LINCS: Leveraging, Integrating, Networking, Coordinating Supplies

INVENTORY MANAGEMENT

CERTIFICATION TRACK

for Entry- to Mid-Level Professionals in Supply Chain Management

Developed by the LINCS in Supply Chain Management Consortium, comprised of the following educational institutions:

Broward College (Lead Institution)
Columbus State Community College
Essex County College
Florida State College at Jacksonville
Georgia Institute of Technology
Harper College
Long Beach City College
Northwestern University
Rutgers, the State University of New Jersey
San Jacinto College
St. Petersburg College
Union County College

In partnership with the Council of Supply Chain Management Professionals.

This material was funded in whole by a $24.5M TAACCCT grant awarded by the U.S. Department of Labor's Employment and Training Administration to the LINCS Consortium.

Title Page

LINCS in Supply Chain Management Consortium
Broward College, Lead Institution
1930 S.W. 145th Avenue, Suite 224
Miramar, FL 33027
(954) 201-8440

Author: LINCS in Supply Chain Management Consortium

Title: Inventory Management Certification Track

Release Date: 03/20/2017

Version: v2.21

Website: www.LINCSeducation.org

To learn more about LINCS, visit www.LINCSeducation.org

Preface

The information in this Preface is an overview of LINCS in Supply Chain Management.

Supply Chain Management (**SCM**) as a paradigm is nothing new to business and industry. However, academia and employers have recently seen SCM become a major focus. There are currently several industry-recognized certifications in SCM, largely focused on individuals with experience in management through the executive level. The curriculum in the certification tracks listed below is directed at those who have entry- to mid-level experience.

The curriculum for these certification tracks include eight topics in SCM:

1. SCM Principles
2. Customer Service Operations
3. Transportation Operations
4. Warehousing Operations
5. Supply Management and Procurement
6. Inventory Management
7. Demand Planning
8. Manufacturing and Service Operations

Each certification track can be taken on its own to earn one certification; multiple certifications can be earned in any order. Each certification track covers the basic elements of the primary certification track, which allows the learner to obtain a foundational understanding of the **best practices** and processes associated with each topic.

Common Learning Blocks accompany each certification track, providing an overview of SCM. It is highly recommended that both the standalone Common Learning Blocks document **and** the certification track document be thoroughly reviewed **prior** to taking a national certification examination.

The content provided within this certification track relates specifically to **Inventory Management**. The national certification examination will include questions on both the **Inventory Management** content and the **Common Learning Blocks** content.*

*NOTE: Materials listed under *Optional Supplemental Resources* sections (in some certification track documents only) are not included on the national certification examination.

Inventory Management Certification Track Table of Contents

Abstract

Inventory management is an important function in controlling assets in the supply chain. Individuals working in the supply chain should have at least a basic understanding of the roles, costs, and benefits of inventories. This certification track is intended to provide students with an understanding of the basics of inventory management and to enable effective contributions to an organization.

Inventory is a function in the overall supply chain processes of an organization. Inventory is often obtained from suppliers in the form of raw materials and other goods and materials through the procurement department. Inventory also includes work in process and finished products from manufacturing operations.

Key elements in this certification track include the importance and use of inventory in the supply chain, exposure to the different types of inventory, techniques for effectively managing and controlling inventory levels, the relationship between forecasting and inventory management, and the financial impacts of inventory investments.

The goal of this certification track is to prepare students to successfully pass the inventory management national certification examination. The content of the certification track was developed by LINCS in Supply Chain Management Consortium. **SCPro™ Fundamentals Certification** examinations are owned and administered by the Council of Supply Chain Management Professionals (CSCMP).

Learning Block 1: Introduction to Inventory Management

Learning Block 1 Description

Effective **inventory management** is a key factor in the success of any organization. Companies are increasingly looking to provide improved **customer service** levels at reduced costs; the amount, type, and cost of **inventory** within a company has direct impacts on both **service levels** and the **profitability** associated with those service levels.

It is important to understand what inventory is, the various types of inventory that exist, how inventory is managed, and employee roles in managing inventory. Inventory is important because in many ways it is the lifeblood of the **supply chain**. Examples that show the impact of insufficient inventory include the following:

- Lost sales to **customers**
- Equipment downtime due to lack of spare parts
- A complete lack or limited amount of **components** and **raw materials** to assemble products

Learning Block 1 Learning Objectives

Upon completing this learning block, the learner will be able to:

- Understand the role and importance of inventory
- Discuss the main reasons for carrying inventory
- Describe the main approaches to managing inventory
- Outline how inventory items can be classified
- Explain the key roles and responsibilities for managing inventory at **distribution centers (DCs)**
- Discuss the ways inventory management functions with other processes in a company

Unit 1: Inventory Basics

Inventory includes raw materials, **work in process (WIP)**, **finished goods**, **merchandise**, spare parts, and other operating supplies which may be found in factories, **warehouses**, **retail** stores, or other types of storage facilities.

One of the greatest challenges for managing inventories is balancing supply with **demand**. Ideally, an organization would have sufficient inventory to satisfy customer demands for products without losing any revenue due to insufficient stock. However, an organization does not want to have too much

inventory on hand, because it costs money to both acquire and hold inventory (the costs of carrying inventory are discussed in Learning Block 6).

Inventory management involves striking a balance between three classes of costs: acquisition costs, **carrying costs**, and **shortage costs**.

Acquisition costs	Carrying costs	Stockout costs
Acquisition costs are incurred during **purchase order** (**PO**) preparation and processing and during receiving and inspecting purchased items.	**Carrying costs** are incurred in maintaining a stock of goods in storage.	**Stockout costs** (also called shortage costs) are incurred when an item is out of stock.

Acquisition Costs

Acquisition costs include the purchase price paid and associated administrative costs. Aside from the cost of materials and services, there are costs associated with placing the PO for those materials or services, including the labor cost to create, review, and transmit the order. The labor cost to receive and pay for ordered items is also an associated cost of acquisition. If large quantities of a product are ordered at the same time, the cost to place the order per unit ordered should be comparatively low.

Carrying Costs

There are costs associated with carrying (another term for stocking) items, such as buildings like warehouses, utilities, systems to track inventory, and labor to manage those inventory tracking systems. Additionally, **purchasing** large quantities of product may require a firm to utilize funds from loans or the issuance of stock. The cost of using borrowed funds comes as a component of carrying costs.

Stockout Costs

A **stockout** occurs when there are not enough products on hand to meet the immediate requests of internal **manufacturing operations** or customer orders. The costs of stockouts may include the following:

- **Backorder costs:** These are incurred when a firm must place an order with its **suppliers** for a rush shipment to meet customer or internal **manufacturing** needs; rush shipments typically incur higher handling and transportation costs.
- **Lost customers:** If customers are not willing to wait for a backorder, they may decide to take their business elsewhere, leading to reduced revenue for the firm.

Unit 2: The Necessity of Inventory

Firms hold inventory to meet the needs of their customers. Customers may be external to the firm or employees of other departments within the firm who require a certain product, material, or part. For example, a firm's **maintenance** mechanic may be viewed as a customer of the firm's spare parts storeroom. When customers place orders, they expect to receive their products in a reasonable amount of time. The same principle holds true for sales at retail locations. When a customer walks into a store, the store must have a reasonable range of inventory on hand to meet the different possible needs of that customer. If one store does not have the products a customer wants, it is likely the customer will simply go to another store to obtain what he/she needs.

Firms also hold inventory as a means of dealing with **uncertainty** in the supply chain. This uncertainty comes from chronic supplier manufacturing delays, late deliveries, poor quality, damaged or incorrect deliveries, and other issues that arise in the supply chain. The challenge for most firms is to hold enough inventory to satisfy manufacturing and customer demands while avoiding excessive financial commitments. To put it simply, a supply chain cannot operate without inventory; however, excess inventory often causes serious financial hardship. Company management must make good decisions about what inventory to acquire, hold, store, and about the scheduling, timing, and frequency of inventory **replenishment**.

Modern firms increasingly try to minimize or eliminate inventory wherever possible to control costs. Ideally, firms wish to hold the minimal amount of inventory that allows them to provide for manufacturing and customer needs without running out of inventory. Running out of inventory can lead to manufacturing delays and lost sales, but carrying too much inventory costs money.

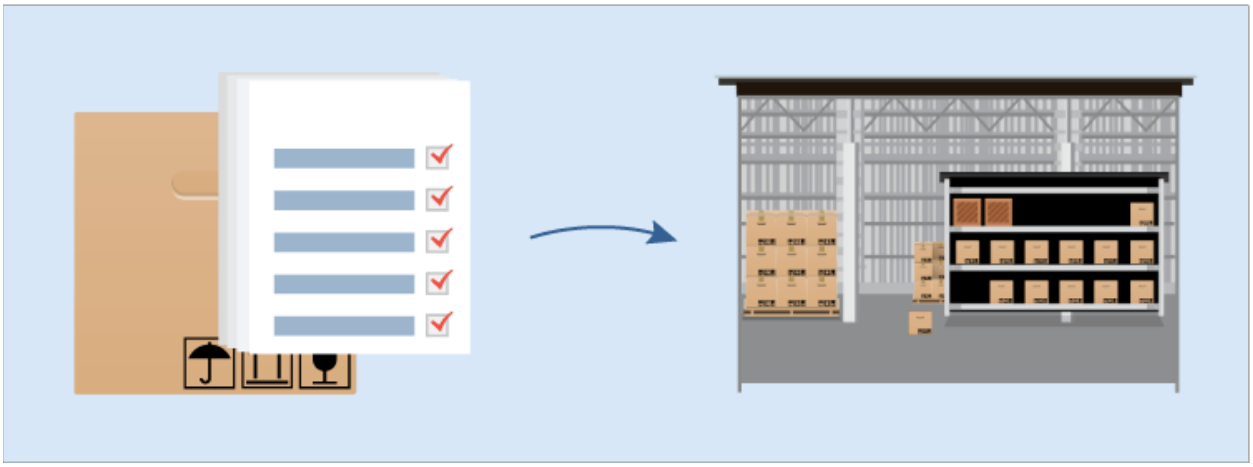

Figure 1. Necessity of inventory. Developed by LINCS in Supply Chain Management Consortium.

Appropriate Reasons for Carrying Inventory

Obviously, a manufacturing company requires inventory of raw materials and components to create finished products and meet its production and order schedules. Many companies also need spare-parts inventory to support customers who may need to repair broken products or to support internal company employees who need those parts to maintain buildings and the equipment in them. Retailers could not operate without inventories of finished goods; without inventory, customers would be looking at empty shelves.

Personnel throughout the supply chain need to manage inventory on a daily—sometimes even hourly, as in the grocery business—basis. Retail store managers, for example, must know the exact number of items they carry on display and in storage to fill customer orders, place orders when inventory is low, and control theft and **losses** due to error. Factory managers also need to know how many units of their products are available for customer orders. Restaurant managers need to order food based on current stock and the expected food consumption (Pollick, 2015).

Figure 2. The cost of holding inventory. Developed by LINCS in Supply Chain Management Consortium.

Problematic Reasons for Carrying Inventory

There are correct and incorrect reasons for carrying inventory. Unfortunately, ordering inventory is often used to compensate for supply chain problems, which leads to excess inventory. Instead of addressing the root causes of problems, companies mask them with high inventories. Examples of these supply chain problems include:

- Poor **demand planning**, poor **forecasting**, and high forecasting error
- Product theft
- Poor supplier performance (inaccurate **lead time**, late delivery, poor quality, etc.)
- Poor production yields that require greater inputs for the desired output
- Poor or nonexistent inventory planning and tracking systems
- Poor inventory counting systems that reduce stock accuracy
- Large-quantity purchases to obtain lower unit prices that are outweighed by higher carrying costs
- Inattention to obsolete inventory disposition; obsolete stock no longer has value

Inventory Carrying Locations

There are a number of points in the supply chain where inventory is found. Inventories of raw materials, components, **semi-finished products**, maintenance items, and **repair items** are often held at supplier facilities or at the buying company's warehouses and other facilities. Inventories of finished or intermediate (semi-finished or processed) goods may be found at locations such as manufacturing facilities, warehouses, DCs (distribution centers), retail locations, or **point-of-sale** (**POS**) locations. *Figure 3* illustrates the various points in a supply chain where inventory is typically held.

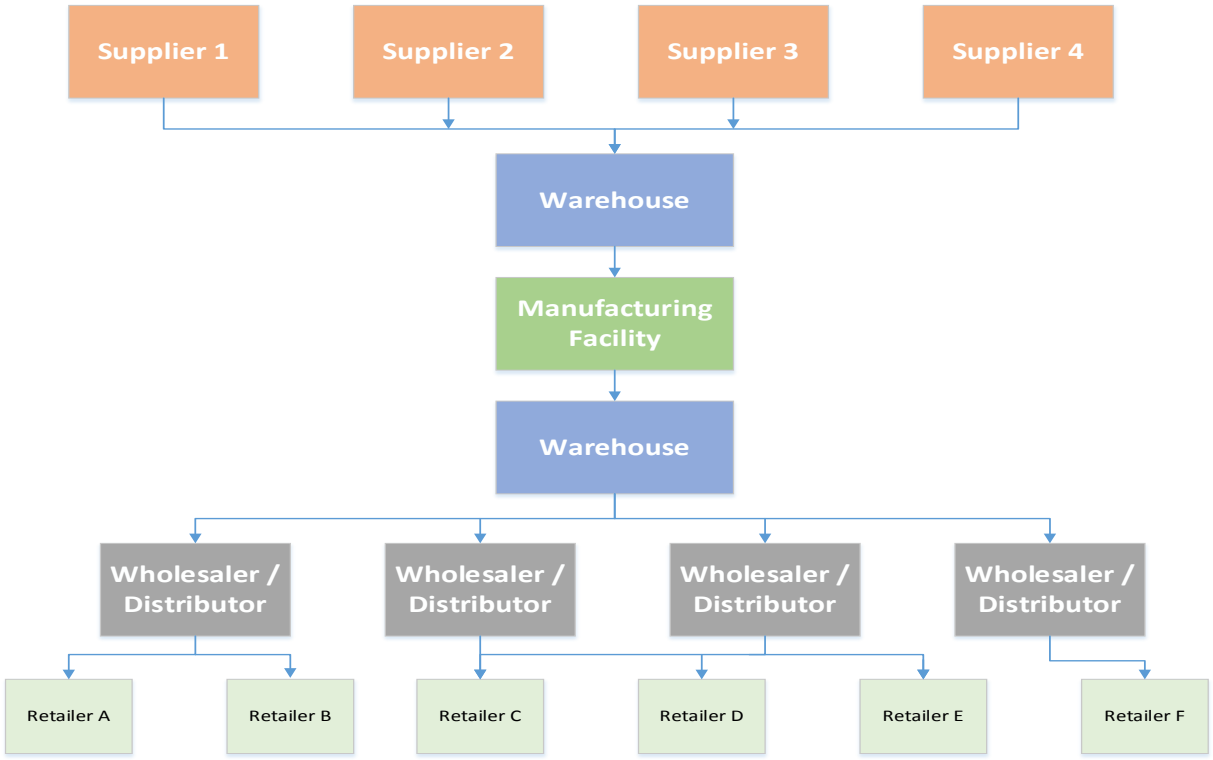

Figure 3. Points in a supply chain where inventory is typically held. Developed by LINCS in Supply Chain Management Consortium.

Unit 3: Functional Types of Inventory

Different types of inventory have unique functions or purposes and may be managed differently depending on where the inventory is held and its role in the supply chain. The various functional types of inventory are:

Cycle Stock	Inventory that is depleted through normal use or sale; firms hold **cycle stock** in DCs and retail stores in anticipation of customer orders or to respond to normal consumption demands.
In-process Stock	Goods being manufactured or in between manufacturing processes (also known as WIP or semi-finished goods).
Safety Stock	**Safety stock** (**buffer stock**) is held to protect against uncertainties in the supply chain. These uncertainties include chronic supplier manufacturing delays, changes in **demand rate** (the rate of demand for stock that can vary over time), and variances in lead-time length.

Seasonal Stock	**Seasonal stock** is held in advance of the season when the firm expects to sell it. Industries that typically require significant seasonal stock include apparel, sporting goods, and specialty holiday.
Promotional Stock	**Promotional stock** is held to respond quickly to marketing promotions or price incentives a firm plans to offer its customers, including holiday promotions.
Speculative Stock (i.e., hedge stock)	**Speculative stock (hedge stock)** is most commonly associated with companies involved in manufacturing or assembly. This type of inventory is held to protect against expected and possible price increases or constrained availability. For example, U.S.-based firms might stockpile component parts and **subassemblies** purchased from firms in Korea, Japan, and Singapore in expectation of future price increases in goods from those countries. This helps protect U.S. firms against supply uncertainties and against increased **import tariffs** and currency fluctuations.
Maintenance, Repair, and Operations (MRO) Inventory	**Maintenance, Repair, and Operations (MRO)** inventory include parts and materials that exist primarily to ensure a **plant or manufacturing facility** and its equipment are safe, reliable, and optimally available for production purposes. Service parts help ensure that key pieces of equipment continue to function effectively.

Unit 4: Managing Inventory

According to Scott (2015), inventory management is a means of controlling and managing the flow of products into, within, and out of an organization. Effective inventory management means using a variety of different inventory management tools and techniques (which is covered in Learning Block 2). Having unnecessarily high levels of inventory adds to expenses by increasing overhead costs. One effective way to manage inventory is to determine the business's inventory demands and to manage inventory levels accordingly. Therefore, the central goal of inventory management is to optimize levels of inventory so there is the right amount of inventory in place to meet customer needs, while ensuring the company is not overinvesting in inventory.

Although the key principles of inventory management are the same across all industries, the areas that need to be emphasized vary from sector to sector. Learning to apply the right inventory management tools is an important part of effectively executing inventory management.

Historically, managing inventory involved answering basic questions such as how much inventory to hold, how much to reorder from vendors and plants, and when to reorder. Regardless of the industry, there are key areas of responsibility for inventory management.

Figure 4. Demand forecasting. Developed by LINCS in Supply Chain Management Consortium

Demand Planning

A key element of inventory planning is to estimate the amount of inventory required over a set time period to meet customer needs. Various forecasting, planning tools, and techniques are used for demand planning and are covered in Learning Block 4. Accurate demand planning prevents both oversupply and undersupply of inventory.

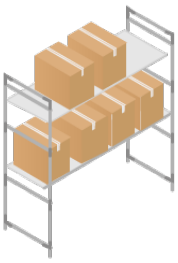

Figure 5. Holding inventory. Developed by LINCS in Supply Chain Management Consortium.

Deciding How Much Inventory to Hold

Rightsizing the inventory is dependent on the specific industry. Retailers may want a one- or two-month supply on hand, while food businesses will want to have much less inventory because of their products' limited shelf life, especially fresh foods, to minimize loss and spoilage. Companies carrying maintenance spares may carry inventory for months or even years until demand arises. Several tools, techniques, and strategies exist for determining how much inventory to hold, which is outlined in Learning Block 2.

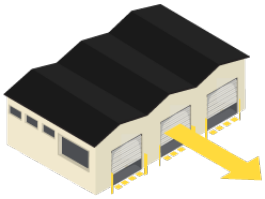

Figure 6. Inventory turnover. Developed by LINCS in Supply Chain Management Consortium

Measuring Inventory Turnover

Inventory turnover, also known as **inventory turns** or **inventory velocity**, is the rate at which inventory moves through a distribution facility. For example, if a warehouse holds an average of 100 bricks over the course of the year and sells 200 bricks over the same year, its inventory turnover is the number of bricks sold divided by the average number of bricks in inventory: 200/100 = 2 inventory turns for the year.

Counting Inventory

Figure 7. Counting inventory. Developed by LINCS in Supply Chain Management Consortium

For **inventory control** purposes, it is necessary to compare the on-hand levels with inventory records by performing a physical count of all items. Inventory counts are usually done either by counting the entire inventory at one time, known as a **physical inventory**, or by counting items at varying times on a prescheduled basis, which is called **cycle counting** (**counting inventory** is covered in Learning Block 3).

Tracking and Controlling Inventory

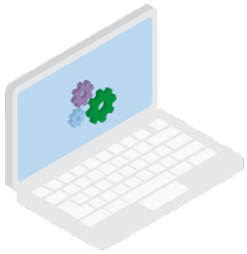

Figure 8. Tracking inventory. Developed by LINCS in Supply Chain Management Consortium

Once a company has acquired inventory, suitable tracking and control methods must be implemented. Accurate tracking of inventory is essential to ensuring where inventory is in the supply chain, how much inventory is moving in and out of the company, and how much inventory is being held at any one point in time. Inventory control involves counting and monitoring inventory items, recording the stocking and retrieval of items, identifying and verifying storage locations, recording changes to inventory, and anticipating inventory needs (inventory control is covered in Learning Block 3).

Unit 5: Inventory Management Jobs

Inventory Management/Control Employee Tasks

Inventory management personnel classify, label, and maintain inventory and keep accurate inventory records, including the location of inventory for easy retrieval. In addition, Inventory management personnel communicate inventory locations and levels to department managers, and keep records of inventory for disposal or transfer (implementing a control system can help reduce **breakage**, damage, and **obsolescence**).

In addition to the primary duties stated previously, inventory control personnel may also be responsible for recording incoming inventory purchases and outgoing inventory types and quantities in the **shipping** and receiving department. Companies also require physical inventory counts to help ensure accuracy of inventory. Through stock counts, inventory control employees must reconcile inventory records with physical inventory on-hand; this occurs either once a year, when stock is physically counted and compared to inventory records, or on an ongoing basis, using cycle counting.

Figure 9. Inventory management. Developed by LINCS in Supply Chain Management Consortium.

Types of Jobs in Inventory Management

The jobs and key duties in inventory management include the following:

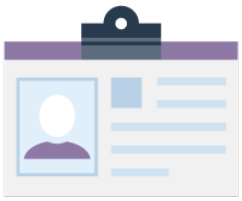

Figure 10. Jobs in inventory management. Developed by LINCS in Supply Chain Management Consortium

- **Inventory Control Analyst:** Includes cycle counting and keeping records
- **Inventory Data Analyst:** Analyzes data and scenarios, evaluates options, and makes recommendations to management
- **Inventory Operations Specialist:** Includes product tracking and placement
- **Quality assurance:** Includes acceptance and inspection of incoming and outbound product
- **Inventory Supervisor:** Includes direct supervision of inventory control personnel

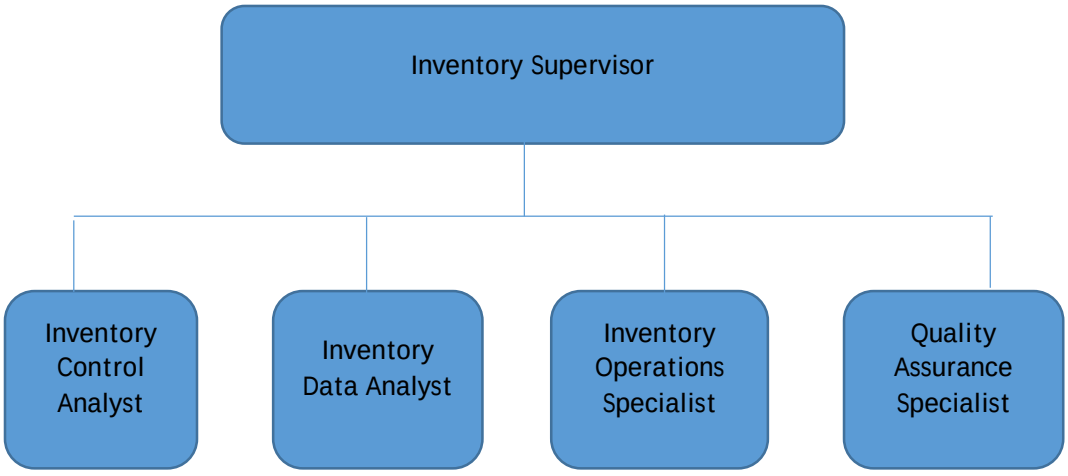

Figure 11. Typical Inventory Organizational Chart. Developed by LINCS in Supply Chain Management Consortium.

Inventory control workers typically report to a **supervisor**. The supervisor typically reports to a **warehouse manager** or **inventory manager**, depending on the size of the organization and its structure. Warehouse managers may in turn report to a distribution director, while inventory managers may report to an **inventory director**, again depending on the size and nature of the operation.

Learning Block 1 Summary

Inventory includes raw materials, WIP (work-in-process), finished goods, merchandise, spare parts, and other operating supplies, which may be found in factories, warehouses, retail stores, or other types of facilities. One of the greatest challenges in managing inventories is balancing supply with demand. Many firms are increasingly attempting to minimize or even eliminate inventory wherever possible, but they must retain enough inventory to meet the needs of internal manufacturing operations and customers, so when a customer

Figure 12. Inventory management. Developed by LINCS in Supply Chain Management Consortium

places an order, it can be received in a reasonable time. Inventory can be viewed in terms of the functions served: cycle stock, in-process stock, safety stock, seasonal stock, promotional stock, and speculative or hedge stock.

Inventory management is a means of controlling and managing the flow of products into, within, and out of an organization. Key areas of responsibility in inventory management include calculating demand expectations, measuring inventory turnover, counting inventory, and **tracking and controlling inventory**. Maintaining accurate, acceptable, and optimized inventory levels is the primary duty of an inventory management employee. Inventory management employees within an organization must effectively collaborate with and support other functional groups.

Learning Block 1 Practice Questions

1. Inventory can be defined as:

a. Raw materials, work in process, finished goods, merchandise, spare parts and other operating supplies, which may be found in factories, warehouses, retail stores, or other types of facilities
b. Only the finished goods in a store
c. Only the goods purchased to supply customer needs
d. Only the materials in a distribution center

2. What is one of the greatest challenges in managing inventory?

a. Obtaining an accurate demand plan
b. Carrying enough inventory to cover all emergencies
c. Having a responsive procurement system
d. Balancing service with demand

3. Firms hold inventory for which reason?

a. To meet the needs of shareholders
b. To meet the needs of customers
c. Firms do not need to hold inventory
d. To reduce investment

4. Cycle stock is held:

a. To protect against uncertainties in demand
b. In advance of the season during which it will be needed
c. For rapid response to marketing promotions
d. To respond to normal demand or consumption

5. Inventory management is a means of :

a. Managing manufacturing operations
b. Increasing the levels of inventory held throughout a company
c. Controlling the flow of products into, within, and out of an organization
d. Eliminating the purchase of inventory

6. Measuring inventory turnover involves:

a. Counting and monitoring inventory
b. Measuring the rate at which inventory moves through a facility
c. Determining how much inventory to hold
d. Counting all items at varying times on a prescheduled basis

7. A key responsibility in inventory management is forecasting the amount of inventory that will be required over a(n):

a. Set period of time to meet customer needs
b. Set period of time to meet some customer needs
c. Set period of time to meet competitor needs
d. Indefinite period of time to meet customer needs

8. The duties of an inventory management employee include:

a. Maintaining high levels of stock at any cost
b. Purchasing replenishment stock
c. Physical inspection of all goods received
d. Maintaining accurate and acceptable inventory levels

9. Firms hold safety stock (buffer stock) for what reason?

a. To protect against expected and possible price increases or constrained availability
b. To have in advance of the season during which the stock will be needed
c. To allow for a quick and effective response to a marketing promotion or price deal
d. To protect against uncertainties in the supply chain

10. What types of industries require significant seasonal stock?

a. Automotive and automotive after-market
b. Wholesale and retail food
c. Apparel, sporting goods, and specialty holiday
d. Home improvement and construction

Learning Block 2: Monitoring and Analyzing Inventory

Learning Block 2 Description

Because many companies have a great deal of money committed to inventory, it is important to review ways to manage inventory effectively. This learning block will look at ways to monitor and analyze inventory. The goal is to reduce costs while optimizing service levels that customers receive by implementing effective inventory management practices. This learning block will also review methods of inventory management to reduce the overall amount of inventory held by a company.

Learning Block 2 Learning Objectives

Upon completing this learning block, the learner will be able to:

- Describe inventory replenishment and its relationship to customer service levels
- Discuss the main ways to categorize and manage inventory
- Define the basic concepts of inventory modeling
- Understand the ideas behind determining how much inventory to hold and when to reorder

Unit 1: Inventory Replenishment

Inventory is expensive to hold, so companies do not want to have too much inventory. Whenever an item is sold to a customer, an item should replace it so that the next customer will also be able to purchase the item. Although it is not possible to sell one item and instantly create an item to replace it, companies strive to ensure they have neither too much nor too little inventory on hand. Inventory replenishment is the **process** of determining how much of a material or product to make or buy and when to procure it so it is available in the right location when a customer wants it. If a particular item is not available at the right place and time, it is known as an out-of-stock situation, or more commonly as a stockout.

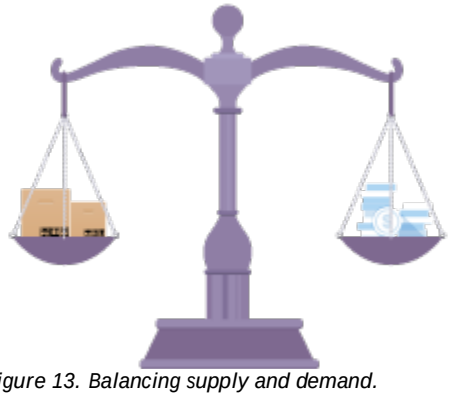

Figure 13. Balancing supply and demand. Developed by LINCS in Supply Chain Management Consortium.

Inventory replenishment is part of the larger inventory management process. Companies try to balance the need for on-hand product for customers against having too much inventory by determining the timing and amount of additional inventory needs. Replenishment helps companies determine how much to ship to refill their inventories and when they should ship those products.

Companies often base their inventory stocking and replenishment policies on their desired service levels.

For instance...

If a retail store wants a

98% service level,

they have to have enough inventory on hand to ensure customers get their desired products in

98 out of 100 visits to the store.

Marketing, sales, demand planning, and inventory personnel work together to determine the correct service level for a company or a particular product.

Unit 2: Key Inventory Metrics

Companies typically use a variety of key metrics, another word for measures, to compute inventory management effectiveness and efficiency. The following key metrics are commonly used for managing inventory:

Inventory Turns	The number of times inventory turns over, or cycles, over a one-year period; this is discussed in more detail in Learning Block 6.
Average Inventory Level	The **average inventory level** maintained in the system; the goal is to reduce the inventory levels without negatively impacting other metrics.
Line Item	Represents an individual line or **stock keeping unit** (**SKU**) on an order with a defined quantity

Line Item Fill Rate	The total number of **line items** filled, divided by the total number of line items on an order; this metric applies to single products or orders that contain multiple products
Order Fill Rate	The number of orders filled on time, divided by the total number of orders over the same period; the **order fill rate** should be as close to 100% as possible
Service Level	Represents the likelihood of having available stock in a **replenishment cycle**, which is the time period from placing the order until it is received; companies use the service level to calculate safety stock in the inventory models
Months/Days of Inventory on Hand	This represents how long inventory should last based on past product demand history or projected future product demand; months/days of inventory on hand is more commonly known as average inventory period.

Unit 3: Criteria Used to Categorize Inventory

Inventory personnel must balance all inventory criteria to ensure the most efficient supply chain. This is a delicate evaluation and balancing of financial, customer service, and storage factors. Although low costs are important, sometimes customer service requires more financial investment in inventory.

For example...

There are about 30,000 items at a typical grocery store and about 70,000 items at a mass market discount retailer. If a store holds too much stock beyond what is required to satisfy customer demand, this stock may end up wasting money due to spoilage and stock that remains on the shelf beyond its sell by date. If a store holds too little stock, then it may lose sales when items are not readily available for customers. In this case, it would be better to have slightly more inventory than strictly required by projected demand to help ensure the store does not run out of stock. The key to customer satisfaction is ensuring replenishment processes are optimized to have an ample supply of products, but not so much it becomes cost-prohibitive.

Figure 14. Grocery stores stock thousands of items. Acquired from pixabay.com.

One method for managing different types of items is to categorize them based on particular criteria. There are several key criteria an inventory manager can use, listed and explained as:

1. Dollar value
2. Turnover or velocity
3. System-wide quantity or volume
4. Size
5. Critical Items
6. Shelf life

Dollar Value

One method of determining how to balance anticipated customer demand with how much of an item to hold in inventory is to determine the item's value. Value is expressed in terms of what an item is worth, usually in dollars. Inventory personnel typically look at inventory value on two levels: the total dollar amount on hand across items in inventory, and the total dollar amount held for each SKU or individual product. By sorting items based on value, inventory personnel can determine future investments.

For example...

A computer reseller such as Best Buy would place orders to buy desktop and laptop personal computers (PCs) and peripherals (keyboards, thumb drives, printers, etc.). As Best Buy looks at the items from a value perspective, it places greater emphasis on evaluating the quantity of PCs required than the quantity of thumb drives required due to the significant cost difference of the two items. If the PCs failed to sell due to introduction of newer technology, the costs to scrap or otherwise dispose of the PCs would be much more significant than having thumb drives that failed to sell.

In a manufacturing operation, value can be regarded across three categories of inventory: raw materials generally have the lowest value, WIP (work-in-process) items have the next lowest value, and finished goods have the highest value. Value is added to inventory as it progresses through the supply chain. For example, a textbook manufacturer buys paper, cardboard, ink, and other raw materials required to make books. The paper would then be converted into printed pages, which adds value based on using a printing press and the labor to operate it. These printed pages represent WIP. The printed pages would then be cut, bound, and covered in the bindery, adding further value based on using equipment, glue, and more labor. The books are then finished products that account for the total costs of relevant materials and labor.

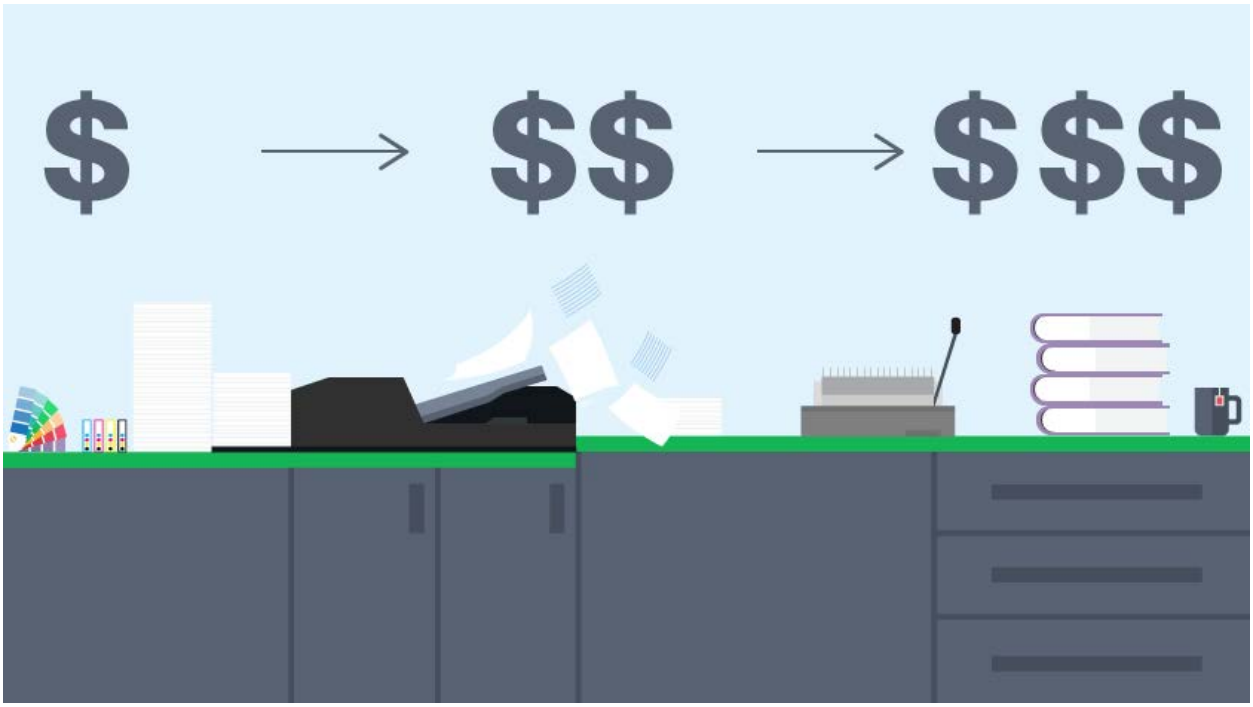

Figure 15. Inventory increases in value as it progresses through the supply chain. Developed by LINCS in Supply Chain Management Consortium.

Turnover/Velocity

Another inventory **classification** is velocity, or how fast an item sells or moves in and out of stock. Companies often focus on the items that sell the most or have the highest velocity through their systems. An item that sells 100 units a week has a higher velocity than an item that has five sales a week. Therefore, companies spend more time monitoring and managing the faster-moving items and ensuring there are effective replenishment strategies for those items.

System-Wide Quantity/Volume

System-wide quantity in a company represents the quantity of a particular item that is on hand, or immediately available. System-wide quantity can also be defined as the total amount of all SKUs or individual items a company has in stock across its stocking locations. For a retailer, the volume on hand of a single item would include the items in store locations and items in warehouse or DC (distribution center) stocks. Volume of stock is used, for example, to determine if enough stock is available to meet anticipated demand and to determine if more stock is required, or if too much stock of a particular item exists.

Size/Cube

Size or **cube** is the amount of space taken up by an item or a case of an item. The size of an item has a direct relationship to the utilization of any storage facility. Although it might be easy to carry 1,000 cases of vitamins, it takes more room to carry 1,000 cases of paper towels. The amount of space inventory takes up represents **inventory carrying costs** in a company.

Critical Items

An additional—but sometimes overlooked—criterion is critical items. An item can have low value and low velocity but still be highly critical. For example, a bolt that is crucial to holding an aircraft engine onto the wing is not likely to be very expensive. Only one such bolt may be needed each year to replace a worn or damaged bolt, but that part must be in stock or the plane cannot fly. The bolt is an example of a highly critical item.

Shelf Life

Shelf life is the length of time that an item can be held or stored until it is unfit for sale, use, or consumption. Shelf life usually applies to prescription drugs, food, and other perishables but is also a factor in rubber products such as hoses, belts, and O-rings. Excessive inventory coupled with low velocity might result in spoilage and scrap, resulting in the costly disposition of unusable products.

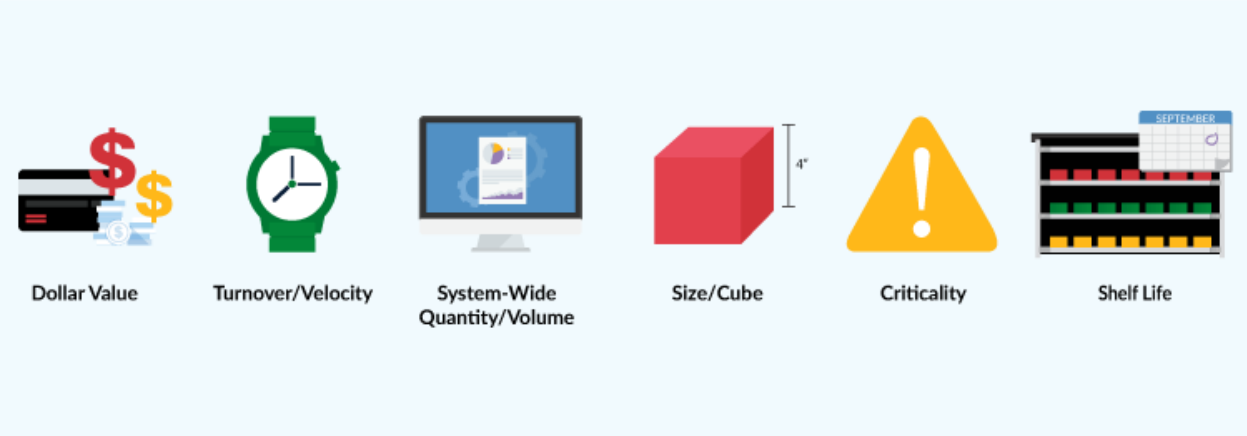

Figure 16. Inventory classifications. Developed by LINCS in Supply Chain Management Consortium.

Unit 4: Inventory Models

ABC Analysis

In addition to the six criteria previously listed in Unit 3 to categorize inventory, a company may also elect to apply **Pareto's principle**, also called the 80/20 rule. This analysis uses value, velocity, or volume to determine which items are most important and which ones require the highest levels of attention. Ranking inventory items in terms of importance using Pareto's principle enables the separation of the vital few from the trivial many. The principle assumes that a relatively small percentage of a population may account for a large percentage of the overall impact or value: for example, a company might establish that approximately 20% of its inventory accounts for 80% of its total inventory cost.

In inventory terms, Pareto's principle forms the basis for ABC analysis, which suggests that a relatively small number of items or SKUs may account for a considerable proportion of the value or impact of stock held. *Figure 17* demonstrates ABC analysis as it applies to inventory management. The diagram

illustrates that approximately 20% of the items held in stock account for approximately 80% of the total value of inventory. The items that make up this 20% are referred to as A items. The items in the B category account for approximately 50% of the items in the product line, but make up only an additional 15% of total inventory value. Finally, the C items are the remaining 30% of the items that account for approximately 5% of the overall value of inventory.

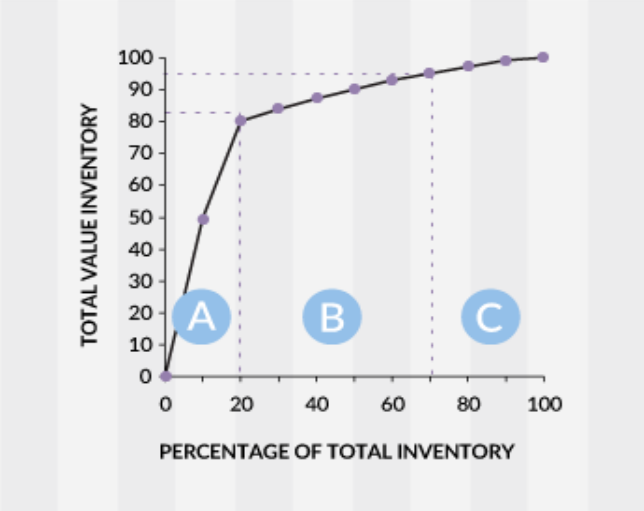

Figure 17. ABC Inventory analysis. Developed by LINCS in Supply Chain Management Consortium.

An ABC analysis provides a good starting point for inventory management and control. ABC analysis is used for the following purposes:

- **Differentiating service level categories:** A items have a higher service level than B items, and B items have a higher service level than C items.
- **Specifying lead time categories:** A items should have the shortest lead times, followed by B items; C items would normally have the longest lead times.
- **Cycle (or continuous) stock counting:** A items are typically counted 12 times annually, B items six times per year, and C items three times annually.
- **Warehouse layout and inventory location:** The fastest-moving A items should be stored in the most convenient positions, such as ground locations or the first racking level, and closest to shipping and dispatch areas.

It should be noted that a common mistake in using ABC analysis is to think of B and C items as being relatively unimportant and thus focus only on the A items, such as a decision to ensure very high in-stock levels for A items but little or no availability for B and C items. All items in the A, B, and C categories are important to some extent, and each category requires its own strategy to ensure stock is available at the appropriate level.

When performing ABC analysis, companies need to choose the criterion or category (service levels, lead times, etc.) to determine what to control. For example, in a warehouse that exclusively provides materials for a manufacturing operation, supplier lead times might be the most critical criterion. The result of classifying materials delivered by suppliers will enable the company to monitor supplier performance closely to assure on-time delivery and prevent costly manufacturing stoppages and slowdowns. It might also enable decisions to stock higher quantities of items with the longest lead times.

Time-Based Inventory Analysis

There are certain times of the year when a company holds more inventory than at other times. When a company sells more or less product in a similar pattern every year (called seasonality), during the end-of-year holiday shopping season, many retailers make a large portion of their total annual sales. To prepare for a given holiday season, companies have to stock more inventory. From a supply-chain perspective, companies often begin receiving product in June or July to ramp up their inventory levels so there will be enough items on hand to sell during the peak holiday season. These companies thus order more than they need immediately to build up inventory before the holiday selling season begins.

Figure 18. The holiday season requires companies to pre-order additional inventory. Developed by LINCS in Supply Chain Management Consortium

Other industries might have months of the year or seasons, other than the year-end holiday season, when they sell more products. For instance, the back-to-school season is a time when companies sell more children's clothing and school supplies. Lastly, there are monthly or quarterly sales incentives in industries that require a company to have enough inventory to sell at the end of a month or quarter.

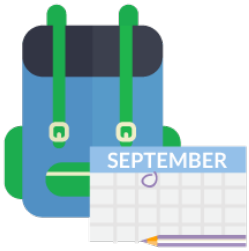

Figure 19. Back-to-school shopping requires some retailers to stock higher levels of inventory. Developed by LINCS in Supply Chain Management Consortium

Another key issue in time-based inventory management is evaluating the lead time necessary to receive additional product. The lead time is the amount of time from placing an order to the time that same order is received. For retailers, this is the time elapsed from placing a replenishment order with a manufacturer or supplier to when the order arrives at the retailer's facility. Lead time can be short if the supplier already has the amount of product the company needs and if **transportation** time is also minimal. However, companies who sell products made in China face a different set of parameters; the time from placing an order with a Chinese manufacturer to receiving the product could be 10 or 12 weeks. Obviously, with longer lead times, more inventory has to be carried to cover demand until the replenishment order is received.

Figure 20. Order cycle time. Developed by LINCS in Supply Chain Management Consortium

Unit 5: Minimum/Maximum (Min-Max) Inventory Reordering System

The **Min-Max** process is a basic reordering system that has been integrated into many **Enterprise Resource Planning** (**ERP**) systems and other types of inventory software. The Min or minimum value represents the stock level that triggers a reorder, while the Max or maximum value represents the new targeted stock level resulting from the reorder. The difference between the Max and Min is often called the **Economic Order Quantity** (**EOQ**).

This Min-Max process continually tracks the existing total stock level, which is usually the sum of the stock on hand plus the stock that is on order for each unique item in the inventory. When total stock

quantity drops to the Min value, a reorder is triggered in the system. The reorder quantity targets the Max value for the desired new total stock level. When the reorder is triggered, the system will initiate a purchase requisition to authorize **procurement** to purchase the desired quantity.

Figure 21. Min/Max inventory replenishment system. Developed by LINCS in Supply Chain Management Consortium.

Learning Block 2 Summary

When customers buy items, companies must make or buy replacement items to prepare for future sales. Replacing items that have been sold is called replenishment. The key ways to categorize inventory for analysis are dollar value, **turnover** or velocity, on-hand amount, and size/cube. The criticality or importance of an item should also be considered.

Figure 12. Inventory management. Developed by LINCS in Supply Chain Management Consortium

Basic concepts of inventory modeling include ABC analysis and time-based inventory analysis. ABC analysis should be conducted for multiple inventory categorization criteria to help identify ways to improve inventory management. Time-based inventory analysis focuses on ensuring that companies with different types of seasonality keep items in stock. The order-cycle time can help determine how much inventory should be on hand. The longer the lead time, the more inventory is needed to cover demand. When and how much to reorder are both key inventory questions for each unique item. The Min-Max method of inventory replenishment is a common method for managing inventory; it determines the smallest (Min) amount that should be on hand at all times and the desired EOQ to achieve the desired (Max) stock quantity.

Learning Block 2 Optional Supplemental Resource

The optional supplemental resource listed below may be used to reinforce the content covered within this learning block.

Mercado, E. (2007). *Hands-on inventory management*. Boca Raton, FL: Taylor & Francis Group.

Learning Block 2 Practice Questions

1. ABC analysis considers which element or elements to determine which items are most important and require the most attention?

a. Value, velocity, or volume
b. Profitability
c. Popularity and profitability
d. Customer service level

2. Pareto's principle can also be referred to as which rule?

a. 90/10
b. Inventory balancing
c. 80/20
d. 70/30

3. Which items have the highest percentage of value, velocity, and volume?

a. A items
b. B items
c. C items
d. Non-saleable

4. Which of the following criteria is used to describe an item that is low in sales but is important to a customer?

a. Velocity
b. Volume
c. Criticality
d. Value

5. Which corporate department would most likely never want a stockout condition in order to achieve a service level of 100%?

a. Manufacturing
b. Finance
c. Inventory Control
d. Sales

6. There are times of the year when a given company would hold more inventory than at other times of the year. This is referred to as :

a. Safety stock
b. Seasonality
c. Min-Max levels
d. Excess stock

7. In an ideal world, a company's inventory replenishment philosophy would be :

a. Sell fast and replenish slowly
b. Make large batches to avoid reordering
c. Sell one and then make one
d. Hold extra inventory to reduce total orders

8. Which of the following best describes velocity in terms of inventory analysis?

a. How fast an item sells or moves
b. The amount of inventory on hand
c. How much the total inventory of an item is worth
d. The importance of an item

9. Which metric best describes the number of times that inventory cycles over a one-year period?

a. Line-item fill rate
b. Order fill rate
c. Inventory turns
d. Service levels

10. When determining the quantity of items for a new or replenishment order, the calculated difference between the Min and Max values refers to what term?

a. Customer order quantity
b. Economic order quantity
c. Inventory stock quantity
d. Inventory turn quantity

Learning Block 3: Inventory Control

Learning Block 3 Description

The control of inventory is defined as managing the supply, storage, and accessibility of materials in order to meet a firm's ongoing needs without carrying too much inventory. The effective control of inventory is a key factor in the success of any supply chain. Companies are increasingly aiming to provide improved customer service levels at reduced costs; accurate inventory records and effective investments to control inventory are essential to achieving this **objective**. This learning block covers the key aspects of inventory control.

Learning Block 3 Learning Objectives

Upon completing this learning block, the learner will be able to:

- Explain the role and importance of inventory control
- Describe the tools and techniques used for inventory control
- Discuss key concepts of inventory storage and deployment
- Discuss key systems and methods used to control inventory
- Explain methods used to measure inventory accuracy and stock keeping
- Understand how inventory management works with other functional groups in a company

Unit 1: The Importance of Inventory Control

Inventory control is a key part of inventory management and the overall supply chain process. It involves the creation of inventory records, the maintenance of these records, and the counting or **auditing** of inventory (*see Figure 22*). In its broadest sense, it also deals with **inventory administration**. If inventory control is not functioning properly within a company, the rest of the **inventory system** and supply chain cannot operate effectively.

Responsibility for maintaining good inventory records exists in many areas of a company. Like many **logistics** processes, inventory control crosses several functional boundaries. Personnel who have the word inventory somewhere in their job titles or department names certainly make many contributions to inventory control, but personnel in functional areas such as demand planning, procurement, finance, manufacturing, warehousing, **transportation**, information systems, and sales must make important contributions as well.

The impact a transportation planner may have on inventory serves as an example. Inventory personnel work with the procurement department to place an order for oranges to make orange juice, setting the order quantity and a three-day delivery timeframe. It is essential the oranges arrive within three days. If the inventory planner and procurement personnel do not work closely with the transportation

department and decide to use a carrier that will take five days to deliver the oranges, the manufacturing plant may run out of the oranges which are obviously necessary to make orange juice.

Figure 22. Counting inventory. By Liz Roll/FEMA (This image is from the FEMA Photo Library.) [Public domain], via Wikimedia Commons.

The growing need for information immediacy—often for customer service reasons—has made inventory control more complicated and even more important. For example, some wholesale drug and hospital supply companies are now allowing key customers online access to their inventory systems. These customers—each with their own time constraints—can see whether a given item is in stock. If so, the customer places an order that reserves the relevant quantity of that item to prevent its sale to other customers. In this environment, safety-stock buffers are reduced, but the penalty for record keeping errors is much higher. If inventory accuracy is high, a company can gain an important competitive advantage. However, if inventory levels are not accurately tracked, customer service will suffer.

Unit 2: Tools and Techniques for Inventory Control

Inventory controllers have several tools to aid them in dealing with the complex environment in which they operate. Key tools and techniques used in inventory control are outlined in this learning block and include the 80/20 rule, bar coding, warehouse and inventory management systems, and **radio frequency identification** (**RFID**).

The 80/20 Rule

Managing large numbers of SKUs (stock keeping units) can be difficult, as controls, updates, checks, counts, forecasts, and ordering decisions have to be executed for each SKU. When the number of SKUs runs into the thousands, tens of thousands, or even hundreds of thousands, inventory management becomes a major task.

An SKU is defined as an item that is exactly identical in form, fit, and function.

For example...

An automotive light bulb manufacturer might produce several hundred unique part number (SKU) light bulbs that initially appear identical but under closer examination prove to have a varying numbers of elements, different voltage requirements, and subtly distinctive dimensions. In this example, the SKU of the light bulb has numbers specific to its form (dimensions), its fit (ability to be placed in the intended socket), and its function (ability to function based on voltage requirements).

Inventory managers can take advantage of Pareto's principle to aid in this task (refer back to Learning Block 2, Unit 4); it states that when dealing with large groups of numbers, most of the activity will be concentrated in a relatively small number of items. This is also known as the 80/20 rule, which states that 80% of the value, velocity, or volume of a group of items will be accounted for by 20% of the items. It may not always be an exactly 80/20 breakdown, depending on the specific industry involved, but the basic principle that a smaller number of items will be disproportionately responsible for the majority of activity generally holds true.

For example...

If a company has 1,000 SKUs and $1 million in sales, 200 of these SKUs will produce $800,000 in sales.

Inventory controllers can take advantage of this principle by identifying the items that have the greatest value or velocity and applying special effort to their control. These inventory controllers expend their greatest efforts in controlling inventory where it is most warranted.

Inventory and Warehouse Management Systems (WMS)

Companies today often use inventory management systems that have integrated inventory management software. Inventory management software is used to track inventory levels, orders, sales, and deliveries. It is also used in manufacturing to generate work orders, work center routings, bills of materials, and other manufacturing documents. This inventory management software also enables the analysis of inventory, including inventory usage patterns over time, inventory costs, and ABC analysis.

Another tool used in warehousing today is the **warehouse management system** (**WMS**). As a rule, WMS software packages handle such tasks as receiving, stocking, **picking**, and shipping. The WMS typically

provides management with the ability to track inventory, locate product, measure productivity, and evaluate other performance elements. A WMS also connects and exchanges data with corporate systems that handle such tasks as finance, production, logistics planning, and **order management**.

One of the applications available in a WMS is called a slotting or **inventory deployment** system. These packages analyze inventory requirements and consider layout modifications for storing items. Slotting systems work by taking information about warehousing activity according to SKU or product codes from the WMS and developing recommendations for redeploying inventory in the warehouse to reduce worker picking time and improve overall efficiency. This application may not necessarily be run every day, but it may be used to analyze the efficiency of a warehouse at regular intervals by running the software and changing the activities involved in moving materials from a receiving area or the end of a production process into inventory stock locations (**put away**) and rules in the WMS.

A WMS software system can be used, at regular intervals, to help determine which goods are the most popular. Based on product velocity, WMS software will allocate storage positions for fast-moving goods closest to their points of use.

For example...

A company might store various types of moisturizing hand lotions and suntan lotions in a warehouse. The hand lotion will be more popular in the winter months, while the suntan lotion will be more popular in the summer months. The WMS will be used to determine when each product is becoming more popular and which of the different types of lotion within each product range are most popular, then recommend warehouse storage positions according to the relative popularity of each item. If racking is used in the warehouse, the faster moving products will be stored at the most convenient height for picking and at the area closest to the dock doors from which they will be dispatched.

Barcoding

A **barcode** is a unique item identifier consisting of printed vertical bars interspersed with white space that contains optical characters with information that can be read by a scanner. Increasing transaction accuracy is one of the principal benefits for companies that have adopted barcode capabilities in **order entry**, production, warehousing, and transportation. For example, the use of barcodes for order filling in warehousing can help eliminate common errors like picking the wrong item. Barcode systems also allow double checking for accuracy, which include systems that will work to correct errors quickly, before a transaction is completed or an order is shipped. In warehouse systems, products are scanned when received, put away, moved to replenishment picking locations, picked, and shipped. *Figure 23* is an example of a barcode.

Figure 23. Barcode. Acquired from pixabay.com.

Barcodes are also coded to be used on shipping **containers**. A **shipping container code** is a 14-digit barcode placed on the outside of a shipping carton or **pallet**. This code allows retailers to scan shipments of multiple units of products as they come into their warehouses (*see Figure 24*). This

barcode is used in most retail situations and is referred to by different names, including **ITF-14**, Shipping Container Code (**SCC-14**), **Master Carton Code**, and **Universal Product Code** (**UPC**).

Figure 24. Scanning shipment barcodes. By Liz Roll (This image is from the FEMA Photo Library.) [Public domain], via Wikimedia Commons.

The UPC shipping container symbol is used to mark cartons, cases, or pallets that contain products that have a UPC or product identification number. The container symbols are used by manufacturers and distributors to take inventory or tally shipments quickly and accurately. The shorthand name for the symbol is ITF-14, which is an acronym for **Interleaved 2 of 5** (the type of barcode used) and 14 digits (the length of the container symbol). The ITF-14 symbol contains the following information:

- **Digit 1:** Packaging indicator (type)
- **Digits 2–3:** UPC numbering system
- **Digits 4–8:** Manufacturer identification number
- **Digits 9–13:** Item identification number
- **Digit 14:** Check digit

There are no official restrictions on values 1 through 7 other than the contents must have the same UPC as indicated by the container symbol.

Radio Frequency Identification (RFID)

Radio frequency identification (RFID) is a type of technology that uses radio waves to identify objects automatically, whether they are pallets, cartons, or even individual product packs. The most common means for RFID identification is to have a serial number, which identifies a specific object, on a microchip attached to a miniature antenna—commonly called an RFID *tag* (See *Figure 25*). The antenna transmits information, such as a unique product code, value, and storage location, from the chip to a reader (similar to the reader used at the checkout counter of a grocery store). The reader converts the radio waves reflected back from the RFID tag into digital information. The digital information can then be passed on to computers that have software programmed to use the RFID information. For items passing through a warehouse, RFID information could include the type, quantity, value, and location of these items.

Figure 25. RFID tag. Developed by LINCS in Supply Chain Management Consortium.

RFID tags are used in many industries.

For example...

An RFID tag attached to a car during production can be used to track its progress through the assembly line. Tool rooms in critical manufacturing environments, like aircraft assembly, use RFID to assure tools checked out of a storeroom are returned at the end of a shift.

RFID technology can be used to track and manage inventory. Tracking and managing corporate inventory is important for most every organization, but is particularly crucial when there is a large volume of inventory or when inventory moves frequently between locations.

Inventory visibility is critical when inventory moves and when companies need to manage unplanned events. For example, when inventory goes missing from a shipment or within a facility, tracking these assets down costs money and adds inefficiency to the process. Using RFID tags allows for easier inventory tracking and better exception management by helping ensure companies know the precise location of inventory and the time and status of inventory movement.

Unit 3: Inventory Storage and Deployment

Inventory storage is defined by static location in a facility of some kind. Inventory deployment, on the other hand, is the logistics component that brings value to the customer by efficiently and effectively **staging** and **distributing** goods while achieving ways to reduce or eliminate the need for storage locations. The ways in which inventory is stored can affect the speed with which it can be deployed or used. However, alternatives for reducing or eliminating inventory storage include **cross-docks**, **quick response** (**QR**), traditional warehousing, and **semi-permanent storage**, each of which is outlined in the following sections.

Cross-Dock: No Inventory Storage

With a cross-dock method, manufacturing components, customer orders, and other products are received and then sorted and shipped without ever being stored. This method reduces inventory carrying costs and moves inventory to the POS more rapidly. With the exception of direct store delivery by the manufacturer, this method results in the highest velocity of inventory turnover because it eliminates intermediate storage.

Information technology is the key to cross-docking. Information on incoming and outgoing goods must be accurate and timely so staging **operations** can be scheduled properly. For example, barcoded labels can help route products from receiving to shipping areas while minimizing the amount of paperwork and manual labor required.

Quick Response (QR): Minimal Inventory Storage

According to Coyle, Bardi, and Langley (2003), mass merchandisers and many small retailers are already using QR inventory strategies, which rely on POS data to indicate when inventory needs to be replenished. QR means that when a customer purchases a product in a store, the scanned barcode sends an electronic message throughout the store's inventory system. Inventory management computer software tracks the number of units purchased. When the units purchased in store equals a specific total number of units, the store's computer system sends an electronic message to the DC's computer system.

The QR process is done for all items in the store. At some point during the day, SKUs sent to a particular store are loaded on the store-bound truck at the DC to replace the stock customers have purchased. The DC also sends information electronically on the product being shipped to the retail store. **Historical demand data**, which is a record of previous demand for products purchased over time, are used to predict possible fluctuations in demand. Minimal stock levels are then determined for each store, and overall minimum inventories are kept at DCs that serve a specific set of stores. Overall, an optimum amount of inventory is kept throughout the system.

Traditional Warehousing: Temporary Inventory Storage

Traditional warehousing is used primarily because trading partners still rely on **push distribution** strategies. Push inventory management is a strategy that promotes stocking DCs and retail points in anticipation of future demand (push vs. pull strategies are covered in Learning Block 5). Items are stored until they are needed for subsequent use in the supply chain.

Semi-Permanent Inventory Storage

The primary purpose of semi-permanent storage, also known as **specialty storage**, is the storage of goods as either buffer or safety stock. There are various conditions that apply to the semi-permanent storage of inventory. The following conditions typically lead to semi-permanent storage of inventory:

Seasonal demand	Speculative or forward buying	Products that require conditioning
Stock held in advance of the demand season; industries that typically require significant seasonal stock include apparel, sporting goods, and specialty holiday	Products held in anticipation of future price hikes or **shortages**, like heating oil stored in anticipation of winter demand	Generally consumables, like beef aging in a **refrigerated warehouse** or wine and liquor aging in barrels

Erratic demand	Lot quantity/bulk discount	Maintenance requirements
Highly specialized items such as medical equipment	Product held after it was purchased to take advantage of lot quantity or bulk discount offered by a supplier	Maintenance spare parts held in the event of equipment wear or failure

Unit 4: Inventory Control Systems and Methods

Good record keeping is largely a reflection of the inventory system in place to support it. Companies use various systems to help keep control of inventory and ensure inventory accuracy. Although a full description of what should be included in an inventory control system is beyond the scope of this learning block, a few key considerations are outlined.

Figure 26. Manual vs. computerized systems. Developed by LINCS in Supply Chain Management Consortium.

Manual vs. Computerized

Computer systems can dramatically impact all phases of inventory management and control, including counting, monitoring, recording, and retrieving inventory items, identifying and verifying storage locations, recording changes to inventory, and anticipating inventory needs such as inventory handling requirements. Computer systems can help make these activities easier than relying on manual systems that are labor-intensive and are prone to errors. Although lower costs, wider availability, improved features, and increased user-friendliness have made computer systems for inventory control more accessible, some companies still rely on manual systems.

At the core of a manual system, though rarely used in today's inventory control context, is the **stock card**, an item record that has a system for filing and control comprised of index cards, rotary card files, or hand-operated sorting systems. The index cards contain a record of the inventory on hand, and are manually adjusted when stock is added to or taken out of the

system by recording on the stock card the quantities involved in each transaction.

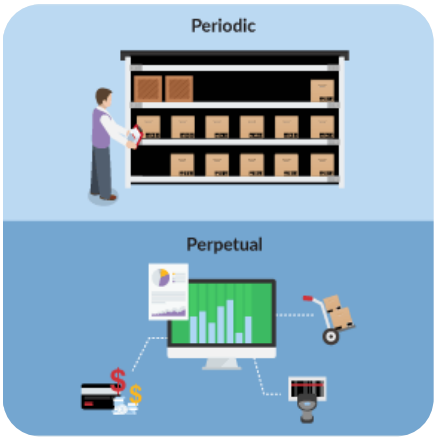

Figure 27. Periodic vs. perpetual accounting. Developed by LINCS in Supply Chain Management Consortium.

Periodic vs. Perpetual Accounting

An inventory system must involve either continuous tracking of inventory or periodic updates on inventory status, generally at the time ordering decisions are made. A perpetual or continuous system normally accounts for all transactions as they take place and is capable of providing on-hand inventory status information at any time. A periodic system requires someone to physically count what is on hand when information is needed. **Perpetual inventory control** is closely associated with computer systems and **periodic control** with manual systems.

Figure 28. Batch vs. real-time processing. Developed by LINCS in Supply Chain Management Consortium.

Batch vs. Real-Time Processing

Another key decision in developing an inventory system is determining when and how often the system is updated with transaction information. Batch systems—a form of periodic accounting for inventory and value—accumulate transactions like sales and receipts and process them on a set schedule, normally daily; real-time processing incorporates changes as they occur.

A comparison of batch and real-time processing in a warehouse setting makes clear the differences. In a batch environment, orders would be collected over a given period of time, such as every few hours, then a batch of orders would be released to the warehouse for picking. In a real-time environment, orders would be released to the warehouse for picking as soon as they arrive.

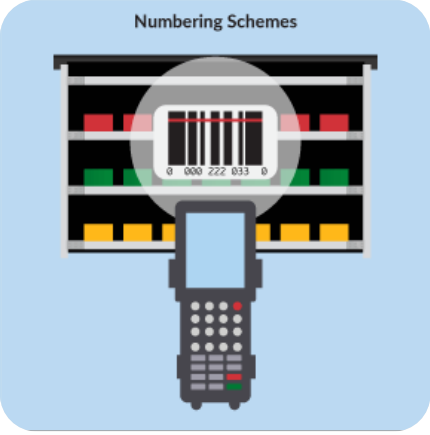

Figure 29. Numbering schemes. Developed by LINCS in Supply Chain Management Consortium.

Numbering Schemes

Inventory control systems involve the control of SKUs, defined in Unit 2 as items that are identical in form, fit, and function. How to identify or number SKUs is another key decision in establishing an inventory system. Instead of using descriptions that can be hundreds of characters long and hard to distinguish at a glance, most companies use item numbers of only five to six characters or numbers. Item numbers uniquely identify items, serving as a shorthand or abbreviated item description.

Item numbers are always important for companies that are searching their inventories, completing transactions, filling orders, and filtering or searching reports. Item numbers become more important when companies need to trace a lot or batch of defective products that needs to be recalled. Item numbers can also be incorporated into a barcode. Companies using barcodes will also typically use RFID scanning equipment to read barcodes that are then linked to a WMS and used for inventory management purposes.

Inventory and Stock Location Control

Most warehouses have a system in place for placing and retrieving stock. With an inventory locator system, finding the product location for stocking or retrieval becomes an easier task. Many warehouses use a WMS, barcodes, and RFID equipment to support stock location, retrieval, and put away procedures, including system-directed location and retrieval.

System-Directed Put Away and Retrieval

System-directed put away involves the movement of inventory items from receiving into their optimal, system-determined storage locations. The system directs warehouse operatives to the nearest open storage locations using item-specific put away rules like velocity, size, and weight that are built into the system to predetermine the best put away location for each item. With system-directed retrieval, warehouse operatives are directed to the nearest location in a warehouse to retrieve an item based on retrieval rules such as shortest travel route (Z R Data Systems, 2010).

Storage/Picking Address

Warehouses have a visual lettering or numbering system in place for identifying stock locations for products stored in the warehouse; these are called storage or picking addresses (see *Figure 30*). The row of a rack is typically assigned a letter and/or number (e.g. A1, A2, etc.). Even numbers might be assigned to the right side of the aisle and odd numbers to the left side of the aisle. Some warehouses choose to assign a number to the aisle itself. Sections of rack, levels, and individual storage bays may also be assigned numbers. A pick address might be A2.1.1.1.1, where:

- **A2:** Rack row
- **1:** Aisle
- **1:** Bay
- **1:** Sections of rack
- **1:** Levels

Figure 30. Storage/picking addresses. Acquired from pixabay.com.

Unit 5: Measuring Inventory Accuracy and Record Keeping

Inventory accuracy is defined as any storage location that meets the following criteria: (a) it has the correct item number, (b) it has the correct quantity for that item number, and (c) there are no exceptions. Companies must be able to confirm their inventory records are accurate—the amount of inventory recorded is equivalent to the amount of inventory actually in stock. If inventory records are accurate, then inventory management can rely on the records to determine when to order more stock or when to reduce stock that may not be used as frequently. Inaccurate records can lead to over- or under-ordering replenishment inventory.

It is necessary for inventory control purposes to verify the on-hand counts in inventory records with a physical inspection and count of all items. This is usually accomplished either by counting the entire inventory at the same time, called a physical inventory, or by counting different items at specified times, called cycle counting. Inventory accuracy is calculated by dividing the total number of correctly counted locations by the total number of locations counted. For example, if 100 locations are counted and 95 are correct, then overall inventory accuracy would be 95%.

The general trend has been for companies to move from physical inventories to cycle counting. Cycle counting is generally believed to be less expensive and more conducive to promoting accuracy in inventory records.

Periodic Physical Inventories

Carrying out physical inventories of stock over a condensed period of time is expensive. This kind of inventory count can take a great deal of time to plan, prepare, and conduct, and can be very expensive to accomplish. A major **opportunity cost** is associated with physical inventories because they usually require production and **warehousing operations** to be shut down. Sales may also be discontinued, customer service might be affected, and companies may have had to build up stock to cover the shutdown period. Smaller firms may even pull sales people from their regular functions to assist with counting inventory. Unfortunately, there is the potential that, if counting is not done accurately, **inventory integrity** might actually be worsened rather than improved.

Figure 31. Physical inventory. Developed by LINCS in Supply Chain Management Consortium.

Technology has made taking physical inventories and cycle counts easier. The use of barcode symbols and handheld scanning **terminals** has greatly increased accuracy and productivity in counting. Radio and cellular devices facilitate **communication** between counters and the counting managers. **Electronic scales** weigh small items and can be programmed to show the number of items in a batch based on the total weight of the items.

Cycle Counting

Cycle counting entails the systematic counting of each item carried in stock, at least once per year, at a planned interval or frequency. Cycle counting is often based on an **ABC classification**: i.e., A items are counted more frequently than B items and B items more frequently than C items. Cycle counting is also used to correct known inventory errors or handle special situations. It is intended to be a system of both *controlling* and *measuring* how well the inventory control process is functioning.

Cycle counting is a very useful tool for the inventory manager to maintain and improve inventory accuracy. The procedures for establishing and conducting cycle counts are similar to the procedures for taking a periodic physical inventory, but less preparation is required because cycle counts are ongoing activities that are built into the overall facility workflow. A key planning step is determining the interval time for counting each item carried in stock. Accuracy declines over time, and the degree of decline is generally associated with the number of transactions that occur for an item. The higher the desired integrity of an item, the more frequently it should be counted, so an item's **stock velocity** (**stock movement**) is often incorporated into setting a desired accuracy level. In this case a higher **stock accuracy level** will be required for items with a higher stock velocity.

Learning Block 3 Summary

Inventory control involves the creation of inventory records, the practices dealing with these records, and the counting or auditing of inventory. Inventory control also serves to strike a delicate balance between the three classes of costs: **ordering costs**, carrying costs, and stockout costs. Inventory systems control the accumulation of SKUs, items that are identical in form, fit, and function.

Managing large numbers of SKUs can be difficult. Controls, updates, checks, counts, forecasts, and ordering decisions have to be accomplished for each SKU. Inventory managers can take advantage of Pareto's principle to aid in this task. There are also several tools that aid inventory controllers with the complex environment in which they operate.

Accuracy in inventory record keeping can be measured and monitored using a group of quality management techniques known as **statistical process control**. Good record keeping is a reflection of the inventory system implemented to support it. Inventory and location system integrity can be improved significantly through the utilization of barcoding technology and RFID. Expert system technology, which are computer systems that provide decision support through the incorporation of and reference to decision rules devised by company experts, also shows substantial promise for supporting inventory management.

Figure 12. Inventory management. Developed by LINCS in Supply Chain Management Consortium

Inventory storage is how and where inventory is typically stored. Inventory deployment is the logistics component that brings value to the customer by efficiently staging and distributing goods while looking to reduce or eliminate the need for storage. Storage alternatives that reduce or eliminate inventory storage include cross-docks, quick response, **temporary storage**, and semi-permanent storage.

Computer systems can dramatically impact all phases of inventory management and control. An inventory system must involve either continuous inventory tracking or periodic inventory status updates (generally at the time ordering decisions are made). Inventory system records must be verified through on-hand counts of all items.

Learning Block 3 Practice Questions

1. Inventory control is defined as:

a. Managing the supply, storage, and accessibility of materials to meet customer's needs
b. Planning the manufacturing operations
c. Choosing a transportation mode
d. Routing material from trucks to the receiving docks

2. To aid in inventory control, inventory personnel often utilize Pareto's principle, which asserts that:

a. When analyzing a large group of items, most of the activity will be concentrated in a relatively small number of items
b. When analyzing a large group of items, most of the activity will be concentrated in a relatively large number of items
c. When analyzing a small group of items, most of the activity will be concentrated in a relatively large number of items
d. When analyzing a small group of items, most of the activity will be concentrated in a relatively small number of items

3. Warehouse Management Systems (WMS) are computer systems that utilize specialized inventory software used to:

a. Design barcodes
b. Create demand plans
c. Perform production planning
d. Track inventory levels, orders, sales, and deliveries

4. Cross-docking is utilized to:

a. Protect stock against uncertainties in demand
b. Sort and ship manufacturing components, customer orders, or other products as they are received, without ever being stored
c. Respond quickly and efficiently to a marketing promotion
d. Hold stock in response to demand or normal usage

5. The primary purpose of semi-permanent storage is for the:

a. Storage of buffer or safety stock
b. Increased levels of inventory held throughout a company
c. Receipt and shipment of goods without ever being stored
d. Reduction in the amount of total inventory held

6. Good record keeping is a reflection of the:

a. Manual card procedures
b. Overall inventory system
c. Best location
d. Inventory reduction

7. Counting the entire inventory at the same time is defined as:

a. Cycle counting
b. Physical inventory
c. Partial stock count
d. One-time stock count

8. Many warehouses use RFID technology and place microchips on products to:

a. Identify the cost of what is in stock
b. Perform stock counts
c. Determine the physical condition of an item
d. Identify and track items in an inventory control system

9. Cycle counting is defined as which process?

a. Counting the entire inventory at the same time
b. Counting inventory at seasonal intervals
c. Systematic counting of each item carried in stock at least once per year at a planned interval or frequency
d. Counting inventory when a problem is detected

10. Inventory control systems provide control for SKUs (stock keeping units), which are defined as:

a. Items that are exactly identical in form, fit, and function
b. Items that are somewhat similar in form, fit, and function
c. Items that are identical in form and fit but not necessarily in function
d. Items that are not identical in form and fit but perform the same function

Learning Block 4: Inventory Management and Forecasting

Learning Block 4 Description

Functions in SCM are interconnected; inventory management and forecasting are no exception, as there is a direct relationship between the two. If companies can forecast demands accurately, excessive inventory should not be necessary. Demand planning is the function in the overall supply chain that links sales and marketing forecasts to achieve an accurate inventory plan.

Learning Block 4 Learning Objectives

Upon completing this learning block, the learner will be able to:

- Describe the link between inventory management and forecasting
- Discuss uncertainty in the inventory process
- Understand how improved inventory visibility and **demand forecasting** can reduce total inventory
- Explain basic types of forecasting models
- Explain measurements of forecast accuracy

Unit 1: Demand Forecasting

Demand forecasting is an estimate of a company's future needs. Of course, companies have to forecast for finished goods to support anticipated sales, but they also have to plan for raw materials, semi-finished goods, and other necessities like packaging supplies. As an example, a company might have its sales department create a forecast and then have supply chain personnel create the inventory or demand plan to support the **forecasted sales**.

Figure 32. Demand forecasting. Developed by LINCS in Supply Chain Management Consortium.

Among the many inputs that must be estimated for inventory management, two are particularly important in effective forecasting: demand and lead time. Demand forecast is how much companies think they will sell of a particular product over a given period of time. Lead-time forecasting is much easier than demand forecasting, but lead times often have wide variations. For example, the amount of time it takes a shipping company to deliver an order can vary widely; it might take four days to deliver from a domestic supplier, but much longer from an overseas supplier.

There are two types of forecasts: **independent forecasts** and **dependent forecasts**. Independent forecasts are unique needs, typically for an end product.

For example...

At an automobile manufacturer, an independent forecast would be how many cars would be sold in a week. The forecasts for the parts that go in a car depend on the total number of cars sold. Every car requires four tires (or five, counting the spare), so the forecast for tires depends on the forecast for cars.

The time between the creation of a forecast and the event it attempts to predict impacts the accuracy of the forecast. It is easier to forecast how many cars a company will sell next week than it is to forecast how many cars the company will sell fifty-weeks in advance. The longer the interval between the forecast and the event it is predicting, the higher the likelihood the forecast will lose accuracy. For this reason, companies have both short-term and **long-term forecasts**. **Short-term forecasts** are often referred to as **operational** or **tactical** forecasts, while long-term forecasts are often referred to as **strategic** forecasts.

Unit 2: Basic Forecasting Models

Typically, companies use historical data to try to predict future sales. The simplest forecast is using the demand for the last sales period to craft a forecast for the next sales period. Similarly, to estimate next week's sales, a company might refer back to what it sold during the same week in the previous year.

However, most companies try to incorporate more complex data into their forecasts. A very simple but often reasonably accurate forecast is called a **moving average**. A moving average is created by using recent sales numbers to predict an upcoming period.

There are much more complex methods of statistical forecasting, but one key is that a company should be able to explain to non-experts how that company's forecast arrived at a particular number; simpler forecasts can be explained more easily. However, there are many software packages companies can use to automate forecast generation.

Simple Moving Average Forecast

If a company wanted to create a sales forecast for the month of April by calculating a three-month simple moving average forecast, the company would add up what it sold in January, February, and March and then divide by three. The result would be the three-month simple moving average forecast for April.

- **January sales:** 50 units
- **February sales:** 150 units
- **March sales:** 250 units

The simple moving average is then (50 + 150 + 250 units = 450/3). Based on a three-month simple moving average from January to March, the forecast for April is 150 units. One drawback of the simple moving average is that it weights each time period equally. If there is a trend, either upward or downward, the simple moving average will not capture it.

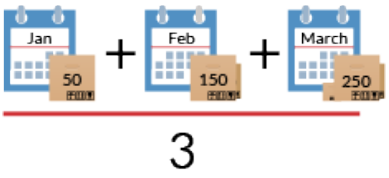

Figure 33. Simple moving average. Developed by LINCS in Supply Chain Management Consortium.

Weighted Moving Average Forecast

An extension of the simple moving average is the **weighted moving average**. The weighted moving average adds an additional factor to the simple moving average: the time periods in the forecast must be weighted (i.e., given different levels of emphasis). The weighted moving average typically puts more weight on more recent time periods, thus doing a better job of capturing trends.

A weighted moving average applies a factor, or weight, to each period to reflect how much emphasis a company wants to put on each time period, then multiplies the weighting factor by the demand or **actual sales** for each time period. Companies generally want to put more weight on more recent sales numbers and less on older numbers. The weighting factor is an amount between zero and one; together, all the weights must add up to one.

The sales from January to March in the previous example show an increase, so the most weight would be placed on the most recent month of March, less weight on the next most recent month, and the least weight on the most distant month. For example, this company might decide to weight March at 60% (0.6), February at 30% (0.3), and January at 10% (0.1).

- **January sales:** 50 units × 0.1 = 5
- **February sales:** 150 units × 0.3 = 45
- **March sales:** 250 units × 0.6 = 150

The new forecast for April would be: 5 units + 45 units + 150 units = 200 units.

Figure 34. Weighted moving average. Developed by LINCS in Supply Chain Management Consortium.

With the simple moving average, the forecast for April was 150 units, but the weighted moving average predicts April sales of 200 units. The weighted moving average forecast is larger, reflecting the recent month-over-month increase in sales, which the simple moving average could not detect.

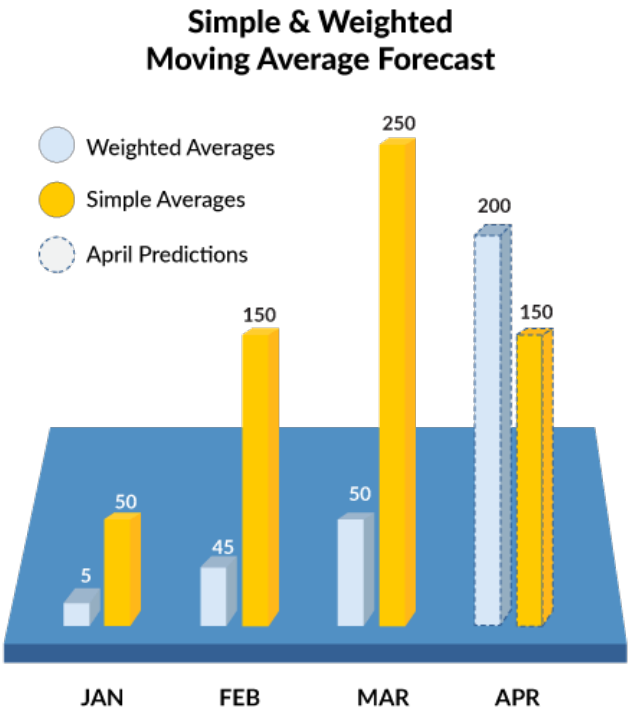

Figure 35. Simple vs. weighted moving average. Developed by LINCS in Supply Chain Management Consortium.

Unit 3: Forecast Error

Simple Forecast Error

Unfortunately, forecasts are not always completely accurate; nearly all companies find it difficult to predict demand with 100% accuracy. Instead, companies try to minimize **forecast error** to keep costs down. Companies can determine the accuracy of their forecasting by measuring their margin of error, which is known as forecast error. Forecast error can be calculated by subtracting the forecasted sales from the actual sales for the same period. If a company sold 300 units in April, a forecast error can be calculated for the simple and weighted moving average forecasts using the information in *Figure 36*.

	April Actual	April Forecast	Forecast Error
Simple Moving Average	300	150	150
Weighted Moving Average	300	200	100

Figure 36. Simple vs. weighted moving average data. Developed by LINCS in Supply Chain Management Consortium.

In this example, the difference between the two methods is 50 units. Using the weighted moving average, the company is still short and might have a product stockout, but by a smaller number than if the company had used the simple moving average.

Mean Absolute Percent Error (MAPE)

There are more comprehensive measures of forecast error. Another commonly used calculation of forecast error is **Mean Absolute Percent Error** (**MAPE**), which converts the units of error into a percentage and uses the absolute value of forecast errors so under-forecasts and over-forecasts do not balance each other out. For example, if one month a company over-forecast by 5% and the next month it under-forecast by 5%, the error would be -5% for the first month and 5% for the second month. The average of the two months would be zero, implying that over the two months the forecast was perfect. However, if the company used the absolute value of both months (i.e., 10%) and divided by two, the average forecast error would be 5%. Therefore, averaging the sum of the absolute error is preferable to averaging the sum of the error.

The formula for this is expressed as:

Combined absolute value divided by time units = average forecast error

10% ÷ 2 = 5%

Unit 4: Accounting for Variability/Uncertainty in the Inventory Process

Figure 37. Demand changes. Developed by LINCS in Supply Chain Management Consortium.

Demand Changes

Demand for products can sometimes change rapidly, and inventory is necessary to cover these changes. Companies can communicate regularly with their customers to obtain up-to-date information on how much product is selling so they can plan accordingly. Larger retailers have electronic systems through which manufacturer suppliers can see which products are selling in which stores in real time.

Figure 38. Lead time changes. Developed by LINCS in Supply Chain Management Consortium.

Lead-Time Changes

Lead times can change due to manufacturing interruptions, inclement weather, or a number of other unforeseen factors, and inventory must be available in case products are not delivered on time. Companies can work with suppliers to understand the nuances of lead times for procured items, and they can also work with their own employees to reduce the amount of time it takes to prepare orders. Also, companies can work with their transportation providers to confirm how long a particular move will take and strive to have those transportation providers reduce lead times. Transportation providers can often use faster shipping modes, such as air versus ground, but the company will most likely have to pay a premium. Companies need to look at the tradeoffs between shorter and more reliable lead times and the extra costs of faster transportation modes.

Figure 39. Obsolescence and damage. Developed by LINCS in Supply Chain Management Consortium.

Obsolescence and Inventory Damage

Products in inventory can become obsolete or unusable, such as produce that decays over time. With the help of the purchasing and marketing departments, a determination can be made on how long a given product can be sold and efforts can be undertaken to reduce inventory as the product ages. Product in inventory can also be damaged, whether through worker carelessness or mishandling of product, driving the need for safe handling procedures.

Unit 5: Improving Visibility to Reduce Inventory

Accurate and assessable visibility for all SKUs is critical to a company's overall success. To prevent inventory discrepancies, inventory systems must provide continuous SKU visibility. Problems can occur when the system does not provide real-time visibility to track transactions. When there is a lag in updates, the system might show an item is available, but it cannot be located. Most individuals have experienced this situation when a store clerk pulls up system information reporting an item should be on a shelf when it is not.

Visibility principles also apply to forecasting—companies should not only use their internal company forecasts to plan inventory levels, but should also have access to their customers' forecasts to

determine inventory levels more accurately. Close working relationships between companies and their customers can provide access to customer sales forecasts. The sooner companies becomes aware of their customers' needs, the faster and more effectively they can respond to meet them.

Lastly, it is important to look beyond the walls of the company when considering the visibility of inventory. If suppliers and customers are not aware of how much inventory companies have or need, there is more inventory than necessary in the supply chain. It is this lack of visibility from a total supply chain perspective that unnecessarily increases inventory and thus raises costs for everyone, including the **end customer**.

Figure 40. Improving visibility. Developed by LINCS in Supply Chain Management Consortium.

Learning Block 4 Summary

Figure 12. Inventory management. Developed by LINCS in Supply Chain Management Consortium

Demand forecasting and inventory management have an important relationship. If a forecast is more accurate, less inventory needs to be held. Reducing uncertainty or **variability** in the inventory process allows companies to carry less inventory overall. Uncertainties in the inventory process include demand changes, lead-time changes, inaccuracies in inventory levels, and the product becoming obsolete, unusable, or damaged. Forecasting demand means estimating future needs. Independent forecasts are needed to predict demand for most finished goods, and dependent forecasts rely on the need to complete these finished goods. Simple moving averages and weighted moving averages provide straightforward formulas to start creating forecasts, while MAPE offers a more detailed estimate. Finally, measuring forecast error is important for determining how accurate any forecasts actually are.

Learning Block 4 Optional Supplemental Resource

The optional supplemental resource listed below may be used to reinforce the content covered within this learning block.

Mercado, E. (2007). *Hands-on inventory management*. Boca Raton, FL: Taylor & Francis Group.

Learning Block 4 Practice Questions

1. Which of the following forecast methods better takes into account a recent trend in sales, whether upward or downward?

a. Weighted moving average
b. Simple moving average
c. Last week's or last month's numbers
d. Last year's numbers

2. Accurate forecasts result in:

a. Higher inventory requirements
b. Potential manufacturing interruptions
c. More business with suppliers
d. Lower quantity safety stock and fewer overall inventory requirements

3. Which is the preferred method of estimating a company's future needs?

a. Production planning
b. Marketing analysis
c. Needs assessment
d. Demand forecasting

4. The weighting factors in a weighted moving average forecast should add up to:

a. 0.0
b. 1.0
c. 0.6
d. 0.1

5. What is the three-week simple moving average forecast for the following numbers?

Week	Units
Week 1	200 units
Week 2	300 units
Week 3	400 units

a. 200 units
b. 250 units
c. 400 units
d. 300 units

6. In a bicycle assembly facility, what is the independent forecasted demand?

a. Tires for the bicycles
b. The assembled bicycles
c. Brake assemblies
d. Shipping containers

7. When forecasting the requirements for kitchen tables, the demand for complete tables vs. the demand for table legs is:

a. Forecast demand vs. actual demand
b. Dependent demand vs. independent demand
c. Independent demand vs. dependent demand
d. Actual demand vs. forecast demand

8. The term often used to describe demand forecasting and inventory control together is:

a. Supply chain management
b. Supply planning
c. Forecast error
d. Demand planning

9. When calculating forecast error, forecasts that are too high and too low balance each other out and indicate a more accurate forecast than actually occurred. To account for this, companies use what kind of forecast error for each period?

a. Real
b. Absolute
c. General
d. Simple

10. A flaw or drawback of the simple moving average is when:

a. Equal weights are included for each time period
b. Equal weights are not used
c. They are very difficult to calculate
d. They are almost never accurate

Learning Block 5: Managing Inventory in the Supply Chain

Learning Block 5 Description

This learning block addresses key tools and techniques and third-party-based systems for managing inventory in the supply chain. It also outlines how demand variability throughout the supply chain can lead to over- or under-stocking of inventory at different points in the chain.

Learning Block 5 Learning Objectives

Upon completing this learning block, the learner will be able to:

- Discuss the role and importance of inventory in the supply chain
- Understand how demand variability throughout the supply chain can lead to over- or under-stocking of inventory (also known as the **bullwhip effect**)
- Describe tools and techniques used for managing inventory in the supply chain
- Discuss options for **outsourcing** inventory management activities, entirely or in part, to a third party

Unit 1: Inventory and the Supply Chain

Practically every product that reaches a final customer has been worked on or handled by multiple functions or organizations, all of which are collectively referred to as the supply chain. A supply chain involves a flow starting from the initial point of origin to the ultimate **consumer**. It includes raw material suppliers, manufacturers, distributors, retailers, and customers. SCM is about integrating supply and demand within and across multiple companies and organizations.

The Role of Inventory in the Supply Chain

Much of the activity involved in managing supply chains is based on the purchase, transfer, control, and visibility of inventory. The central purpose of inventory in supply chains is to achieve the best possible balance of the supply and demand of goods. To manage the flow of goods through the supply chain effectively, companies have to deal with sources of supply and customer demands. Companies must try to balance meeting customer demands, which are not always easy to accurately forecast, with both stocking and ordering a sufficient supply of materials and goods. Holding inventory at various points in the supply chain helps balance supply and demand and buffer against uncertainty. These points include retail stores, wholesaler locations, distributor locations, manufacturer locations, and raw material provider locations.

Inventory always exists at various points in the supply chain to meet supply and demand needs. For example, a glass manufacturing company will manufacture glass products in large batches because it is a more economical means of production. Production in large batches allows the glass manufacturer to acquire and store raw materials used in production against future production needs to meet future sales demands. On the other end of the supply chain, a retailer of glass windows might intentionally store inventory to meet current and future customer demands.

The Impact of Not Managing Inventory

Failing to manage inventory well across the supply chain could have a detrimental effect on company performance. For example, if a cereal manufacturer overproduces a cereal that has an eight-month shelf life, some of the cereal may reach its expiration date without having been sold and may have to be discarded. Inventory mismanagement can impact many of the areas in the supply chain with the following results:

Figure 41. Purchasing. Developed by LINCS in Supply Chain Management Consortium.

Purchasing might overcommit on raw materials purchases from suppliers that are used for the production of goods. In the cereal example, the purchasing department might obtain and pay for the raw foodstuffs used in the production of the cereal; some of this raw material would go to waste in the finished product when it is no longer usable.

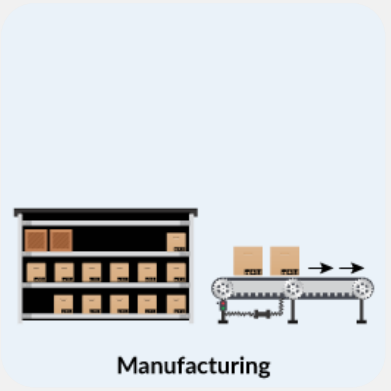

Figure 42. Manufacturing. Developed by LINCS in Supply Chain Management Consortium.

Production capacity is used to manufacture the cereal. If capacity on the production line is under pressure, then capacity would have been wasted on product that is not needed, especially if there is a demand for that capacity from other products. Additionally, the cost of labor could be high for products needlessly produced.

Figure 43. Inventory. Developed by LINCS in Supply Chain Management Consortium.

If a product has a defined shelf life, some of the products may have to be disposed of when that limit is reached. Carrying costs will have been unnecessarily incurred for discarded product.

Figure 44. Warehousing. Developed by LINCS in Supply Chain Management Consortium.

Warehouse space and labor is expensive and storing unsaleable goods could lead to decreased profitability. In the cereal example, storage and labor costs accumulate by using storage space that could have been used to store other products.

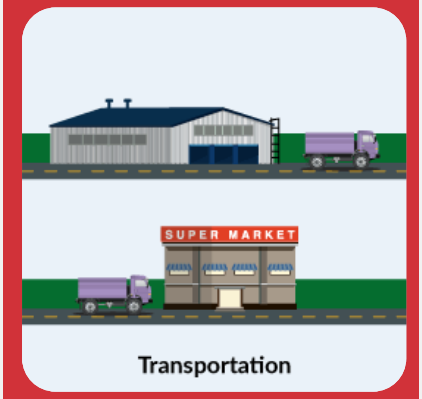

Figure 45. Transportation. Developed by LINCS in Supply Chain Management Consortium.

In this example, the cereal may have been transported to a wholesaler or a retailer and then disposed of after its sell-by date. In effect, the transportation costs for the discarded portion of the product has been wasted.

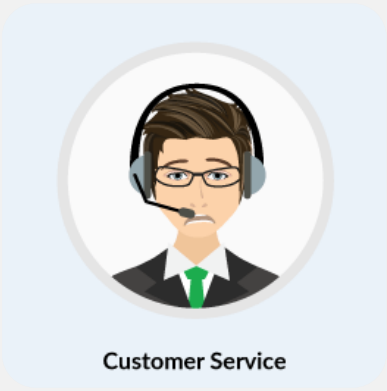

Figure 46. Customer service. Developed by LINCS in Supply Chain Management Consortium.

Customer service could be impacted because the manufacturer of the cereal might not have other products currently demanded by customers due to overproducing the cereal in question.

Unit 2: The Bullwhip Effect

The bullwhip effect typically occurs when orders placed with manufacturers and suppliers create a larger variability than the sales defined for an end customer. The bullwhip effect results from many factors in the supply chain, including lack of communication among various functions, disorganization, and poor demand planning. Variations in one part of the supply chain is compounded in other parts of the chain as each function overestimates or underestimates demand, resulting in exaggerated fluctuations and leading to over- or under-stocking of inventory.

The bullwhip effect affects inventory holdings throughout the supply chain. For example, if a customer demands six units of a particular product, the retailer might order ten units from the distributor, resulting in an extra four units for additional floor stock. The distributor, in turn, might order 16 units from the manufacturer, leaving it with six available units for future demand. The manufacturer might order enough supplies and materials to manufacturer 30 units for efficiency and to meet anticipated demand.

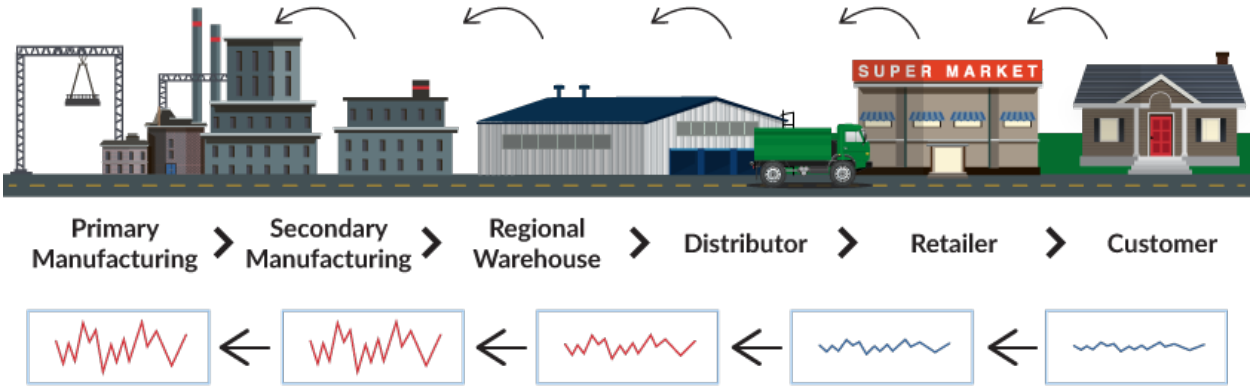

Figure 47. Bullwhip effect. Developed by LINCS in Supply Chain Management Consortium.

The result is that 30 units have been made by the manufacturer when the actual customer demand was for six units, creating a potential surplus of 24 units. If there is no immediate customer demand, the various companies in the supply chain might have to decrease prices and increase marketing and advertising expenses to sell the remaining 24 units.

The bullwhip effect is a common problem in many supply chains. Collaborative forecasting and planning and understanding the bullwhip effect's causes can help alleviate excess and unwanted stock.

Unit 3: Collaborative Planning, Forecasting, and Replenishment (CPFR)

Communication and collaboration is crucial in a supply chain; it can lead to reduced uncertainty in forecasting, which can help avoid the bullwhip effect. **Collaborative planning, forecasting, and replenishment** (**CPFR**) is one way to reduce uncertainty by ensuring that supply chain functions develop common forecasts for individual SKUs to reduce uncertainty, decrease inventory levels, and improve customer service.

According to Bozarth (2015), CPFR follows a defined framework that combines the intelligence of multiple trading partners during the planning and **fulfillment** of customer demand; it has the stated objective of increasing product availability for customers, while reducing inventory, transportation, and logistics costs. CPFR involves supply chain partners' collaborating to forecast demand requirements, which helps reduce forecast inaccuracies within the overall supply chain. Demand and supply plan leaders routinely practice these more advanced planning techniques.

Companies cooperate using CPFR to manage inventory, provide inventory visibility, and order and replenish product throughout the supply chain. Information is often shared between partners in the supply chain through regular meetings and via secure Internet links. Information sharing helps supply-chain partners plan for and meet customer demand, including variability due to anticipated and actual customer demand, lead times, forecasts, and production levels. Sharing information allows supply-chain partners to receive real-time updates on inventory and demand, which reduces uncertainty and amount of inventory needed.

For example...

A major retailer discovered that one of its suppliers, a pharmaceutical company, was not able to meet the buyer's requirements for holding enough stock to satisfy demand on a regular basis. The two companies met to see how the problem could be resolved and developed a process that would link customer demand with replenishment needs throughout the entire supply chain. They developed a test run, or pilot program, in which they looked at the forecast demand for a vitamin at the retail firm that was routinely running out of stock. They first tested the collaborative concept on paper, then demonstrated in a lab that the Internet could be used for exchanging the necessary information. The retailer and supplier then set up a joint planning group to forecast demand and a real-time system for sharing demand through a secure Internet link. The supplier was able to see demand in real time and adjust its manufacturing and delivery schedules accordingly. This information led to a substantial increase of the vitamin stock at the retailer's stores, reduced supply lead times, and increased overall sales for both companies.

Unit 4: Managing Inventory Flows in the Supply Chain

A number of approaches and systems exist for managing inventory flows in the supply chain, including push vs. pull systems, **inventory postponement**, **just-in-time** (**JIT**) systems, and **vendor-managed inventory** (**VMI**). Companies may use one or more of these approaches to help them manage inventory flows more effectively. The approaches are outlined as follows.

Push vs. Pull Systems

Inventory management approaches generally distinguish between **pull ordering systems** and **push ordering systems**. Sometimes called a reactive system, the pull approach relies on customer demand to *pull* product through the supply chain. In contrast, the push or proactive approach uses inventory replenishment to anticipate future demand.

For example, a fast-food giant such as McDonald's operates on a pull system, while a typical apparel retailer operates on a push system. McDonald's cooks hamburgers in response to current demand: individual purchases trigger more food item production. In contrast, Banana Republic attempts to anticipate what customers will want and pushes apparel items to the locations where customers will purchase them so items are available when shoppers walk in the door.

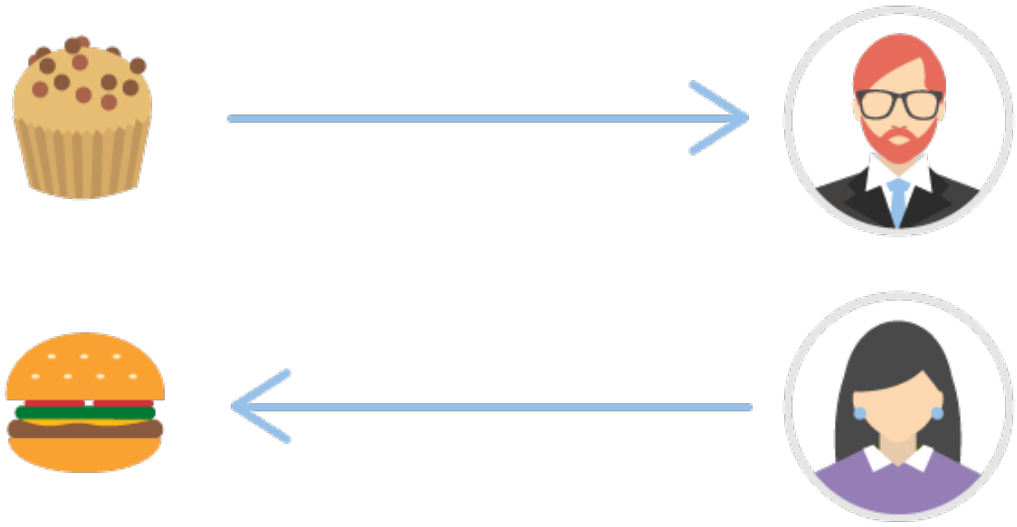

Figure 48. Examples of push vs. pull systems. Developed by LINCS in Supply Chain Management Consortium.

A key advantage of pull systems is that they can respond quickly to sudden changes in demand. Alternatively, a push approach meets system-wide inventory needs in an orderly and disciplined way that follows a master plan. The trigger to initiate an act in a push environment originates **upstream**, with **downstream** entities managing the consequences. The trigger is often a forecast of anticipated demand that sets the supply chain in motion. Pull systems sometimes involve only one-way communication between point of need and point of supply, but push systems necessarily involve more two-way communication between point of need and point of supply.

For instance...

Pharmaceutical companies are currently shifting from a push model to a pull model. They have traditionally employed large sales staffs to push new products to doctors, who would eventually prescribe them to consumers. Now, pharmaceutical companies spend hundreds of millions of dollars targeting consumers directly with advertisements that urge them to talk to their doctors about one drug or another. The companies want downstream consumers to initiate the pull signal through their doctors.

Postponement

Postponement is an inventory management tool in which products are manufactured to a semi-finished state and then finished to meet individual customer orders, because it is often more cost-effective to hold semi-finished inventory rather than trying to anticipate and build every final product configuration different customers might demand. Across a wide range of industries, it is easier to forecast at a base item level rather than trying to forecast specific end products. There is good evidence to support the effectiveness of postponement. One study by Davila, T. and Wouters, M. (2007) revealed that an effective postponement strategy reduces both inventory carrying costs and lost sales, and that the ability to satisfy customer orders, as measured by fill rates, increases with postponement.

For instance...

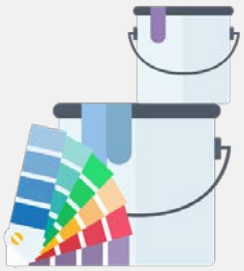

Figure 49. Paint stores use the principle of postponement. Developed by LINCS in Supply Chain Management Consortium.

Paint stores are a classic example of the principle of postponement. Once a customer selects a color, an employee opens a can of base white paint in the appropriate finish, adds coloring, and shakes the can on a machine to produce precisely the desired color. For companies like Sherman-Williams and Lowe's, this approach prevents enormous amounts of waste that would occur if they tried to stock every one of the thousands of possible color and gloss combinations. The machine changeover costs required to produce those colors in a factory alone would be staggering. The approach also simplifies the tasks of forecasting manufacturing because without it paint companies would have to estimate, for example, how many people in southern Alabama would want a color called Evening Sunset in a semi-gloss. It is exponentially easier to plan at the total gallon level for flat, semi-gloss, and gloss paint rather than at the individual color level.

Companies use postponement as a way to differentiate themselves from their competitors. Follett Corporation, a medium-sized company located in eastern Pennsylvania, designs and manufactures beverage and ice dispensers for institutional and industrial use. One of its product lines is designed specifically for postponement. The base product, which is produced according to a forecast, is finished only after a customer places a specific final order. Follett's products are often needed quickly for replacement purposes in restaurants, hotels, cafeterias, or hospitals. Postponement allows the company to ship customized products in days rather than weeks, thereby providing a lead-time advantage over competitors.

Just-in-Time (JIT)

Just-in-time (JIT) delivery is a method for supplying products using a strategy of shipping in smaller, more frequent lots with deliveries that arrive as they are needed rather than requiring the stockpiling of materials or parts. Most individuals have exposure to JIT systems in their homes. Public water and electric utilities provide their products on a demand-responsive, JIT basis that does not require individuals to hold any inventory. Meters monitor what individuals use, and they are charged accordingly.

Benefits of a JIT delivery system include the following:

1. Minimized handling of materials
2. Reduced inventory and space requirements
3. Imposed quality discipline
4. Reduced total production costs
5. Reduced product cycle time (i.e., the time required to get products to the marketplace)

Figure 50. Just-in-time delivery. Developed by LINCS in Supply Chain Management Consortium.

The JIT approach can reduce inventory by employing extremely small lot sizes and very short lead times. For example, Boeing asked its suppliers to produce and deliver components using JIT techniques. Boeing adopted an enterprise-wide online supply-chain tool that it calls consumption-based ordering, which allows Boeing to share its inventory levels with suppliers. Using this tool, suppliers build and ship only when Boeing's inventory levels fall below a certain carefully calculated threshold. This shift in responsibility has allowed Boeing and its suppliers to set inventory levels based on consumption rates, enabling Boeing to reduce its inventory levels and storage facilities at production sites. The JIT method also enhanced Boeing's ability to forecast and improved cash flow.

Unit 5: Third-Party Systems

A **third-party logistics firm** (**3PL**) is an external supplier that performs all or part of a company's functions. Third parties can include suppliers of services such as transportation, warehousing, distribution, financial services, marketing services, and manufacturing services. Inventory management can also be handled by an outside firm. Two common approaches to third-party inventory management are SMI and **consignment stocking**.

Supplier-Managed Inventory (SMI)

SMI, also known as **supplier-managed inventory**, is a supply chain model in which the supplier has the responsibility for maintaining the purchaser's inventory levels. In traditional supply chain models, when purchasers require a product, they place an order with a supplier. The purchaser is in control of the timing and size of the order being placed. In this traditional arrangement, the purchaser maintains its own inventory plan. With the SMI model, the supplier has access to the purchaser's inventory and production data and is responsible for generating replenishment shipments to ensure service levels are maintained.

Inventory target levels are set jointly by the purchaser and the supplier. Actual change in ownership may occur anywhere along the supply chain, but typically occurs when the goods arrive at the purchaser's facility. SMI can realistically be used for any type of item, as long as the supplier is reliably maintaining the desired quantities in customer locations. The SMI process can be applied to raw materials, assembly hardware, and other critical recurring replenishment items. The specific arrangements are defined in collaboration between purchasers and suppliers.

Consignment Stocking

In consignment stocking, a supplier provides products to a buyer that are stored at the buyer's facilities, but the inventory is still owned by the supplier. The buyer assumes responsibility for the stock when stock is withdrawn from that consignment inventory, pays for the quantity used, and notifies the supplier of the need to replenish inventory. For example, a retailer can hold clothes for sale in its stores but does not pay the manufacturer of these clothes until they are sold.

From time to time, the amount of inventory still remaining in stock will be verified by both supplier and buyer. Consignment stocking is a strategy that helps the supplier by assuring volumes of product to sell and helps the buyer by reducing investment in inventory. Consignment stocking is often used in the distribution industry. The consignment stocking process can also be used for MRO items placed on site at a purchaser's facility by a supplier, such as vending carousels that house special maintenance tools and other needed items.

Learning Block 5 Summary

A supply chain encompasses several participants who move physical goods anywhere from the point of origin to the point of final consumption. Thus, inventory plays a very important role in supply chains. Much of the activity involved in managing supply chains is based on the purchase, transfer, or management of inventory. The most basic role that inventory plays in supply chains is balancing the demand and supply of goods. Supply chain factors like order placement timing, demand and supply variations, and lack of communication and disorganization can result in an effect known as the bullwhip effect. CPFR can help to avoid this by helping supply chain members develop a common forecast for individual SKUs to reduce uncertainty, decrease inventory levels, and improve customer service. Specific approaches include pull vs. push systems, consignment stocking, postponement, JIT delivery, SMI, and third-party inventory management services.

Figure 12. Inventory management. Developed by LINCS in Supply Chain Management Consortium

Learning Block 5 Optional Supplemental Resource

The optional supplemental resource listed below may be used to reinforce the content covered within this learning block.

Clearly Inventory. (2011). *Inventory basics—All about inventory management*. Retrieved from http://www.clearlyinventory.com/inventory-basics/inventory-management

Learning Block 5 Practice Questions

1. The basic purpose that inventory serves in supply chains is:

a. Reducing costs
b. Balancing supply and demand
c. Increasing lead times
d. Increasing costs

2. Variability in the supply chain due to order placement, order fulfillment, demand and supply variations, lack of communication, and disorganization can result in:

a. VMI
b. The bullwhip effect
c. JIT delivery
d. Postponement

3. If different entities collaborate and communicate across the supply chain, that can lead to:

a. Misunderstandings
b. Increased costs
c. Reduced uncertainty
d. More uncertainty

4. The pull approach, also known as a reactive system, relies on:

a. Reverse flows in the supply chain
b. Manufacturing components ahead of the forecasted time
c. Safety stock
d. Customer demand to move product through a supply chain

5. Postponement is a tool used in inventory management in which:

a. Customers decide to discontinue purchasing certain products
b. Products are produced in a semi-finished state and then finished to meet customer orders
c. Products are produced in a finished state to meet customer orders
d. Inventory is held for customers who wish to postpone ordering

6. Generally, JIT systems are designed to:

a. Supply materials and inventory ahead of time
b. Increase costs of manufacturing
c. Manage lead times and eliminate waste
d. Eliminate inventory entirely

7. A third-party firm may be defined as:

a. A company that has more than two owners
b. Is an external supplier that can perform all or part of a company's functions
c. Is always used by companies to manage inventory
d. Has no role to play in managing inventory

8. SMI is a supply chain model where the:

a. Purchaser has the responsibility for maintaining the supplier's inventory levels
b. Supplier has the responsibility for increasing the purchaser's inventory levels
c. Supplier has the responsibility for maintaining the purchaser's inventory levels
d. Supplier has the responsibility for maintaining the purchaser's sales levels

9. In consignment stocking, a supplier:

a. Consigns waste materials for pickup
b. Provides products to a buyer that are held in stock at the buyer's facilities, but the inventory is still owned by the supplier
c. Provides products to a buyer that are held in stock at the buyer's facilities, but the inventory is not owned by the supplier
d. Is responsible for managing inventory at the purchaser's site

10. CPFR emphasizes supply chain functions that:

a. Supply product using a strategy of shipping in smaller, more frequent lots
b. Develop a common forecast for individual SKUs to reduce uncertainty
c. Use a system where suppliers maintain the purchaser's inventory levels
d. Work to develop independent forecasts

Learning Block 6: Inventory Performance Measurement and Financial Implications

Learning Block 6 Description

Stocking inventory can be a significant cost for many companies. Many organizations incur large financial investments for materials and goods in order to meet their manufacturing and distribution needs. The materials and goods include raw materials, WIP items, and finished products. In addition to the value of the goods themselves, companies incur labor costs to manage inventory and additional costs to store inventory on an ongoing basis.

It is thus essential that **inventory performance** is monitored and managed in order to ensure overall company effectiveness, efficiency, and profitability. This learning block addresses how to measure the effectiveness of managing inventory and the financial implications of having inventory.

Learning Block 6 Learning Objectives

Upon completing this learning block, the learner will be able to:

- Discuss key metrics for inventory performance
- Explain inventory-related costs
- Understand the impact of inventory on **income statements** and **balance sheets**
- Explore other areas of inventory management that affect cost

Unit 1: Types of Measures or Metrics

Most organizations establish **performance measures**, or metrics, for inventory and regularly measure actual performance against these metrics. Measuring inventory performance plays an important role in determining where future courses of action should be taken. Metrics can be used to determine where deficiencies in performance exist, so appropriate actions can be taken for improvement. This unit discusses the importance of inventory as a metric in SCM, including **total inventory dollars**, inventory as a percentage of sales, inventory turns, **days of supply**, and **return on assets** (**ROA**) or **return on investment** (**ROI**).

Figure 51. Inventory metrics. Developed by LINCS in Supply Chain Management Consortium.

Inventory: An Important Metric for Supply Chain Management

The status of a firm's inventory (e.g., high-level, low-level, expired) is often used as a test for the overall strength of the SCM and decision-making processes. For example, if a firm has excessive amounts of inventory in the form of safety stock, this could result in unnecessary carrying costs and additional lost opportunity costs of having working **capital** tied up in assets that cannot be converted to sales.

Ultimately, carrying too much inventory for too long could be a symptom of ineffective planning and decision-making in SCM. Other symptoms of a deeper problem could include demand forecasting and planning that is regularly and significantly inaccurate, long supplier lead times, internal operations with bottlenecks and inefficient inventory handling, or transportation carriers that do not provide quality service by delivering late or damaged products.

Certain metrics, such as inventory turns, days of inventory, and cash-to-cash cycle, have become popular because they indicate how well supply chains are performing. These inventory metrics can measure how quickly inventory is moving through supply chains, how likely firms will be able to handle the fulfillment of customer demands, how firms' **liquidity** is impacted by their investment in inventory, and how supplier relationships are being managed. As outlined in the following sections, companies use a few key measures to track inventory performance, including total inventory dollars, **inventory dollars as a percentage of sales**, inventory turns, and **inventory days on hand**.

Total Inventory Dollars

The term total inventory dollars are defined as the total dollar value of inventory companies have on hand in all locations in the supply chain. The metric of total dollars of inventory on hand indicates the amount of investment companies have tied up in inventory, which is a useful measure because inventory represents investments of companies' cash. Cash that is tied up in inventory cannot be used for other projects.

Businesses typically pay for their inventory within a limited time period (e.g., within 30 days of receipt of the purchase, often referred to as net 30). After receiving items for suppliers, it may take several weeks or months before that inventory can be used in manufacturing or sold to customers. Therefore, investments in inventory impact cash flow, which is the movement of money in or out of companies that is usually measured during a limited period of time. Overinvestments in inventories reduce the amount of cash that could be available for other purposes. Good cash flow management requires companies to examine their investments in inventory to avoid overinvestments, so it is important to know the total dollar investment companies have in inventory.

Figure 52. Total inventory dollars. Developed by LINCS in Supply Chain Management Consortium.

Companies that use this metric will generally report the inventory either at cost or at the retail sales price. Reporting the value of the inventory based on what companies pay for the inventory (e.g., raw materials, packaging supplies, component parts, or finished goods) is reporting at cost and is the generally accepted way of reporting inventory dollars. The other option is reporting the inventory dollar value based on the price customers would pay. Either option can be used, but companies should choose one valuing method, make clear what choice they have made, and apply it consistently.

Inventory as a Percentage of Sales

This metric divides average inventory by average sales, in dollars. The formula is:

(Average inventory value ÷ average sales) x 100 = total inventory %

For example, a company with $550,000 in ending inventory and $1.0 million in sales has a total inventory percentage of sales of 55%. Companies are able to calculate this figure on a monthly, quarterly, or annual basis and use it to determine how much inventory is needed to achieve specific sales targets. If that same company expects a 10% growth in sales, then its annual revenue will total $1.1 million. The corresponding inventory figure will be $650,000 based on the inventory percentage of sales figure at 55%. Using this figure for financial planning purposes, companies can ensure they have sufficient inventory to cover sales.

Another key use for this metric is to see if there are trends that reveal whether inventory as a percentage of sales is going up or down over a period of time. If sales are increasing, this would usually indicate that a greater proportion of inventory is being required to support sales, but it may also indicate inefficient management of overall inventory. If the inventory, as a percentage of sales, is going down, then this may indicate the company is being more efficient in using its inventory to support sales.

Using this metric is beneficial because it is easier to compare inventory performance to other companies without sharing dollar values, which is often confidential. For publicly held companies (e.g., Walmart, Johnson & Johnson, Publix), inventory is a dollar number that is reported yearly, so it is not confidential. However, family-owned or other privately held companies might be more comfortable sharing percentages rather than dollar numbers because they do not have to report inventory as a dollar number. The value for average inventory must be consistent with the value used to calculate total inventory dollars (previous metric). Inventory value can be based on either inventory at cost or inventory at retail price.

Inventory Turns

Inventory turns is one of the most generally accepted and common metrics of inventory performance. The formula is:

Sales ÷ Average Inventory Value = Inventory Turns

Inventory turns is calculated as sales divided by average inventory and is typically calculated using annual sales, in which a full year of sales in dollars is divided by average inventory in dollars. Average inventory is calculated by taking the beginning inventory for a year, on January 1 for example, adding it to the ending inventory, on December 31 in this illustration, and dividing that number by two to obtain the average inventory carried over the year.

For example…

A firm may value its product sales at $40,000 and calculate its average, on-hand inventory at $10,000. The number of inventory turns per year would, therefore, be $40,000 divided by $10,000, or four turns per year. The firm could then state that inventory turns over four times per year on average or that an average inventory item stays on the shelf for one fourth of a year.

Inventory turns is also called inventory velocity, indicating the speed at which the average amount of inventory on hand is sold or goes through companies' supply chains during each period. For instance, if inventory turns are 52, then that company's inventory sells out every week; on the other hand, if inventory turns are one, then average inventory is sold once per year. In this case, the company that turns its inventory over 52 times a year will have a much higher inventory velocity than the company that turns its inventory over once a year.

Inventory turnover varies among industries, depending on the type of inventory and how well the inventory is being managed. For example, car manufacturers' rate of inventory turnover will be higher than it will be for firms that stock spare parts for maintaining cars because these parts tend to be used less frequently. However, inventory turnover typically ranges from 5–10 turns for many manufacturing firms and from 10–20 turns for distribution, wholesale, and retail firms.

Days of Supply

Another commonly used inventory metric is days of supply, which measures the amount of days' use of inventory is on hand. For instance, some companies hold about 30 days of supply to give them enough inventory to cover demand for a full month. The key to using this metric well is knowing how to choose the number of days of supply.

It is not necessarily the best idea for companies to pick simply 30 days of supply because that approximates a month, or indeed any number of days, and to use it across all products. They might need more or fewer days than other products require, depending on the sales rate, the variability of sales, and other factors. Products that get replenished quickly might only need a few days of supply, while others that are not used often could stay in inventory for several more days or even weeks.

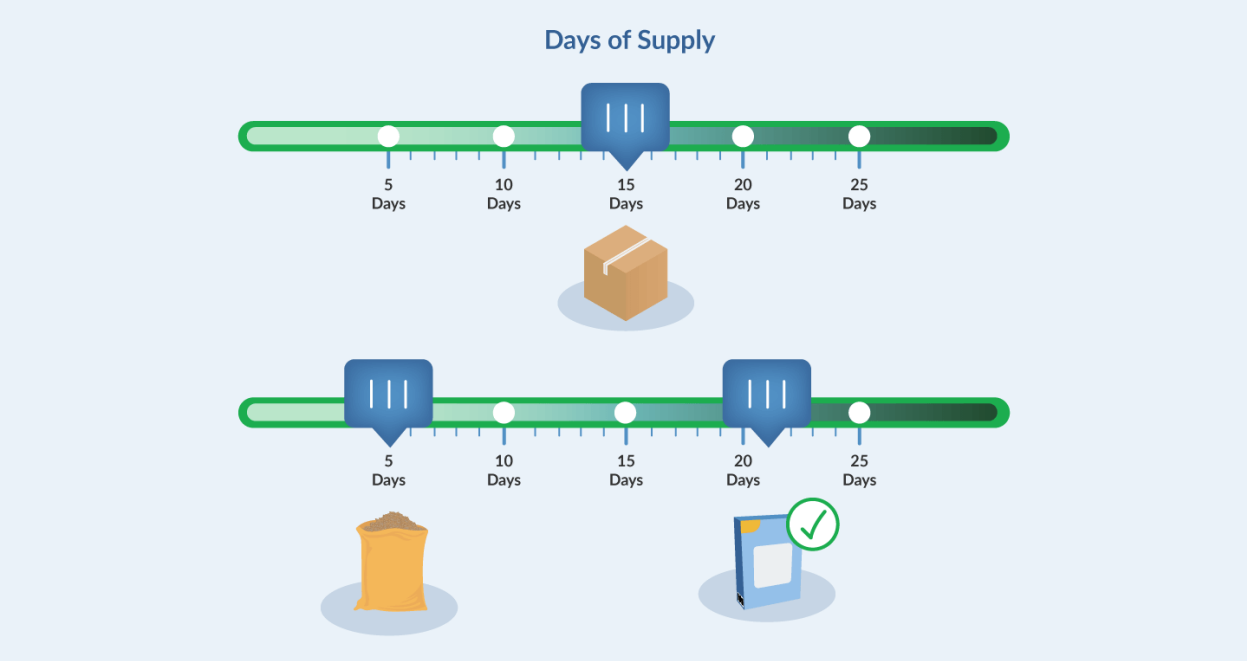

Figure 53. Days of supply. Developed by LINCS in Supply Chain Management Consortium.

Return on Investment

Another key performance metric is return on investment (ROI). ROI is used to determine the benefit of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) on an investment is divided by the cost of the investment; the result is expressed as a percentage. The ROI formula is described as:

- ROI (%) = (Net Profit/Investment) × 100,
  Where Net Profit = Gross Profit – Expenses

For example...

If a company has a net profit of $100,000 and the investment was $1,000,000, the ROI would be ($100,000/$1,000,000) × 100 = 10%.

Higher ROIs indicate better performances by companies. Unfortunately, if there are more inventories or assets, this results in a lower ROI number, so inventory should be kept to a minimum. In the example, the inventory might be 30%, or $300,000, of the company's investment that is being used to generate its ROI of 10%. If this investment in inventory figure increases by an additional $100,000 without any increase in return, then a greater investment in inventory (and a greater investment overall) would have been required, which means ROI would have decreased.

As another example…

If a company has a net profit of $100,000, and the investment was $1,100,000, including an additional investment in inventory, then the ROI would be ($100,000/$1,100,000) × 100 = 9%.

Unit 2: Inventory Costs

As previously mentioned, a key inventory cost is the amount of dollars invested in inventory. The other cost, which is less widely known, is inventory carrying costs. Carrying cost is separate from the value of the goods necessary to maintain or hold inventory. Every dollar a company has in inventory cannot be used elsewhere on other projects. For instance, in a pharmaceutical company, every dollar in inventory cannot be invested in research and development for a new drug, while in a retail company, every dollar in inventory cannot be used to build a new store.

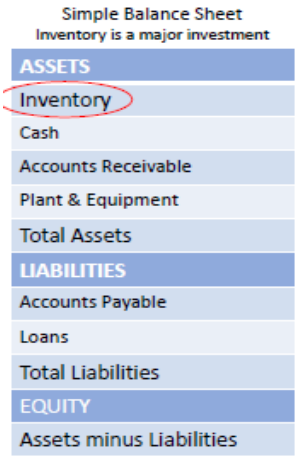

Figure 54. Balance Sheet showing Inventory as a major element of cost. Developed by LINCS in Supply Chain Management Consortium

Components of Inventory Carrying Cost

The four parts of inventory carrying costs are **hurdle rate**, **inventory service costs**, **inventory risk costs**, and **storage space cost**, each of which is outlined next:

Hurdle rate	The **hurdle rate** is the first and biggest part of inventory carrying cost; companies' finance departments set this rate as the minimum rate of return for any new company investment, from creating a new product to building a new DC to the cost of capital. For any of these investments, companies demand a certain payback or rate of return.
Inventory Carrying Costs	The second part of inventory carrying cost is the **inventory service cost**, which refers to the taxes and insurance related to inventory. Some states tax the value of inventory a company holds, while products in the inventory must generally be insured in case of fire, flood, or other disaster that requires replacing or repairing products or equipment.

Inventory Risk Cost	The third part of inventory carrying cost is **inventory risk cost**. This includes obsolescence, damage, **shrinkage**, and **transshipment costs**. Obsolescence occurs when products' values are reduced from the time they were first purchased or brought into the facility throughout the time they are stored. For example, produce easily becomes obsolete because it goes bad if stored too long. As another example, the value of computers decreases because of the rapid technological advances in that industry.
Storage Space Cost	The last part of inventory carrying cost is **storage space cost**. This category includes handling costs associated with moving goods in and out of storage and costs for storage itself, such as rent, heating, and lighting. These types of costs are generally allocated based on the volume of inventory being stored.

Calculating Inventory Carrying Costs

Calculating the inventory carrying cost for stored goods involves three steps:

1. Identify the value of the item stored in inventory (i.e., the manufactured cost of goods sold).
2. Measure each individual carrying cost component as a percentage of product value, and add the component percentages together to measure inventory carrying cost. Thus, inventory carrying cost is typically expressed as a percentage of product value (*see Figure 55*).
3. Multiply overall carrying cost as a percentage of product value by the value of the product to measure the annual carrying cost for a particular amount of inventory. An example is a company that manufactures scientific calculators at a manufactured cost of $150 per unit. *Figure 55* lists the carrying cost components as a percentage of product value; the annual cost of carrying a single calculator is calculated as follows: $150 × 0.30 = $45.

Cost	Percentage of Product Value
Hurdle Rate	12%
Inventory service	5%
Inventory risk	10%
Storage Space	3%
Total	**30%**

Figure 55. Inventory carrying cost. Developed by LINCS in Supply Chain Management Consortium.

It is important to note that items with basically similar carrying costs should use the same estimate of carrying cost per inventory dollar. However, items subject to rapid obsolescence or items that require special servicing to prevent deterioration may require separate cost estimates.

Finance departments can typically provide percentages for each component of inventory carrying cost. This inventory carrying cost should be applied to raw materials, WIP, and finished goods inventory. It is generally cheaper to hold raw materials inventory because it has a lower value and consequently lower carrying costs. Finished goods usually have the highest carrying costs because they have the highest value among the three inventories listed.

A relationship exists amongst inventory turnover, average inventory value, and inventory costs. According to Coyle et al. (2003), as inventory turnover increases, average inventory and the cost of carrying the average inventory decreases (*see Figure 56*).

Number of Inventory Turns/Year	Average Inventory	Inventory Carrying Cost	Incremental Savings in Carrying Cost	Cumulative Savings in Carrying Costs
1	$20,000,000	$6,000,000	----------	----------
2	$10,000,000	$3,000,000	$3,000,000	$3,000,000
3	$6,666.667	$2,000,000	$1,000,000	$4,000,000

Figure 56. The relationship among inventory turnover, average inventory, and inventory carrying costs (assuming an inventory carrying cost of 30%). Developed by LINCS in Supply Chain Management Consortium.

Unit 3: Impact of Inventory Cost on Financial Statements

The need to manage companies' investments in inventory comprises a major part of working capital management, which is an important part of financial management. In fact, inventory usually comprises the largest component of current asset accounts on balance sheets.

Key Financial Statements

Financial statements are reports about an organizations' financial results and financial conditions. Using financial statements includes determining if the assets of a business can generate cash, recognizing where the cash is coming from, and understanding how the cash is being used; these actions are ultimately used to determine if businesses are able to pay back their debts, follow financial results, and establish whether they are profitable. The two key financial statements used in businesses around the world are the income statement and the balance sheet.

Inventory Impact on the Income Statement and Balance Sheet

Income statements show the profitability of companies by taking revenues and deducting expenses to result in net incomes or profits, and balance sheets show the assets and **liabilities** for companies. Assets are items of economic value that companies own, like inventory Liabilities are what companies owe to others, such as accounts payable to suppliers, loans and mortgages, and any other debts on the books.

Inventory is reported as a current asset on the company's balance sheet. Inventory is a significant asset that needs to be monitored closely. From a financial perspective, too much inventory can result in cash flow problems, especially when inventory has been paid for and is not generating cash through sales; however, too little inventory can result in lost sales and lost customers. Inventory is also reported as a cost on the balance sheet at the amount paid to purchase the merchandise.

Unit 4: Inventory Returns

Most companies think about good product that is going out to customers when they think about inventory; however, there are also products that come back from customers, which are referred to as **returns**, or reverse logistics. Even companies with the most sophisticated supply chains encounter complexities when handling returns. The following sections discuss returns in more detail.

What Constitutes a Return?

Returns can include good products that can be resold, bad products that cannot be resold, and products that can be resold after repair or repackaging. For example, a returned cell phone with heavy water damage may be beyond repair and cannot be resold, but a cell phone with minor damage like a broken screen can be repaired and resold as a refurbished product.

Figure 57. Inventory returns. Developed by LINCS in Supply Chain Management Consortium.

Some companies have their own processes to evaluate returned product, while others hire outside firms to assess returns. For example, a third-party logistics firm might receive damaged cell phones either to repair and return them to customers or to dispose of them, depending on the level and type of damage.

Inventory Planning and Returns

From an inventory planning perspective, a large volume of product returns can severely impact the inventory measures discussed before. For example, an inventory planner might have barely managed to reach the target for inventory turns; however, two truckloads of product come back from a customer and adversely affect that number. Now, this additional inventory received back cannot be considered sold inventory, so total sales will decrease. Currently, over one third of Internet sales are returned, and the statistics are even higher in the retail industry. This increase in returns has led to the creation

of new business models focusing on 3PL returns specialized services, including deeply discounted acquisition and resale of the returned inventory (Kim, 2013).

Manufacturers and retailers use factory **outlet stores**, which are retail stores that sell outdated, irregular, or large quantities of products to sell items that have either been returned or are no longer selling well in their regular stores. These outlets allow these companies to recoup some costs for products, even if they sold at discount. In reselling repaired, repackaged, or returned products, the goal is to sell them for as close to the original price as possible. The final and least desirable option for receiving returned products is to sell products at **salvage value** (i.e., the value that can be derived from the scrap value of the item), which is often pennies on the original dollar, or simply throw the products away.

Learning Block 6 Summary

Inventory performance can be measured using key metrics such as dollars on hand, inventory investment as a percentage of sales, inventory turns or inventory velocity, and days on hand. The costs related to inventory include the value of the product on hand and the inventory carrying costs. The components of inventory carrying costs are hurdle rate, inventory service cost, inventory risk cost, and storage space cost. Inventory performance affects the profitability of a company on the income statement and the ROI on the balance sheet. Inventory management also involves managing returns and inventory exceptions. Measurements are used to see how well inventory performance is being managed at the product category or even the SKU level and to evaluate what service levels should be maintained to meet customer needs while keeping costs to a minimum.

Figure 12. Inventory management. Developed by LINCS in Supply Chain Management Consortium

Learning Block 6 Optional Supplemental Resource

The optional supplemental resource listed below may be used to reinforce the content covered within this learning block.

Mercado, E. (2007). *Hands-on inventory management*. Boca Raton, FL: Taylor & Francis Group.

Learning Block 6 Practice Questions

1. The definition of a hurdle rate is:

a. The rate a company can borrow money from a bank to buy inventory
b. The minimum rate of return on any new investment
c. The service level needed for a product
d. The cost of inventory on hand

2. On a company balance sheet, inventory is which of the following?

a. An asset
b. A liability
c. A cost
d. A revenue

3. Transshipment costs are a part of which component of inventory carrying costs?

a. Hurdle rate
b. Inventory service costs
c. Inventory risk costs
d. Storage space costs

4. The metric *total dollars of on-hand inventory* provides an indication of:

a. Inventory turns
b. Investment that a company has tied up in inventory
c. Inventory that a company has tied up in safety stock
d. The amount of money that a company has tied up in equipment

5. Which is the least desirable outcome for a return?

a. Sale for full retail price
b. Sale at an outlet
c. Sale as scrap
d. Throwing away

6. Inventory carrying costs should be applied to:

a. Raw materials, WIP, and finished goods inventory
b. Only raw materials and finished goods inventory
c. Only finished goods inventory
d. Only raw materials and WIP inventory

7. Which of the following categories of inventory has the lowest inventory carrying cost?

a. Work in process
b. Finished goods
c. Raw materials
d. Returns

8. Days on hand refers to the amount of inventory that, if a company reaches zero days on hand, the company will:

a. Run out of product
b. Know the number of calendar days left in the month
c. Meet the desired customer service level
d. Have too much inventory

9. Taxes and insurance are a part of which inventory carrying cost component?

a. Inventory risk cost
b. Inventory service cost
c. Storage space cost
d. Hurdle rate

10. An example of shrinkage in inventory risk cost is:

a. A planned inventory reduction
b. Stolen product or evaporated liquid product
c. Moving inventory to another location
d. Loss caused by a fire or flood

References

Bozarth, C. (2015). SCM collaborative planning, forecasting, and replenishment (CPFR): A tutorial. *The Supply Chain Resource Cooperative*. Retrieved from http://scm.ncsu.edu/scm-articles/scm-cpfr

Clearly Inventory. (2011). *Inventory basics—All about inventory management*. Retrieved from http://www.clearlyinventory.com/inventory-basics/inventory-management

Coyle, J. J., Bardi, E. J., & Langley, C. J. (2003). *The management of business logistics* (7th ed.). Chula Vista, CA: Southwestern College.

Davila, T., & Wouters, M. (2007, April 27). An empirical test of inventory, service and cost benefits from a postponement strategy. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/00207540600725002

Forrester, J. W. (1961). *Industrial dynamics*. Cambridge, MA: MIT Press.

Kim, S. (2013, December 24). *Online Retailers Tackle High Rate of Customer Returns.* Retrieved from http://abcnews.go.com/Business/online-shopping-transactions-returned/story?id=21312312

Mercado, E. (2007). *Hands-on inventory management*. Boca Raton, FL: Taylor & Francis Group.

Pollick, M. (2015). What is inventory? *WiseGeek*. Retrieved from http://www.wisegeek.com/what-is-inventory.htm

Scott, S. (2015). Top ten ways to manage inventory. *Houston Chronicle*. Retrieved from http://smallbusiness.chron.com/top-ten-ways-manage-inventory-11099.html

Z R Data Systems. (2010). *John B. Sanfilippo & Son, Inc*. Retrieved from http://www.zrdata.com/Case%20Studies%20Details/case_studies_jbss.aspx

Practice Questions Answer Key

Learning Block 1
1. A
2. D
3. B
4. D
5. C
6. B
7. A
8. D
9. D
10. C

Learning Block 2
1. A
2. C
3. A
4. C
5. D
6. B
7. C
8. A
9. C
10. B

Learning Block 3
1. A
2. A
3. D
4. B
5. A
6. B
7. B
8. D
9. C
10. A

Learning Block 4
1. A
2. D
3. D
4. B
5. D
6. B
7. C
8. D
9. B
10. A

Learning Block 5
1. B
2. B
3. C
4. D
5. B
6. C
7. B
8. C
9. B
10. B

Learning Block 6
1. B
2. A
3. C
4. B
5. D
6. A
7. C
8. A
9. B
10. B

Inventory Management Certification Track Glossary

***:** Indicates terms that come, in part or in whole, from the Supply Chain Management Terms and Glossary from August 2013.

A

ABC Classification*: A method of classifying inventory items relative to their impact on total control. ABC typically uses movement and cost data to calculate the value of stock usage over the prior period, and uses the result as an element in ranking items under an 80/20 Pareto's principle for cycle counting purposes to focus efforts on those selected items and possibly reduce the cost associated with frequent counting of slow moving items. The group is divided into classes called A, B, and C (and sometimes D). The A group represents the highest value and 10 to 20% by number of items. The B, C, and D (if used) groups are each lower values but typically higher populations. Items with higher usage value (the 20%) are counted more frequently. Specific bars to be used in setting ABC levels will vary by organization as they will impact the financial control applied to inventory and the level of effort spent counting. See also *Cycle Counting*.

Actual Sales: Indicates the quantity of item purchases by customers.

Auditing*: Determining the correct transportation charges due to the carrier. Auditing involves checking the accuracy of the freight bill for errors, correct rate, and weight. Also refers to the act of performing an audit of processes or financial results.

Average Inventory Level*: The average inventory level over a period of time. Implicit in this definition is a sampling period which is the amount of time between inventory measurements (e.g., daily inventory levels over a two-week period of time and hourly inventory levels over one day). The average inventory for the same total period of time can fluctuate widely depending upon the sampling period used.

B

Balance Sheet: A balance sheet keeps track of profits and losses (i.e., return on working capital), and this measure is used in determining the economic bottom line.

Barcode*: A symbol consisting of a series of printed bars representing values. A system of optical character reading, scanning, and tracking of units by reading a series of printed bars for translation into a numeric or alphanumeric identification code. A popular example is the UPC code used on retail packaging.

Best Practice*: A specific process or group of processes that have been recognized as the best method for conducting an action. Best practices may vary by industry or geography, depending on the environment being used. Best practices methodology may be applied with respect to resources, activities, cost object, or processes.

Breakage: Damaged materials.

Buffer Stock: See *Safety Stock*.

Bullwhip Effect*: Also known as the Whiplash Effect, it is an observed phenomenon in forecast-driven distribution channels. The bullwhip effect creates disruption and expense within organizations and has a ripple effect for customers and suppliers. The oscillating demand magnification upstream a supply chain is reminiscent of a cracking whip. The concept has its roots in J. Forrester's *Industrial Dynamics* (1961) and thus it is also known as the Forrester Effect.

C

Carrying Costs: Costs of holding inventory; is derived from carrying the inventory on the books. See also *Inventory Carrying Costs*.

Capital*: The resources, or money, available for investing in assets that produce output.

Classification*: An alphabetical listing of the commodities, the class or rating into which the commodity is placed, and the minimum weight necessary for the rate discount; used in the class rate structure.

Collaborative Planning, Forecasting, and Replenishment (CPFR)*: A concept that aims to enhance supply chain integration by supporting and assisting joint practices. CPFR seeks cooperative management of inventory through joint visibility and replenishment of products throughout the supply chain.

Communication*: Communication involves the transfer of information among people and places. There are various methods of communication, and more than one may occur at a time. Communication involves sending and receiving information through different methods: written communication, verbal communication, nonverbal communication, and visual communication.

Components*: Material that will contribute to a finished product but is not the finished product itself. Examples would include tires for an automobile, power supply for a personal computer, or a zipper for a ski parka. Components for manufacturers may be considered finished products for their suppliers.

Consignment Stocking: In consignment stocking, a supplier provides products (inventory) to a buyer, which is held in stock at the buyer's facilities, but the inventory is still owned by the supplier. The buyer assumes responsibility for the stock when stock is withdrawn from that consignment inventory, makes payment for quantities used, and notifies the supplier of the need to replenish inventory.

Consumer: Someone who purchases goods and/or services for personal use.

Container*: 1) A box, typically 10 to 40 feet long, that is primarily used for ocean freight shipments. For travel to and from ports, containers are loaded onto truck chassis or railroad flatcars. 2) The packaging, such as a carton, case, box, bucket, drum, bin, bottle, bundle, or bag, that an item is packed and shipped.

CPFR: See *Collaborative Planning, Forecasting, and Replenishment*.

Counting Inventory: It is necessary for inventory control purposes to verify the on-hand counts in inventory records with a physical inspection and count of all items. This is usually done either by counting the entire inventory at the same time, which is called a physical inventory, or by counting all items at varying times on a prescheduled basis, which is called cycle counting.

Cross-Dock*: A distribution system in which merchandise received at the warehouse or DC is not put away, but instead is readied for shipment to retail stores.

Customer*: 1) In distribution, the trading partner or reseller. 2) In direct-to-consumer, the end customer or user.

Customer Service*: Activities between buyers and sellers that enhance or facilitate the sale or use of sellers' products or services.

Cycle Counting*: An inventory control and management practice that refers to a process of regularly scheduled inventory counts (usually daily) that cycle through the inventory. A volume-based cycle-count strategy allows users to determine how often certain items or locations are counted using frequency or dollar values segregated into ABC categories. Another method is the geographic-based cycle-count strategy in which complete counts are sequenced to allow for a complete cycle through the facility within a given time frame. Cycle counting can eliminate the need for wall-to-wall physical counts and can maintain a higher level of on-going accuracy.

Cycle Stock: This is the portion of a company's inventory that is depleted through normal use or sale. Firms hold cycle stock to respond to demand or normal usage.

D

Days of Supply*: Measure of quantity of inventory on hand in relation to number of days for which usage which will be covered. For example, if a component is consumed in sale or manufacturing at the rate of 100 per day, and there are 1,585 units available on hand, this represents 15.85 days of supply.

DC*: See *Distribution Center*.

Demand*: What customers or users actually want. It is typically associated with the consumption of products or services as opposed to a prediction or forecast.

Demand Forecasting: A key responsibility in inventory management by forecasting the amount of inventory that will be required over a set period of time to meet customers' needs. Various forecasting tools and techniques are used for this. Accurate demand forecasting is important as both over supply and under supply of inventory can have adverse business impacts and result in excessive costs. The more accurate the forecast can be the better a company can service its customers.

Demand Planning*: The process of identifying, aggregating, and prioritizing all sources of demand for the integrated supply chain of a product or service at the appropriate level, horizon, and interval.

Demand Rate: The rate of demand for stock that can vary over time.

Dependent Forecasts: Forecasts that rely on the need to complete finished goods and are often inputs in finished goods.

Distributing*: The activities associated with moving materials from source to destination. Can be associated with movement from a manufacturer or distributor to customers, retailers, or other secondary warehousing/distributing points.

Distribution Center (DC)*: The warehouse facility that processes inventory from suppliers and manufacturing for distribution in the supply chain.

Downstream*: Referring to the demand side of the supply chain. One or more companies or individuals who participate in the flow of goods and services moving from the manufacturer to the final user or consumer.

E

Economic Order Quantity (EOQ)*: An inventory model that determines how much to order by determining the amount that will meet customer service levels while minimizing total ordering and carrying costs.

Electronic Scales: A device to determine the weight of items.

End Customer: The final consumer who purchases the product.

Enterprise Resource Planning (ERP) System: A class of software for planning and managing "enterprise-wide" the resources needed to take customer orders, ship them, account for them and replenish all needed goods according to customer orders and forecasts. Often includes electronic commerce with suppliers. Examples of ERP systems are the application suites from SAP, Oracle, PeopleSoft and others.

EOQ*: See *Economic Order Quantity*.

F

Financial Statements: A written report that quantitatively describes the financial health of a company. Examples include income statements, balance sheets, and cash flow statements.

Finished Goods*: Products completely manufactured, packaged, stored, and ready for distribution.

Forecasted Sales: Estimated customer sales for a given time period.

Forecast Error: The measurement of how wrong, or off, forecasts are.

Forecasting*: Predictions of how much of a product will be purchased by customers. Relies on both quantitative and qualitative methods.

Fulfillment*: The act of fulfilling customer orders. Fulfillment includes order managing, picking, packaging, and shipping.

H

Hedge Stock*: Excess inventories held to provide a buffer against risks associated with contingent event. Events include price increases and availability reductions associated with work stoppages, plant shutdowns, disasters, or acts of terrorism.

Historical Demand Data: Data used to predict possible fluctuations in demand.

Hurdle Rate*: The required rate of return in a discounted cash flow analysis, above which an investment makes sense and below which it does not. See also *Inventory Carrying Cost*.

Import Tariffs: A tariff on goods coming into a country from abroad that are often used by governments as a way of reducing imports and protecting local industries.

Income Statement: Shows the profitability of companies by taking revenues and deducting expenses to get net income or profit.

Independent Forecasts: Forecasts that are needed to predict demand for most finished goods.

Interleaved 2 of 5 (ITF-14): The practice of assigning an employee multiple tasks that are performed concurrently. Frequently used to define the practice of assigning multiple picking orders to a single picker who will pick them concurrently as he/she moves down the aisle.

Inventory*: Inventory includes components, raw materials, work in process, finished goods, and supplies required for the creation of goods and services. Inventory can also refer to the number of units and/or value of the stock of goods held by a company.

Inventory Administration: The tasks associated with maintaining information about materials and stock levels.

Inventory Carrying Cost*: One of the elements comprising a company's total supply-chain management costs. These costs consist of the following: are hurdle rate, insurance and taxes, inventory risk costs, and storage space costs. See also *Hurdle Rate*.

Inventory Control: The output of processes and procedures that ensure that the amount of material on hand equals the amount of material recorded in the computer systems.

Inventory Days on Hand*: Total gross value of inventory for the category (raw materials, work in process, partially finished goods, or fully-finished goods) at standard cost before reserves for excess and obsolescence, divided by the average daily usage. It includes only inventory that is on the books and currently owned by the business entity.

Inventory Deployment: A technique for strategically positioning inventory to meet customer service levels while minimizing inventory and storage levels. Excess inventory is replaced with information derived through monitoring supply, demand, and inventory at rest and in motion.

Inventory Director: One of the top management positions to whom the Distribution Director and Inventory Managers report

Inventory Dollars as a Percentage of Sales: The average value of inventory divided by the total sales of the product associated with the inventory, where sales are quantified using the same unit values as used for inventory.

Inventory Integrity: A term used to represent the results on a set of inventory accuracy metrics.

Inventory Management*: The process of ensuring the availability of products through inventory administration.

Inventory Manager: The person who balances the inventory criteria to have the most efficient supply chain.

Inventory Performance: A term used to represent the results on a set of inventory performance metrics.

Inventory Postponement: A technique that maximizes possible benefit and minimizes risk by delaying further investment into a product or service until the last possible moment.

Inventory Risk Cost: The cost associated with product losing value while in storage due to obsolescence, damage, shrinkage, or transshipment costs. See also *Inventory Carrying Cost*.

Inventory Storage: Relates to how and where inventory is typically stored.

Inventory Service Cost: This covers the taxes and insurance related to inventory. For taxes, countries and states often tax the value of inventory a company holds. For insurance, the product in inventory must be insured in case a fire, flood, or other emergency occurs, and the inventory has to be replaced.

Inventory System: An inventory control in which a running total of all inventory is kept by regularly adding purchases to, and subtracting sales from, the quantity at hand.

Inventory Turnover*: See *Inventory Turns*.

Inventory Turns*: This ratio measures how many times a company's inventory has been sold (turned over) during a period of time. The cost of goods sold divided by the average level of inventory on hand. Operationally, inventory turns are measured as total throughput divided by average level of inventory for a given period; How many times a year the average inventory for a firm changes over, or is sold.

Inventory Velocity*: The speed in which inventory moves through a defined cycle (e.g., from receiving to shipping).

ITF-14: See *Interleaved 2 of 5*.

J

JIT*: See *Just-In-Time*.

Just-In-Case: An inventory strategy in which companies keep large inventories on hand. This type of inventory management strategy aims to minimize the probability that a product will stockout.

Just-In-Time (JIT)*: An inventory control system that controls material flow into assembly and manufacturing plants by coordinating demand and supply to the point that desired materials arrive in time for use.

L

Lead Time*: Average time that elapses from placing orders with suppliers to receiving goods. It includes the time required for order transmittal, order processing, order preparation, and transit.

Liabilities: A contractual obligation to deliver cash or similar payment to another entity.

Line Items: A SKU that is being ordered in a quantity of one or more.

Link*: The transportation method used to connect the nodes (plants, warehouses) in a logistics system.

Liquidity: The extent that any asset can be converted into cash.

Logistics*: The process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements.

Long-term forecasts: Product sales estimates for a timeframe greater than 12 months.

Losses: The losing of physical inventory.

Maintenance Repair, and Operations (MRO)*: Any activity—such as tests, measurements, replacements, adjustments and repairs—intended to retain or restore a functional unit in or to a specified state in which the unit can perform its required functions.

Manufacturing: The phase of the product life cycle in which a prototype is built and tested, and then the mass production of the product is completed.

Manufacturing Operations: Operations specifically used for making products from dish soap to automobiles; they make tangible items that can be sold to consumers through stores, shops, and online.

MAPE: See *Mean Absolute Percent Error*.

Master Carton Code: A 14-digit barcode placed on the outside of a shipping carton or pallet. This code allows a retailer to scan a shipment of multiple units of product as it comes into the warehouse.

Mean Absolute Percent Error (MAPE): A commonly used different calculation of forecast error that converts the units of error into a percentage. More importantly, it uses the absolute value of the forecast error so that under forecasts and over forecasts do not balance out each other.

Merchandise: Goods to be bought and sold.

Min-Max System*: A replenishment and inventory management system that sets a minimum inventory level and is used to trigger a reorder when the available and incoming receipt total is less than the minimum. The amount of the order is the difference between the calculated (less than minimum) inventory and a predefined maximum. Min-max systems are typically not time phased.

Moving Average: A simple but reasonably accurate forecast that uses recent sales numbers to predict sales for the next period.

O

Objective: The goal that the manager is ultimately interested in achieving for the company.

Obsolescence*: A loss in the utility or value of property that results over time from intrinsic limitations (as outmoded facilities) or external circumstances. See also *Inventory Risk Cost*.

Operational: Relating to the routine functioning and activities of a business.

Operations: The planning and manufacturing (conversion) of goods.

Opportunity Cost*: The opportunity cost of carrying inventory. This should be based on a company's cost of capital standards using the formula: Cost of Capital × Average Net Value of Inventory.

Order Entry*: The process of receiving orders from customers and entering them into companies' order processing systems. Orders can be received through phone, fax, or electronic media. Activities may include examining orders to ensure an orderable configuration and to provide accurate prices, checking customers' credit and accepting payments (optionally), identifying and reserving inventory (both on hand and scheduled), and scheduling and committing to a delivery date.

Order Fill Rate: 1) An indicator that provides insights into achieving the perfect order and into the fulfillment process. 2) The percentage of incoming customer orders that are filled on time. This can be calculated by taking the total number of completely filled orders and dividing by the total number of orders.

Order Management*: The process of managing activities involved in customer orders, manufacturing orders, and purchase orders. For customer orders, this includes order entry, picking, packing, shipping, and billing. For manufacturing, this includes order release, routing, production monitoring, and receipt to inventory.

Ordering Costs: Costs incurred in preparing and processing purchase orders as well as receiving and inspecting purchased items.

Outlet Store: Stores that manufacturers and retailers use to sell product that has either been returned or is not long selling well in their normal stores.

Outsourcing*: To utilize a third-party provider to perform services previously performed in-house. Examples include manufacturing of products and call center/customer support.

P

Pallet*: The platform that cartons are stacked on and then used for shipment or movement as a group. Pallets may be made of wood or composite materials. Some pallets have electronic tracking tags, and most are recycled in some manner.

Pareto's Principle*: An analysis that compares cumulative percentages of the rank ordering of costs, cost drivers, profits or other attributes to determine whether a minority of elements have a disproportionate impact. For example, identifying that 20% of a set of independent variables is responsible for 80% of the effect.

Performance Measures*: Indicators of the work performed and the results achieved in an activity, process, or organizational unit. Performance measures should be both non-financial and financial. Performance measures enable periodic comparisons and benchmarking.

Periodic Control: An inventory control method that relies on periodic physical counts of all on-hand inventory to compare to reports on the inventory that is believed to be held.

Perpetual Inventory Control: An inventory control method that relies on the accuracy of computer tracking of inventory movements into, thru, and out of facilities. Periodic physical counts of small samples of inventory are conducted to verify the accuracy.

Physical Inventory: Inventory that is physically present and can be counted at the same time.

Picking: The process of collecting the appropriate items in the right quantities to fill a customer order. A combination of different methods can be used within a single warehouse.

Plant or Manufacturing Facility: A facility where materials or products are produced.

PO*: See *Purchase Order*.

Point-of-Sale (POS): The time and place at which sales occur, such as at cash registers in retail operations, or order confirmation screens in online sessions. Supply chain partners are interested in capturing data at the POS because it is a true record of sales and is not derived from other information, such as inventory movement.

POS: See *Point-of-Sale*.

Postponement*: The delay of final activities (e.g., assembly, production, and packaging) until the latest possible time. A strategy used to eliminate excess inventory in the form of finished goods which may be packaged in a variety of configurations and to maximize the opportunity to provide a customized end product to the customer.

Process*: A series of time-based activities that are linked to complete a specific output.

Procurement*: The activities associated with acquiring products or services. The range of activities can vary widely between organizations to include all of parts of the functions of procurement planning, purchasing, inventory control, traffic, receiving, incoming inspection, and salvage operations.

Profitability: Shown by the income statement; takes revenues and deducts expenses to get net income or profit.

Promotional Stock: This type of stock is held so that a firm's logistics/distribution system may respond quickly and effectively to a marketing promotion or price deal that a firm intends offering to its customers, including holiday promotions.

Pull Ordering System*: A system in which each warehouse controls its own shipping requirements by placing individual orders for inventory with the central DC. This is a replenishment system in which inventory is pulled into the supply chain (or demand chain by POS systems or ECR programs).

Purchase Order (PO)*: The purchaser's authorization used to formalize a purchase transaction with a supplier. The physical form or electronic transaction buyers' use when placing orders for merchandise.

Purchasing*: The functions associated with buying the goods and services required by the firm.

Push Distribution*: The process of building product and pushing it into the distribution channel without receiving any information regarding requirements.

Push Ordering System*: A situation in which a firm makes inventory deployment decisions at the central DC and ships to its individual warehouses accordingly.

Put Away*: The activities involved in moving materials from a receiving area or the end of a production process into inventory stock locations.

Q

QR*: See *Quick Response*.

Quality Assurance: Inspection and acceptance of incoming and outgoing product.

Quick Response (QR)*: A strategy widely adopted by general merchandise and soft lines retailers and manufacturers to reduce retail out-of-stocks, forced markdowns, and operating expenses. These goals are accomplished through shipping accuracy and reduced response time.

R

Radio Frequency Identification (RFID)*: The use of radio frequency technology including RFID tags and tag readers to identify objects. Objects may include virtually anything physical, such as equipment, pallets of stock, or even individual units of product.

Raw Materials*: Crude or processed material that can be converted by manufacturing, processing, or both, into new and useful products.

Refrigerated Warehouse: Facility for preserving perishable items, such as vegetables, furs, pharmaceuticals, etc.

Repair Items: Parts or materials used in the restoration of a broken, damaged, or failed device.

Replenishment: Items from the bulk storage area are picked to restock the primary picking area as stock levels reach a predetermined minimum.

Replenishment Cycle: The time between when one order is placed to the time the next order must be placed to replenish depleted inventory.

Retail*: An individual or organization that purchases products from a manufacturer or distributor and resells them to the ultimate consumer. This group includes a wide range of businesses from door to door and corner stores to global companies and online stores.

Return: Material that has been rejected by customers or buyers' inspection department and is awaiting shipment back to the supplier for repair or replacement.

Return On Assets (ROA)*: Financial measure calculated by dividing profit by assets.

Return on Investment (ROI)*: The profit or loss resulting from an investment transaction, usually expressed as an annual percentage return. ROI is a popular metric to use in showing the value of an investment in new facilities, equipment, or software versus the cost of the same.

RFID*: See *Radio Frequency Identification*.

ROA*: See *Return On Assets*.

ROI*: See *Return On Investment*.

S

Safety Stock*: The inventory a company holds above normal needs as a buffer against delays in receipt of supply or changes in customer demand.

Salvage Value: The resale value of an asset at the end of its useful life.

SCC-14: A barcode used to check in shipments of multiple units of product at the warehouse.

Seasonal Stock: This type of stock is accumulated by firms and held in advance of the season during which the firm will need it. Industries that typically require significant seasonal stock include apparel, sporting goods, and automotive.

Semi-Finished Product: Goods that are in process of being manufactured or in between manufacturing processes.

Semi-Permanent Storage: See *Specialty Storage*.

Service Level*: A metric shown as a percentage that captures the ability to satisfy demand or responsiveness. Order fill rates and machine or process up-time are examples of service level measures.

Shipping*: 1) The act of conveying materials from one point to another. 2) The functional area that prepares the outgoing shipment for transport.

Shipping Container Code: A 14-digit barcode placed on the outside of a shipping carton or pallet. This code allows a retailer to scan a shipment of multiple units of product as it comes into the warehouse.

Short-term forecasts: Short range demand planning generally focused on a period of time extending about 1 year or less in the future.

Shortage: Occurs when inventory items are out of stock.

Shortage Costs: Costs incurred when inventory items are out of stock.

Shrinkage*: The costs associated with breakage, pilferage, and deterioration of inventories. Usually pertains to the loss of material through handling damage, theft, or neglect. See also *Inventory Risk Cost*.

Size (Cube): The amount of space an item or a case of an item might occupy. The size of an item has a direct relationship on the utilization of a storage facility.

SKU: See *Stock Keeping Unit*.

Software: Refers to the brain of the machine—the programs that make the machine run, such as the operating system, Internet browsers, and applications on smartphones.

Specialty Storage: The storage of goods as either buffer or safety stock. Used where there is seasonal or erratic demand, speculative or forward buying, or the products require conditioning.

Speculative Stock: Most commonly associated with companies involved in manufacturing or assembly. This type of inventory is held to protect against expected/possible price increases or constrained availability.

Staging*: The practice of picking material for a production or sales order and moving to a separate area for purposes of consolidation or identifying shortages.

Statistical Process Control*: A method for achieving quality control in processes. The technique hinges on the observation that any process is subject to seemingly random variations, which are said to have common causes, and non-random variations, which are said to have special causes.

Stock Accuracy Level: Accuracy may be measured a number of ways such as the number of correct cycle counts as a percentage of total annual cycle counts.

Stock Card: An item record for which a system for filing and control has been developed. These include index cards, rotary card files, and hand-operated sorting systems.

Stock Keeping Unit (SKU): A unique, individual item with a unique form, fit and function.

Stock Velocity (Stock Movement): See *Inventory Velocity*.

Stockout: A situation in which no stock was available to fill a customer or production order during a pick operation. Stockouts can be costly, including the profit lost for not having the item available for sale, lost goodwill, substitutions, or lost customer.

Stockout Costs: The opportunity cost associated with not having sufficient supply to meet demand.

Storage Space Cost: This category includes handling costs associated with moving goods into and out of storage, and storage costs such as rent, heating, and lighting. These types of costs are generally allocated based on the magnitude of stored inventory. See also *Inventory Carrying Cost*.

Strategic*: Describes a specific action to achieve a specific objective.

Subassemblies: Units assembled separately but designed to fit with other units into a finished manufactured product.

Supervisor: The person to which inventory control workers report. Supervisors typically report to a warehouse manager or inventory manager, depending on the size of the organization and its organization structure.

Supplier*: An individual or an organization who supplies goods or services to companies. This is also sometimes referred to as a vendor.

Supplier-Managed Inventory (SMI): A supply chain model in which suppliers have the responsibility for maintaining purchasers' inventory levels

Supply Chain*: Starting with unprocessed raw materials and ending with the final customer using the finished goods, the supply chain links many companies together. The material and informational interchanges in the logistical process, stretching from acquisition of raw materials to delivery of finished products to the end user.

Supply Chain Management: The design and management of all functions involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers.

T

Tactical: Short range planning generally focused on a period of time extending about 1 year or less in the future.

Temporary Storage: Traditional warehousing, used primarily because trading partners still rely on push distribution strategies. Items are stored for subsequent use in the supply chain in case they are needed.

Terminal: Includes places, either covered or not (e.g., quays, warehouses, container yards, and road, rail or air cargo terminals), in which goods are made available to buyers after being unloaded.

Third-Party Logistics Firm (Provider)*: A firm that provides multiple logistics services for use by customers. Preferably, these services are integrated, or bundled, together by the provider. These firms facilitate the movement of parts and materials from suppliers to manufacturers, as well as finished products from manufacturers to distributors and retailers (also referred to as 3PL).

Total Inventory Dollars: The total dollar value of inventory that a company has on hand at all locations in the supply chain.

Tracking and Controlling Inventory: Accurate tracking of inventory is important to know where inventory is in the supply chain, how much inventory is moving in and out of the company, and how much inventory is being held at any point in time. Inventory control involves counting and monitoring inventory items, recording stocking and retrieving items, identifying and verifying storage location, recording changes to inventory, and anticipating inventory need.

Transportation: The physical movement of people and goods between origin and destination points, thereby creating time and place utilities.

Transshipment Cost: The cost of moving inventory from where it is not needed to where it is needed. See also *Inventory Risk Cost*.

Turnover*: A calculation of the number of times the inventory of an item would be consumed during a period, given average inventory levels and consumption.

U

Uncertainty: Occurs when not everything in the supply chain is foreseen or understood before it happens.

Universal Product Code (UPC)*: A standard product numbering system used by the retail industry. UPC codes are administered by the Uniform Code Council, identify the manufacturer and the item, and are included on virtually all retail packaging.

UPC*: See *Universal Product Code*.

Upstream*: Refers to the supply side of the supply chain. Upstream partners are the suppliers who provide goods and services to the organization needed to satisfy demands that originate at point of demand or use, as well as other flows, such as return product movements or payments for purchases.

V

Variability: Occurs when items or processes in the supply chain are either completed in various ways or done incorrectly for various reasons.

Vendor Managed Inventory (VMI): A vendor is responsible for monitoring and replenishing inventory as needed.

VMI: See *Vendor Managed Inventory*.

W

Warehouse*: Storage place for products. Principal warehouse activities include receipt of product, storage, shipment, and order picking.

Warehouse Management System (WMS): The central computing system for managing a warehouse and DC.

Warehouse Manager: The person to whom supervisors report. Warehouse managers report to distribution directors and inventory managers.

Warehousing Operations: Another function of logistics, warehousing controls the receiving, storing, retrieving, and distributing of the inventory.

Weighted Moving Average: An extension of the simple moving average that adds one additional factor. The weighted moving average typically puts more weight on the most recent time periods rather than the older periods, thereby doing a better job of capturing trends.

WMS: See *Warehouse Management System*.

Work in Process (WIP): Partially finished inventory in a queue waiting for manufacturing completion or further processing for eventual sale.

Notes Page

Addendum

Inventory Management Revision Notes

To V2.17

The previous document version was V2.17 (file name LINCS.IM.v2.17.04252017).

Current version is v2.21 (file name LINCS.IM.v2.21.03202017) and contain the following updates:

- Replaced all CanStockPhoto images
- Replaced all unnecessary instances of “above” and “below”.
- The abstract page was corrected to match all other tracks
- All non-working links were replaced or deleted
- Updated reference page