery point:

- **Shipment preparation**. When a temperature-sensitive product is being moved, it is vital first to assess its characteristics. A key issue concerns the temperature conditioning and the packaging of the shipment, which should already be at the desired temperature. Cold chain devices are commonly designed to keep the temperature constant, but not to bring a shipment to this temperature, so they would be unable to perform adequately if a shipment is not prepared and conditioned. A notable exception concerns bananas, which are transported around a temperature of 13o Celsius, for which it is possible to use a reefer to cool down the shipment. Other concerns include the destination of the shipment and the weather conditions for those regions, such as if the shipment will be

exposed to extreme cold or heat along the transport route. Using a reefer with its own power unit usually mitigates such concerns. The load unit carrying the temperature-sensitive cargo must also be prepared. For instance, a refrigerated container must be steam cleaned to remove the risk of bacterial contamination and brought to the specified conditions of the shipper, namely temperature and humidity. Another issue concerns atmospheric control, which is maintaining appropriate oxygen and carbon dioxide levels, helping control (delay) the ripening. This control can apply to the whole conveyance (reefer) but commonly involves wrapping products in polyethylene bags, which controls how gases permeate during transport.

- **Modal choice**. Several key factors play into how the shipment will be moved.

- Distance between the origin and the final destination (which often includes a set of intermediary locations), the size and weight of the shipment, the required exterior temperature environment, and any time restrictions (perishability) of the product all affect the available transportation options. Short distances can be handled with a van or a truck, while a longer trip may require an airplane or a container ship. In this case, the cost/perishability ratio becomes a factor in the modal choice.

- **Custom procedures**. If the freight crosses boundaries, custom procedures can become very important, since cold chain products tend to be time-sensitive and more subject to inspection than regular freight (e.g. produce, pharmaceuticals, and biological samples). The difficulty of this task differs depending on the nation (or economic bloc) and the gateway since there are variations in procedures and delays. A common issue relates to sanitary inspection that may require fumigation. Customs issues are commonly identified as the most crucial in establishing reliable international cold chains.

- **The "Last Mile"**. The last stage is the actual delivery of the shipment to its destination, which in logistics is often known as the "last mile". Key considerations when arranging a final delivery concern not only the destination but the timing of the delivery, so the critical labor and warehousing space is available. Trucks and vans, the primary modes of transportation for this stage, must meet the specifications necessary to transfer the cold chain shipment. Since many deliveries of cold chain products, particularly groceries, are taking place in an urban setting, they are impeded by congestion and parking difficulties Also important is the final transfer of the shipment into the cold storage facilities as there is potential for a breach of integrity and damages to fragile goods such as produce.

- **Integrity and quality assurance**. After the shipment has been delivered, and temperature recording devices or known temperature anomalies must be recorded and made known. This is the step of the logistical process that creates trust and accountability, particularly if liability for a damaged shipment is incurred. If problems or anomalies that compromise a shipment do occur, an effort must be made to identify the source and find corrective actions. This is particularly relevant to the high value of cold chain goods. While a standard container load can have a value between $50,000 and $100,000, a reefer load can reach $1 million. For the case of pharmaceuticals, the value of the cargo can reach $50 million.
- Therefore, the setting and operation of cold chains are dependent on the concerned supply chains since each cargo unit to be carried has different requirements in terms of location, demand, level of concentration, load integrity, and transport integrity. Because of the additional tasks involved, as well as the energy required for the refrigeration unit, transportation costs for cold chain products is much higher than regular goods. The ongoing rise in standards of living and economic specialization will remain important drivers for years to come in the growing demand for perishable goods and the cold chain logistics supporting their transport.

The cold chain has three main components: transport and storage equipment, trained personnel, and efficient management procedures. All three elements must combine to ensure safe vaccine transport and storage.

The cold chain has 4 main components, each of which must work perfectly to ensure the safe transport and storage of cold chain products:

Temperature-controlled storage — specialized refrigerated facilities where cold chain cargo is stored until it's shipped out to a distribution center or its destination.

Temperature-controlled transport — using customized insulated cold containers that help transport goods via airways, waterways, roadways, or railways.

Trained and diligent personnel — that are familiar with the complexities of handling sensitive cold chain cargo.

Efficient operational and management procedures — to minimize risk during day to day operations as well as contain it in case of unexpected incidents.

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VII- Supply Chain Management in Indian Agriculture

Definition:

"Supply chain means flow & movement of goods from the producers to the final consumers".

Supply Chain is a sequence of flows that aim to meet final customer requirements, that take place within and between different stages along a continuum, from production to final consumption.

The Supply Chain not only includes the producer and its suppliers, but also, depending on the logistic flows, transporters, warehouses, retailers, and consumers themselves. In a broader sense, supply chains also includes, new product development, marketing, operations, distribution, finance and customer service.

A Graphical Presentation of Supply Chain

Supply Chain Management: The term 'Supply Chain Management' is relatively new. It first appeared in logistics literature in the 1980s, as an inventory management approach with emphasis on the supply of raw materials. Logistics managers in retail, grocery, and other high inventory industries began to realize that a significant competitive advantage could be derived through the management of materials that flow in their 'inbound' and 'outbound' channels.

Supply Chain Management involves following processes:

- Integrated Planning
- Implementation
- Coordination
- Control

Therefore, SCM is the integrated planning, implementation, coordination and control of all Agri-business processes and activities necessary to produce and deliver, as efficiently as possible, products that satisfies consumer preferences and requirements.

Contrasting Supply Chain Management with Traditional Management Chain

Element	Traditional Management	Supply Chain Management
Inventory management approach	Independent Efforts.	Joint reduction in channel inventories.
Total cost approach	Minimize firm costs	Channel-wide cost efficiencies
Time horizon	Short-term	Long-term
Amount of information sharing and monitoring	Limited to needs of own current transactions	As required for planning and monitoring purposes
Amount of coordination of multiple levels in the channel	Single contact for the transaction between channel pairs	Multiple contacts between levels in firms and levels of channel
Joint planning	Transaction-based	On-going
Breadth of supplier base	Large to increase competition and spread risk	Small to increase coordination
Channel leadership	Not needed	Needed for coordination focus
Speed of operations, information and inventory flows	'Warehouse' orientation (storage, safety stock). Interrupted by barriers to flows. Localized to channel pairs	'Distribution Centre' orientation (focus on turnover speed). Interconnecting flows; JIT, Quick Response across the channel

Agriculture Supply Chain Networks

An agriculture supply chain system comprises organizations/cooperatives that are responsible for the production and distribution of vegetable/Fruits/Cereals/Pulses or animal-based products. In general, we distinguish two main types:

1. 'Agriculture food supply chains for fresh agricultural products' (such as fresh vegetables, flowers, fruit). In general, these chains may comprise growers, auctions, wholesalers, importers and exporters, retailers and speciality shops and their input and service suppliers. Basically, all of these stages leave the intrinsic characteristics of the product grown or produced untouched. The main processes

are the handling, conditioned storing, packing, transportation and especially trading of these goods.

2. 'Agriculture food supply chains for processed food products' (such as portioned meats, snacks, juices, desserts, canned food products). In these chains, agricultural products are used as raw materials for producing consumer products with higher added value. In most cases, conservation and conditioning processes extend the shelf-life of the products.

Issues Related to Agriculture Supply Chains

Participants in Agriculture supply chains, e.g. farmers, traders, processors, retailers, etc, understand that original good quality products can be subject to quality decay because of an inadequate action of another participant.

For example, when a farm leaves a can of milk for pick-up on a roadside, under the sun, without any cover, there will be a loss of quality that may even render the raw material unfit for processing.

Similarly, if processors, on the other hand, use packaging items and/or technologies that do not maintain freshness and nutritional characteristics of their products as much as possible, retailers will be likely to face customer complaints.

Characteristics of Agriculture Supply Chains and its impact on Logistics

Supply Chain Stage	**Issues with Product & Process Characteristics**	**Impact on Logistic/Flow of goods.**
Overall	Shelf-life constraints for raw materials, intermediates and finished products and changes in product quality level while progressing the supply chain (decay). Recycling of Materials Required.	• Timing constraints (goods have to be supplied quickly to avoid decay). • Information requirements (correct information of goods is essential).
Growers / Producers	• Long production times (producing new or additional agro-products takes a lot of time) • Seasonality in production • Variability of quality and quantity of	• Responsiveness • Flexibility in process and planning

	supply	
Food processing industry	• High volume, low variety (although the variety is increasing) production systems • Highly sophisticated capital-intensive machinery leading to the need to maintain capacity utilization • Variable process yield in quantity and quality due to biological variations, seasonality, random factors connected with weather, pests, other biological hazards • A possible necessity to wait for the results of quality tests • Alternative installations, alternative recipes, product-dependent cleaning and processing times, carry over of raw materials between successive product lots, etc. • Storage buffer capacity is restricted, when material, intermediates or finished products can only be kept in special tanks or containers • Necessity to value all parts because of the complementary nature of agricultural inputs (for example, beef cannot be produced without the co-product hides) • Necessity for lot traceability of work in process due to quality and environmental requirements and product responsibility	• Importance of production planning and scheduling focusing on high capacity utilization • Flexibility of recipes • Timing constraints, ICT possibility to confine products • Flexible production planning that can handle this complexity • Need for configurations that facilitate tracking and tracing
Auctions / Wholesalers/ Retailers	• Variability of quality and quantity of supply of farm-based inputs • Seasonal supply of products requires global (year-round) sourcing • Requirements for conditioned transportation and storage means	• Pricing issues • Timing constraints • Need for conditioning • Pre-information on quality status of products

Issues Related to Supply Chain Management in India

Some issues related to supply chain management in India include:

- Fragmented logistics network
- Economic interruptions
- Increased demand for specific goods and services
- Labor shortages
- Lockdowns
- Transit restrictions

Other supply chain management challenges include:

- Cost control
- Data collaboration and syncing
- Digital transformation
- Increasing freight prices
- Material scarcity
- Port congestion
- Rising risks in the supply chain
- Unexpected delays
- Difficult demand forecasting
- Higher labor costs from suppliers and manufacturers

Some supply chain management challenges in 2023 include:

- Material scarcity
- Increasing freight prices
- Difficult demand forecasting
- Port congestion

Challenges of Supply Chain Management

Globally, supply chains have faced headwinds from unforeseen demand and limited logistics capacity. The key challenges faced in supply chain management include:

• Rising risks in the supply chain

Risks in the supply chain primarily arise from volatility in the markets. Changing consumer demand, trade wars, raw material shortages, climate change, stricter environmental regulations, economic uncertainties and policy changes, industrial unrest, etc., contribute to supply chain management risks and challenges.

• Unexpected delays

Global supply chains inevitably involve large distances and many steps, making them vulnerable to delays. Long lead times for goods make the shipments susceptible to unexpected delays.

• Cost control

Costs of raw materials, energy, freight, and labor have seen a spike around the globe. To ensure operations without production interruptions and continued delivery of quality goods at reasonable rates - businesses must tighten cost control.

• Collaboration and syncing of data across the supply chain

Access to supply chain data is key to the efficient management of supply chains. Due to the multitude of data points in global supply chains, data management is a key challenge in supply chain management.

• Increasing freight prices

The rise in energy prices and the increased demand for container shipping have pushed freight prices. Container shipping demand experienced an increase from the e-commerce surge seen during the pandemic.

• Difficult demand forecasting

The pandemic and the consequent supply chain disruption made demand forecasting difficult and nearly impossible to estimate numbers for manufacturing and the inventory to be stocked.

• Digital transformation

Digital transformation through adopting technologies such as IoT, AI, drones and robotics is necessary to improve supply chain operations. However, the major challenge of supply chain management lies in implementing these technologies across existing supply chain operations.

• Port congestion

The pandemic led to restricted freight loading/unloading operations, causing port congestion. This, in turn, led to delayed dispatches and deliveries.
Supply chain challenges in the recent past have compelled businesses of all sizes to redesign their operational strategies to maintain healthy bottom lines and retain their customer base.
The critical challenges that global supply chains must contend with include:

- Navigating an environment of persistent unpredictability
- Labor shortages
- Ripple effects of global bottlenecks
- Equipment availability

Ways To Overcome the Major Challenges Faced In Supply Chain Management

• Automate processes.

Increased automation will help balance inventory levels, warehousing costs, and customer demand. Automation of forecasting helps optimize inventory, minimize overhead costs, and obviate the possibilities of stockouts and inventory shortages.

• Partner with industry peers

Considering the complexity of the modern supply chain, the traditional methods of operating with excel spreadsheets will not work. Ongoing and continuous collaboration with industry peers, vendors, regulators, manufacturers, financiers and logistics teams is imperative to keep the supply chain in motion. Software

tools with automated permissions, alerts, information-rich dashboards and real-time updates will make these partnerships feasible and easy.

• Get end-to-end visibility

To effectively control supply chain operations, you must have end-to-end process visibility, from procurement of raw materials from suppliers to delivery to the customers. This can be achieved by tracking and monitoring the supply chain with data logging. The analysis of the data obtained enables effective control over the process.

Conclusion

An agile and resilient supply chain is the need of the hour. However, resilience and agility cannot be built into a supply chain without carefully considering its design, implementation, and operation. This requires a change in mindset, the adoption of advanced technology and tools, and the inclusion of risk and agility KPIs along with the traditional KPIs of cost, quality, and service levels.

WAREHOUSE MANAGEMENT

UNIT 5

MODERN WAREHOUSE METHODS

What is modern warehousing

Using new age technology to improve the efficiency and betterment of warehouse.

Some popular technologies being integrated into the modern warehouse include Internet of Things (IoT), Robotics for picking, sorting, and handling of SKUs, Augmented Reality (AR), Radio Frequency Identification (RFID), drones for inventory monitoring, and block chain for data encryption.

Warehouse Transformation: The Future of Warehousing

Warehouses are used as storage spaces for products post-manufacturing, prior to their dispatch for sale or to other facilities down the line, and in later stages if the goods are returned. These facilities are used by businesses to store inventory before they are shipped to customers or dispatched to another location from which they will be sold via retail or redistributed.

Most warehouses work in two ways:

A retailer stores their goods and dispatches them directly from there. This setup is common for ecommerce businesses.

A wholesaler or distributor stores a variety of goods in large quantities in a warehouse before sending them to a retailer or reseller.

Warehouses are crucial assets for many businesses as long-term storage for their goods. They ensure that brick-and-mortar stores do not accumulate too much stock that they cannot yet display or sell.

The future of warehouses is exciting as there is so much potential for improvement and scaling. Upon leveraging technological advances across industries, future warehouses promise to be much more advanced and efficient.

Logistical and Tracking Advancements

Technological innovations and their integration in all aspects of economics and business have led to sweeping changes across industries worldwide. These advancements have led to the evolution of the logistics and tracking industry, thus changing the future of warehousing.

Due to the massive advancements in recent years, industrial warehouse technology is now leading the charge on all levels of supply chain data processing and analytics. What used to be labor-intensive, manual tasks such as processing payments, dispatching orders, and updating tracking information are now accomplished in a blink through advanced automation. All logistical and tracking procedures are only going to get easier with time.

Maintaining accurate inventory was a challenge faced by warehouses in all industries, from makeup products to clothing items. Today, high-end futuristic warehouse technology can track inventory and provide up-to-date numbers to business owners and warehouse managers no matter where they are in the world.

Warehouse of the future: Warehouse Automation

The warehouse of the future is one where automation is seamlessly integrated into all its processes. Modern warehouse design includes non-traditional technology that enables you to maintain an accurate digital inventory and have an on-the-go office.

When it comes to smart warehouse management, warehouse automation is the future. Installation and integration may be complicated in the beginning, but partnering with experts to assist you with automated warehousing solutions could ease the burden of your warehouse transformation.

Automation can streamline processes that otherwise take a lot of time and effort, such as maintaining incoming and outgoing stock, keeping track of orders and payments, and ensuring proper dispatch and delivery. With technology at the centre, the future of warehouse management systems will continue to evolve and become even more efficient than you can imagine.

Artificial Intelligence and Warehouse Innovation

Warehouse inventory tech and supply chain automation is expected to grow exponentially in the next half-decade. Estimates suggest that the $700 billion spent in 2020 on Industrial Internet of Things (IIoT) by growing companies will increase to $1 trillion by 2023.

Artificial intelligence (AI) and machine learning (ML) are changing how the supply chain industry works. They are now optimizing processes beyond what humans can deliver, and at previously unfathomable scales. This means all warehouse duties will be completed more efficiently, freeing time and resources for more specialized tasks.

Leveraging AI is so beneficial because it optimizes capacity planning, improves productivity, and boosts efficiency by helping with higher quality output at a lower cost.

Some of the main benefits of the latest technology used in warehouses, including AI technology, are:

Inventory Management

AI provides accurate numbers regarding inventory levels, and all its related variables, at the drop of a hat. It can also calculate demand forecasting and planning with the basis of calculating data from previous stock inflow and outflow. You can get real-time stock updates along with storage optimization recommendations with the help of AI integration.

Improved efficiency

AI and machine learning help improve efficiency by reducing the costs and resources required in processing orders and running a functional warehouse facility. This is achieved by reducing the amount of time and effort spent to manually input, update, and check data while providing

a smooth and seamless experience. In the span of minutes, AI and ML can gather data from multiple sources and offer much-needed recommendations.

Smoother, cheaper operations

AI warehouse operations can function day and night, ensuring that all warehousing processes are taken care of, such as customer service and order tracking. This reduces the amount of work required of your associates, thus improving productivity while lowering costs. There are also minimal chances of errors because AI systems perform quality checks at every stage of the process. The quality of work is elevated, thus ensuring accuracy and precision in handling all the important details.

Prompt and punctual processing

From accepting orders and processing payments, to updating packing and dispatch information, AI is extremely prompt and seamlessly smooth, thus ensuring faster and punctual deliveries to customers and retailers.

On-Demand Warehousing

An on-demand warehousing platform allows sellers to store inventory in warehouses offering their extra space. These warehouses of the future are different from traditional warehouse storage and enable new activities in distribution centres.

Sellers looking to increase their stocks during a specific season where the demand is higher than usual can opt for on-demand warehousing. AI facilitates these processes, thus enabling modern warehouse management that improves profits and turnover rates. This is the exciting future of warehouse management systems that businesses in any industry can look forward to.

On-demand warehousing is beneficial to warehouse owners and renters alike. Renters are free to avail of warehouse space without needing to sign long-term leases, and they can boost their inventory and inventory management on an as-needed basis. At the same time, warehouse operators can tap into a previously untouched clientele and will not have to worry about empty spaces in their facilities.

The on-demand structure is thus one of the best ways to make the most of existing warehousing infrastructure. Add to this the simplicity and ease of warehouse management with the help of AI and machine learning, and it's a recipe for success.

Trends to watch out for in warehousing

While GST has allowed companies to consolidate their warehousing presence to optimize sizes and locations, industry experts hold the opinion that given the distribution of consumption centres across urban and rural areas, length & breadth of the country and transportation time, it would be prudent to have multiple warehouses to reduce transportation timelines and costs.

Most businesses are moving away from Just-In-Time and lean inventory models because of the large-scale supply chain disruption experienced during the lockdown. Increased stocking requirements will, in turn, enhance the demand for warehouses.

Consumption-led demand has led to the emergence of e-commerce in the Tier-II & III cities. This has led e-commerce players to set up warehouses in smaller cities beyond the top 8 cities.

India is seeing a flurry of start-ups with business models centering around warehouse automation and technology. Some popular technologies being integrated into the modern warehouse include Internet of Things (IoT), Robotics for picking, sorting, and handling of SKUs, Augmented Reality (AR), Radio Frequency Identification (RFID), drones for inventory monitoring, and block chain for data encryption.

The warehousing segment has proven itself to be one of the quickest asset classes to recover from the pandemic. Robust demand and key policy interventions have paved the way for institutional investors and large-scale developers to participate in the growth of the sector.

https://itsupplychain.com/modern-warehousing-methods-and-practices/

Automated storage and retrieval system

https://www.conveyco.com/blog/automated-storage-and-retrieval-types/

Barcoding

BARCODING TECHNOLOGY AND APPLICATION IN LOGISTICS INDUSTRY

Barcode technology, an automatic identification technology developed and generated computer application for data collection, in an effective way achieved by automatic scanning of information. There is a wide scope of advantages with barcode.

Business integration process in supply chain management has become very simple and more useful with the use of barcodes. It's an effective identification tool to track products and also to curtail errors. Different types of supermarkets in the country are into the usage of barcode management and identification system. Barcode was first introduced in supermarkets along image recognition system of mostly used EAN (European Article Number), for this the barcode generation and recognition software is developed. Recognition system generates and identifies barcodes simultaneously making it more convenient and competent for good management and material circulation of medium along with other stores/ outlets.Being affordable, accurate and simple to handle it is widely used, even for personnel management.

Supply chain management has been influenced almost every aspect by barcodes, making it simpler and efficient. For timely and accurate information to operate with better warehouse efficiency and lower inventory on hand employing barcode technology in inventory practices are good.

There are multiple advantages in upgrading barcode scanners. The following are those:

Increased read rates: A laser scanners have their limitations as it can capture only single lines at a time, thus limiting the ability to "read" information. The new barcode reads using image technology, similar to the one found in digital cameras and microprocessors, thus even the poorly printed or damaged codes are read. The maintenance of the equipment is also minimal.

Improved Productivity: Supply chain network such as warehouse, transportation providers,retailers and others scans barcodes as per the entering and exit of packagesfrom their

facilities. There are sophisticated barcode that can read codedpackages and parcels from a moving conveyor belts. Improved productivity,accuracy and efficiency can be seen in a large warehouses and shipping companies depending on the type of scanner used, these improvements inefficiency plays a vital role in retaining a customer base.

Improved real time visibility: Data on a product are transmitted to a host computer, or cloud server by the latest digital barcode scanner. Managers, Sales executives, customers and employees- the main stakeholders are able to track the products' movement and can be ready to take any action if required at their end. The multiple benefits of improved visibility and transparency

Bottlenecks can be identified and resolved the mangers.

Reduction is calls from customers as they can track their shipments

Scheduling and tracking of inventory replenishments on the storefront can be done, leading to better sales.

To understand/ predict the root cause of delays in the supply chain can be done by storing images and data for later retrieval and analysis.

Reduced cost: The new improved and advanced technology, the devices are compact and affordable. Even small organisations can also set up without any investment. Modern barcode scanners are compact, powerful devices, have sleek designs, good user interface and in-built flexibility. For the stakeholders to invest on these upgraded machines are always a better proposition.

TRACIKING INVENTORY

STORAGE OF INVENTORY

INFORMATION MANAGEMENT

Pros and Cons of Bar Code Technology

Many warehouses can benefit from the full spectrum of bar code applications, but you should do the necessary detail cost benefit studies to determine your Return On Investment (ROI). Our recommendation is to begin with the basics and move to more advanced applications if you have the luxury and desire to use a phased in Bar code technology approach.

The following are some of the benefits that can be gained with the use of bar code technology in the warehouse.

Fast and accurate capture of data reduces paperwork and chance of errors. Your objective should be to eliminate manual clerical, time consuming tasks. The bar code data capture and positive confirmation of transactions will significantly reduce errors from keying from manual systems in receiving, put away, replenishment, picking, inventory control, etc.

Reduced labor costs. Some savings will be realized from clerical hours eliminating paperwork. For example the transfer or replenishment to and from transactions reduces the manual effort for writing transactions, controlling and entering them into the warehouse system.

Timely information. It should be noted that not all bar code systems or functions are necessarily on-line. But through on-line or short interval batch updates scanning, update and tracking functions information is much more immediately available for not only inventory functions but other apps using its input. Examples include product receiving reports, labor hours capture by function, cycle counting that may alert you to warehouse back orders, etc. But note you have to have information systems to support these functions.

Productivity measurement. Accurate and timely data capture ability to track individual and department function performance and posting individual results will increase productivity.

Reduced training time. Warehouse processes using bar coding are often easier to teach new employees because it streamlines and clearly defines processes and best practices and more importantly your company's warehouse standard operating procedures. The implementation of bar coding requires standardization and disciple of processes which is a huge benefit.

Better decision making. This culminates in the most accurate and timely data capture you can gain to better utilize your inventory and people assets. You will not be dependent on individual managers to collect data in their timeframes and with their methods. You can implement standardization processes of how warehouse department managers plan and control work.

Bar Code Technology Issues to Consider

Although there are many benefits attainable through bar code technology, there are a few key issues and concerns that should be recognized in making decisions as to how to utilize the technology. A few of these issues are as follows:

Many warehouse operations are based on having individual selling units bar coded by the manufacturer. If they are not, they must be relabeled in the warehouse which can be a costly process. In order to have vendors or manufacturers apply bar code labels, some type of Vendor Compliance process is required. This can be a sizeable task to implement and maintain.

The labeling of all locations with bar code labels can be a time consuming and expensive process. Don't assume that this will happen easily or quickly.

If your business consists of a few items and relatively few orders, the cost and effort to implement the technology may not be justified. Make sure the ROI is calculated and considered before jumping into any technology.

The acquisition and implementation cost of equipment and backbone infrastructure can be significant.

Generally, there is a requirement to have some type or level of Warehouse Management System in place to fully utilize the concept.

Bar code systems of themselves for example to not have labor management systems; whereas a warehouse management system with bar code may have a labor management module.

Remember the bar code technology requirements to utilize the advanced technologies (e.g. Pick to Light and Voice Picking). The evaluation of these requirements and costs should be completed before any final decisions are made with these technologies.

Take into account the implementation tasks, training and culture shift these technologies may require in your operation. Several years ago we saw a large multichannel retailer assume they could take their first bar code inventory to initialize the inventory for their WMS implementation at the same time. The inventory process and re-ticketing was a disaster and therefore the warehouse management system implementation failed. Another example is if your center relies on "tribal knowledge" to know where products are located rather than bar code bin/slot locations, anticipate and train to overcome resistance and problems with picking, inventory, put away etc.

https://www.reliantlogisticsinstitute.com/barcoding-technology-and-application-in-logistics-industry/

https://sps.honeywell.com/us/en/support/blog/productivity/barcode-scanning-for-logistics-when-social-distancing-matters

What is the meaning of RFID in logistics?

Radio Frequency Identification

RFID refers to Radio Frequency Identification. It is an automatic identification method that has become widely used in many fields of application in recent years. Basically, RFID is a contactless communication technology that transmits information to identify goods, merchandise, animals and people.

How does RFID work?

Every RFID system consists of three components: a scanning antenna, a transceiver and a transponder. When the scanning antenna and transceiver are combined, they are referred to as an RFID reader or interrogator. There are two types of RFID readers -- fixed readers and mobile readers. The RFID reader is a network-connected device that can be portable or permanently attached. It uses radio waves to transmit signals that activate the tag. Once activated, the tag sends a wave back to the antenna, where it is translated into data.

The transponder is in the RFID tag itself. The read range for RFID tags varies based on factors including the type of tag, type of reader, RFID frequency and interference in the surrounding environment or from other RFID tags and readers. Tags that have a stronger power source also have a longer read range.

The major advantages of using a robust RFID mechanism:

Real-time visibility of goods

Helps in locating products quickly and accurately

Reduces errors in recording to almost zero

Helps the warehouse managers to strategically plan product locations

High speed goods tracking mechanism

Simplifies the entire supply chain management process by eliminating errors

Advanced multi-functional RFID tags have additional sensors for performing extra tasks such as measuring temperature in case of specific medicines/chemicals that have to be stored accordingly.

RFID applications and use cases

RFID dates back to the 1940s; however, it was used more frequently in the 1970s. For a long time, the high cost of the tags and readers prohibited widespread commercial use. As hardware costs have decreased, RFID adoption has also increased.

Some common uses for RFID applications include:

Pet and livestock tracking

Inventory management

Asset tracking and equipment tracking

Inventory control

Cargo and supply chain logistics

Vehicle tracking

Customer service and loss control

Improved visibility and distribution in the supply chain

Access control in security situations

Shipping

Healthcare

Manufacturing

Retail sales

Tap-and-go credit card payments

Passive RFID tags from Honeywell used on toll roads.

RFID vs. barcodes

Using RFID as an alternative for barcodes is increasing in use. RFID and barcode technologies are used in similar ways to track inventory, but there are some important differences between them.

Can identify individual objects without direct line of sight.	Direct line of sight required for scanning.
Can scan items from inches to feet away, depending on type of tag and reader.	Require closer proximity for scanning.

Data can be updated in real time.	Data is read-only and can't be changed.
Require a power source.	No power source needed.
Read time is less than 100 milliseconds per tag.	Read time is half a second or more per tag.
Contain a sensor attached to an antenna, often contained in a plastic cover and more costly than barcodes.	Printed on the outside of an object and more subject to wear.

RFID challenges

RFID is prone to two main issues:

Reader collision. Reader collision, when a signal from one RFID reader interferes with a second reader, can be prevented by using an anti-collision protocol to make RFID tags take turns transmitting to their appropriate reader.

Tag collision. Tag collision occurs when too many tags confuse an RFID reader by transmitting data at the same time. Choosing a reader that gathers tag info one at a time will prevent this issue.

Pros of RFID in Inventory Management.

The primary benefit of RFID in inventory management relies on their automated, low-labor nature. Automated data collection and storage within an existing warehouse management system or other appropriate systems effectively eliminates many of the constraints and issues experienced when using labels or barcodes for tracking. Additional benefits of RFID tags in inventory management include the following:

Reduced Labor Costs. Since the tags automatically generate and report information when scanned by an AIDC system, it eliminates the labor costs.

No Line-of-Sight Requirements. RFID tags work independently of line-of-sight systems, like barcodes. In other words, workers do not have to turn boxes to align barcodes, apply barcodes or deal with damaged barcodes.

Improves Visibility. More information processed and captured leads to better visibility across your supply chain.

Contains More Information. More information also has natural benefits for tracking and tracing products and keeping consumers, retail partners and other supply chain partners in the loop.

Scans More Items, Faster. RFID tags can also process and catalog information faster than the best handheld barcode scanners.

Less Susceptible to Damage. Due to their construction, often in plastic or hard shells, RFID tags are less likely to be damaged in the packing, shipping and receiving process.

Prevents Overstocking and Understocking. Since everything is tracked, RFID tags can eliminate stocking issues too and improve security in your facility.

Cons in RFID Inventory Management.

Unfortunately, RFID tags are not necessarily the most cost-effective and workable solution in today's global supply chains. Some the primary constraints include the following:

Costs Can Be Higher. Implementation costs of RFID tags can be significantly higher than continuing to use barcodes.

Interference May Cause Problems. Certain materials, like heavy metals and sources of radio waves, may interfere with the transmission of data in an RFID tag.

Upgrading Equipment May Be Necessary. The tags also require scanners to automatically detect and register the tags. In addition, your WMS or other warehouse systems may require integrability with RFID systems.

RFID May Be Incompatible in Other Countries, DCs or Warehouses. Last, RFID tag information is not regulated by any authority. So, information standards in one region may not reflect information standards in another. As a result, you may need to invest heavily in transcribing APIs or EDIs to navigate these barriers.