Introduction to Operation Management

030 **Deliver**

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Inventory

What is inventory?

Inventory refers to the accumulation of materials, customers, or information as they move through processes or networks. It includes physical stock like components and finished goods, queues of customers waiting for service, and databases storing digital information. Effective inventory management is crucial as it involves balancing the amount of inventory to minimize costs while ensuring customer satisfaction. Reducing physical inventory can free up cash, but excessive reduction may lead to unfulfilled orders. Similarly, managing customer queues and digital databases efficiently is vital to maintaining service quality and operational efficiency. This course will equip students with the skills to manage various types of inventory effectively, optimizing resources and enhancing organizational performance.

The role of inventory managing flows in operations and supply chains

All processes, operations, and supply networks inherently involve inventories due to the uneven nature of flows. Just as rivers flow variably, operations experience similar fluctuations. For example, passengers at an airport move through various stages, forming queues at check-in and security, and waiting in departure lounges. Similarly, in manufacturing, components are stored until needed on the assembly line, and finished products await transport. In government, financial data is collected and stored until processed. These inventories arise from mismatches in supply and demand rates. When supply exceeds demand, inventory builds up; when demand exceeds supply, inventory depletes. Effective inventory management aims to balance these rates, though most organizations must manage these disparities at various points in their supply chains.

Understanding the Complexity of Inventoried Information in Operations

There is a complexity when using the "water flow" analogy to describe the movement and accumulation of information. Information inventories can build up due to uneven flow, similar to materials and people, or they can be stored for future processing needs. For instance, an online retailer processes incoming orders, leading to information build-up from uneven flows. Additionally, customer data might be permanently stored in a database for future use, such as processing repeat orders or targeting promotions. In this scenario, the information inventory shifts from being a transformed resource to a transforming one, as it is used to modify other information rather than being altered itself. While managing physical materials involves maintaining the right stock levels to handle flow variations, and managing queues involves resource allocation to meet demand, managing databases focuses on organizing, storing, securing, and retrieving data efficiently.

Complexities of Information Inventories in Operations

When considering the flow and accumulation of information, the “water flow” analogy can be somewhat limited. Information inventories can accumulate due to irregular flow patterns, much like materials and people, or they can be stored for future operational needs. For example, a European automotive manufacturer might gather data on vehicle orders, leading to information build-up from inconsistent order flows. Additionally, customer information could be stored permanently in a database for future use, such as processing repeat orders or planning marketing strategies. In this context, the information inventory transitions from being a resource that is transformed to one that transforms other data. While managing physical materials involves maintaining appropriate stock levels to handle flow variations, and managing queues involves allocating resources to meet demand, managing databases focuses on the organization, storage, security, and efficient retrieval of data.

There are numerous reasons to minimize inventory accumulation whenever possible. These reasons often relate to concerns about cost, space, quality, and operational or organizational challenges. Reducing inventory can help lower storage costs, free up valuable space, maintain product quality, and streamline operations, ultimately leading to more efficient and cost-effective processes.

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The Strategic Importance of Maintaining Inventory

While it might initially seem logical to aim for a smooth and uninterrupted flow of materials, customers, and information, inventories actually offer several advantages for both operations and their customers. If a customer turns to a competitor due to stock shortages, long wait times, or repetitive data collection, the value of maintaining inventories becomes clear. The role of operations management is to ensure that inventory is accumulated only when its benefits surpass its drawbacks. Here are some key benefits of maintaining inventory:

- **Insurance Against Uncertainty**: Inventory acts as a buffer against unexpected changes in supply and demand. For instance, a retail operation cannot predict demand perfectly, so it maintains a minimum level of inventory to cover unexpected demand spikes during delivery times. This is known as safety or buffer inventory. Similarly, hospitals keep essential supplies like blood and bandages on hand for emergencies, and automotive services and airlines stock critical spare parts for quick repairs.
- **Compensating for Lack of Flexibility**: When offering a wide range of customer options, inventory is necessary to ensure supply when the operation is engaged in other activities. This is known as cycle inventory. For example, a manufacturer producing different car models may need to keep inventory to meet demand between production cycles.
- **Taking Advantage of Short-term Opportunities**: Sometimes, opportunities arise that require accumulating inventory, even without immediate demand. For example, a supplier might offer a limited-time discount, prompting a company to purchase more inventory to benefit from the lower prices.
- **Anticipating Future Demands**: Inventory can be used to manage medium-term capacity by producing goods ahead of demand and storing them until needed. This is called anticipation inventory and is useful when demand fluctuations are predictable.
- **Reducing Overall Costs**: Holding larger inventories can lead to cost savings that outweigh the costs of maintaining the inventory. This can occur through bulk-buying discounts or reduced administrative and handling costs from fewer orders.
- **Increasing Inventory Value**: Some inventory items, like fine wines, can appreciate in value over time, making them an investment. Similarly, financial processes aim to maximize cash inventories to earn interest.
- **Filling the Processing Pipeline**: Pipeline inventory exists because resources cannot be moved instantly between supply and demand points. For example, when a retail store orders stock, it becomes pipeline inventory from the time it is allocated until it arrives at the store.
- **Balancing Capacity and Demand with Customer Queues**: Queues help balance capacity and demand, especially when the main service resource is costly, such as doctors, consultants, or specialized equipment. By allowing a short wait time,

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a queue of customers ensures that the service always has clients to attend to, which is beneficial when arrival times are unpredictable.

- **Prioritization Through Queues**: When resources are limited and customers have varying levels of urgency, queues allow organizations to prioritize urgent cases while others wait. For example, in emergency wards, more critical patients are treated first, while others may wait longer.
- **Decision Time for Customers**: Time spent in a queue allows customers to decide on their purchases or services, such as choosing from a menu in a fast-food restaurant, ensuring they are ready to order when they reach the counter.
- **Efficient Resource Utilization**: Queues enable batching of customers, optimizing the use of operational resources. For instance, a queue for an elevator maximizes its capacity, and calling passengers to the gate at an airport allows for efficient and quick boarding.
- **Efficient Multi-level Access with Databases**: Databases provide a cost-effective way to store information and offer access to multiple users, albeit with varying levels of access. For example, a doctor's receptionist can access patient records for appointments, while the doctor can view detailed medical histories.
- **Single Data Capture with Databases**: Databases eliminate the need to repeatedly capture data during each transaction, though periodic checks may be necessary.
- **Speeding Up Processes**: Companies like Amazon store customer information, such as delivery addresses and payment details, to facilitate quick and easy transactions, enhancing customer convenience.

Strategies for Reducing Physical Inventory and Its Impact on Financial Performance

In this section, we will concentrate on physical inventory, as it is commonly associated with the term "inventory" by operations managers. The primary goal for managing physical inventories is to minimize their overall level and cost while ensuring an acceptable level of customer service. Here are some strategies to achieve this:

- **Impact on Return on Assets**: Inventory management significantly influences an operation's financial performance, particularly its return on assets (ROA), a crucial financial metric. Several factors illustrate this impact:
    - **Customer Supply Capability**: Inventory is essential for meeting customer demands. Without it, operations may fail to supply products, leading to lost sales and customer dissatisfaction.
    - **Obsolescence and Damage**: Inventory can become obsolete as new alternatives emerge, or it may suffer damage, deterioration, or loss. This results in increased costs due to wasted resources and reduced revenue from unsellable items.
    - **Storage Costs**: Inventory incurs costs for storage space and maintaining suitable conditions. These costs can be substantial, especially for

hazardous or difficult-to-store items like flammable solvents or frozen foods.

- **Administrative and Insurance Costs**: Ordering and managing inventory involve administrative expenses and insurance costs, which add to the overall cost of inventory management.
- **Working Capital**: Inventory ties up funds in the form of working capital, making them unavailable for other purposes, such as reducing debt or investing in productive assets.
- **Supplier Contracts**: Inventory contracts with suppliers can affect payment timing. If suppliers require payment before the operation receives payment from customers, it increases working capital needs.

Managing Day-to-Day Inventory Decisions

In any operation where inventory accumulates, managers must handle the daily tasks associated with inventory management. Orders from both internal and external customers are received, dispatched, and gradually deplete the inventory. To maintain optimal stock levels, replenishment orders must be placed, and incoming deliveries need to be stored appropriately. Operations managers face three primary types of decisions in managing inventory systems:

- **How Much to Order**: This decision involves determining the size of each replenishment order. It is often referred to as the volume decision. The goal is to balance the cost of ordering with the cost of holding inventory, ensuring that stock levels are sufficient to meet demand without excessive overstocking.
- **When to Order**: This decision focuses on the timing of replenishment orders. Known as the timing decision, it involves deciding at what point in time or at what stock level a new order should be placed. The objective is to avoid stockouts while minimizing inventory holding costs.
- **How to Control the System**: This involves establishing procedures and routines to facilitate effective inventory management. It includes setting priorities for different stock items, determining how stock information should be stored, and implementing systems to support decision-making processes.

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The Volume Decision in Inventory Management

The decision of how much to order, known as the volume decision, involves balancing the costs associated with purchasing and holding inventory. This decision is similar to managing household food and drink supplies, where one must decide how much to buy at a time. Here are the key considerations and costs involved in making this decision:

- **Balancing Costs**: The decision involves weighing the costs of frequent purchases against the costs of holding large inventories. Buying items only when needed minimizes holding costs but requires frequent trips, which can be inconvenient. Conversely, buying in bulk reduces purchase frequency but ties up significant funds and requires storage space.
- **Inventory Costs**: In commercial settings, the same principles apply. Operations managers must identify costs affected by order quantity decisions. These costs include:
    1. **Cost of Placing the Order**: Each replenishment order incurs transaction costs, such as preparing the order, communicating with suppliers, arranging delivery, making payments, and maintaining records. These costs decrease with larger order sizes.
    2. **Price Discount Costs**: Suppliers often offer discounts for large orders, reducing the cost per unit.
    3. **Stock-out Costs**: Running out of stock leads to lost revenue and customer dissatisfaction. Larger orders reduce the risk of stockouts.
    4. **Working Capital Costs**: Inventory ties up funds, creating a lag between paying suppliers and receiving customer payments. This requires financing, either through borrowing or opportunity costs.
    5. **Storage Costs**: Storing inventory incurs costs for space, utilities, and insurance. Special conditions, like refrigeration, increase these costs.
    6. **Obsolescence Costs**: Large orders may lead to items becoming obsolete or deteriorating over time, especially in fast-changing markets or with perishable goods.
    7. **Operating Inefficiency Costs**: High inventory levels can mask operational inefficiencies, as highlighted by lean philosophies.
- **Consignment Stock**: Sometimes, suppliers hold consignment stock, delivering large quantities to customers but only charging for goods as they are used. This arrangement shifts some costs to the supplier while the customer provides storage.

Understanding Inventory Profiles

An inventory profile is a graphical representation that illustrates how inventory levels change over time. It helps visualize the dynamics of stock management and is crucial for making informed inventory decisions. Here's a breakdown of a simplified inventory profile for a stock item in a retail operation:

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- **Order Quantity (Q)**: Every time an order is placed, a fixed quantity (Q) of items is ordered. The replenishment arrives instantaneously in one batch.
- **Demand Rate (D)**: The demand for the item is steady and perfectly predictable, occurring at a rate of D units per month.
- **Inventory Cycle**: The inventory level decreases steadily as demand depletes the stock. Once the inventory is entirely depleted, another order of Q items arrives instantaneously, and the cycle repeats.
- **Average Inventory**: The average inventory level is calculated as ($\frac{Q}{2}$). This is because the inventory level fluctuates between 0 and Q, and the average is the midpoint.
- **Time Interval Between Deliveries**: The time between each delivery is ($\frac{Q}{D}$). This represents how long it takes for the inventory to be depleted from Q to 0 at the demand rate D.
- **Frequency of Deliveries**: The frequency of deliveries is the reciprocal of the time interval, calculated as ($\frac{D}{Q}$). This indicates how often orders need to be placed to maintain the inventory cycle.

The economic order quantity (EOQ) formula

The Economic Order Quantity (EOQ) model is a widely used method for determining the optimal order quantity that minimizes the total cost of inventory management. This approach balances the costs associated with holding stock, such as working capital, storage, and obsolescence, against the costs of placing orders, including order processing and transportation.

In the EOQ model, two plans are compared: Plan A, which involves ordering larger quantities less frequently, and Plan B, which uses smaller, more frequent orders. The goal is to find the order quantity that minimizes the sum of holding and ordering costs. For example, if the holding cost per item per year is €1 and the cost of placing an order is €20, the EOQ can be calculated using the formula:

[$\mathrm{EOQ} = \sqrt{\frac{2 \times \mathrm{Co} \times \mathrm{D}}{\mathrm{Ch}}}$]

Where:

- (Co) is the cost per order,
- (D) is the annual demand,
- (Ch) is the holding cost per unit per year.

The EOQ provides the order quantity that minimizes total costs, balancing the trade-off between ordering and holding costs. Additionally, the EOQ model helps determine the optimal time between orders and the order frequency, ensuring efficient inventory management.

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Sensitivity of the EOQ

An analysis of the total cost curve reveals that while there is a specific order quantity (Q) that minimizes total costs, slight variations from this EOQ do not lead to a significant increase in costs. Essentially, as long as the chosen order quantity is reasonably close to the EOQ, the costs will remain nearly optimal. This means that even if there are minor inaccuracies in estimating holding or ordering costs, they won't cause a major deviation from the EOQ. This is advantageous in practice, as accurately estimating these costs can be challenging.

Gradual Replacement – The Economic Batch Quantity (EBQ) Model

The Economic Batch Quantity (EBQ) model addresses scenarios where inventory replenishment occurs gradually over time, rather than all at once. This is common in situations where parts are produced internally and added to inventory continuously, while demand simultaneously depletes the stock. As long as the production rate (P) exceeds the demand rate (D), inventory levels will rise. Once a batch is completed, production halts, and demand continues to reduce inventory until the next batch begins. This cycle creates a distinct inventory profile typical of batch processes.

The EBQ, also known as the Economic Manufacturing Quantity (EMQ) or Production Order Quantity (POQ), is the optimal batch size that minimizes total costs. It is calculated as follows:

- **Maximum Stock Level (M):** The peak inventory level during production.
- **Slope of Inventory Build-up:** The rate at which inventory increases, calculated as (P - D).
- **Average Inventory Level:** Given by ($\frac{Q(P-D)}{2P}$).

The total cost, combining holding and order costs, is expressed as:

[$Ct = \frac{ChQ(P-D)}{2P} + \frac{CoD}{Q}$]

To find the EBQ, the derivative of the total cost with respect to Q is set to zero and solved, resulting in:

[$\mathrm{EBQ} = \sqrt{\frac{2CoD}{Ch\left(1-\frac{D}{P}\right)}}$]

This formula provides the batch size that minimizes costs, considering both production and demand rates.

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Responding to Criticisms of the EOQ Model

Assumptions and Limitations:

The EOQ model simplifies inventory management by making assumptions about demand stability, fixed ordering costs, and linear stock-holding costs. While these assumptions are not always accurate, they often approximate reality. The total cost curve's flat optimum means small errors in these assumptions don't significantly impact costs. However, the model's limitations become apparent when demand is unpredictable, such as in industries with erratic demand patterns like bookselling.

Stock-Related Cost Assumptions:

The EOQ model assumes consistent stock-related costs, but real-world scenarios can vary. For instance, regular multi-item orders may be cheaper than special one-off deliveries. Similarly, stock-holding costs might not be linear, as increasing stock levels could require new facilities. Operations managers must ensure EOQ decisions align with actual cost structures. If holding costs are higher than assumed, the EOQ model suggests smaller, more frequent orders.

Lean Philosophy and EOQ:

Lean philosophies criticize EOQ for focusing on optimizing order quantities without addressing underlying cost structures. Instead of asking for the optimal order quantity, managers should explore ways to reduce overall inventory levels. Many organizations have reduced order costs by minimizing machine changeover times, which lowers the EOQ. The EOQ model should be seen as a descriptive tool rather than a prescriptive one.

Inventory Cost Minimization:

For businesses like supermarkets and wholesalers, inventory is a primary revenue source. They focus on maximizing stock turnover and profit margins, goals not addressed by the EOQ model. Products with high turnover or those prone to obsolescence may not benefit from EOQ, leading to excess inventory. These organizations often use periodic review systems for inventory replenishment, placing regular orders for entire product ranges rather than individual items. This approach suits businesses with large inventories and varied demand patterns.

Periodic Review Systems:

In contrast to the EOQ model, many organizations, especially those with extensive inventories and diverse product lines, adopt periodic review systems. These systems involve regularly scheduled evaluations of inventory levels to determine replenishment needs. For example, a builder's supply merchant might carry tens of thousands of stock-keeping units (SKUs), grouped into categories like paints or metal fixings. Instead of calculating EOQ for each item, they place consolidated orders at regular intervals, such as weekly, to cover the entire supplier's range. This method allows for efficient inventory management by aligning order quantities with actual usage patterns and demand variability.

Handling Less Popular or Erratic Items:

For items with less predictable demand, periodic review systems offer flexibility. Less popular products or those with erratic demand can be included in regular orders or, if necessary, ordered separately for expedited delivery. This approach ensures that inventory levels are maintained without overstocking, reducing the risk of holding excess inventory that may not sell quickly.

Balancing Inventory Objectives:

Organizations must balance the need to minimize inventory costs with other strategic objectives, such as maximizing space utilization and ensuring high stock turnover. The EOQ model, while useful for understanding cost dynamics, may not fully address these broader business goals. By integrating periodic review systems and considering the unique characteristics of their inventory, businesses can achieve a more holistic approach to inventory management.

If Customers Won't Wait – The News Vendor (Single-Period) Inventory Problem

The news vendor problem is a classic example of a single-period inventory decision, where an order quantity is determined for a specific event or time period, and unsold items become obsolete afterward. This scenario is common for products with uncertain demand, where leftover stock has no value at the end of the period. The challenge is to balance the risk of stockouts against the cost of excess inventory.

Example Scenario:

Consider a European automotive manufacturer deciding how many limited-edition car accessories to produce for a special promotional event. Each accessory sold yields a profit of €50, while unsold accessories incur a loss of €30 each. Demand is uncertain, with probabilities assigned to different demand levels:

- Demand Levels: 200, 400, 600, 800
- Probabilities: 0.2, 0.3, 0.4, 0.1

Calculating Expected Profit:

To determine the optimal production quantity, we calculate the expected profit for each potential production size by weighting the profit outcomes by their probabilities:

1. **Produce 200 Accessories:**
    - Expected Profit = $(10{,}000 \times 0.2 + 10{,}000 \times 0.3 + 10{,}000 \times 0.4 + 10{,}000 \times 0.1 = €10{,}000)$
2. **Produce 400 Accessories:**
    - Expected Profit = $(4{,}000 \times 0.2 + 20{,}000 \times 0.3 + 20{,}000 \times 0.4 + 20{,}000 \times 0.1 = €16{,}800)$
3. **Produce 600 Accessories:**
    - Expected Profit = $(-2{,}000 \times 0.2 + 14{,}000 \times 0.3 + 30{,}000 \times 0.4 + 30{,}000 \times 0.1 = €18{,}800)$
4. **Produce 800 Accessories:**
    - Expected Profit = $(-8{,}000 \times 0.2 + 8{,}000 \times 0.3 + 24{,}000 \times 0.4 + 40{,}000 \times 0.1 = €14{,}400)$

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The optimal production quantity is 600 accessories, yielding the highest expected profit of €18,800. This decision balances the potential profit from selling the accessories against the risk and cost of having unsold inventory.

Importance of the Probabilistic Approach:

This approach highlights the importance of incorporating probabilistic demand forecasts into inventory decisions. By considering the likelihood of different demand scenarios, the manufacturer can make more informed decisions that optimize expected profits while minimizing the risks associated with overproduction or stockouts.

Application in the Automotive Industry:

In the automotive industry, where demand for certain products can be highly variable and influenced by factors such as market trends and consumer preferences, using a probabilistic approach like the news vendor model can be particularly beneficial. It allows manufacturers to strategically plan production quantities for limited-edition or seasonal products, ensuring they capitalize on market opportunities without incurring unnecessary costs from excess inventory.

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When Should an Order Be Placed? The Timing Decision

In inventory management, determining the optimal timing for placing a replenishment order is crucial, especially when orders do not arrive instantaneously. Initially, if demand is steady and predictable, the decision is straightforward: place an order as soon as the stock level reaches zero to prevent stock-outs. However, in reality, there is often a lead time between placing an order and its arrival, necessitating a more strategic approach.

Re-Order Point (ROP) and Re-Order Level (ROL):

When there is a lead time, the re-order point (ROP) is calculated as the point at which stock will fall to zero minus the order lead time. Alternatively, it can be defined in terms of the inventory level at which a replenishment order needs to be placed, known as the re-order level (ROL). For example, if the lead time is two weeks and the ROL is 200 items, an order should be placed when inventory reaches 200 items to ensure it arrives before stock runs out.

Variability in Demand and Lead Time:

In most cases, both demand and lead time are not perfectly predictable, leading to variability in inventory levels. This requires placing replenishment orders earlier than in a deterministic scenario, resulting in buffer or safety stock. The safety stock acts as a cushion to accommodate fluctuations in demand and lead time, ensuring that stock-outs are minimized.

Setting Safety Stock Levels:

The key to setting safety stock levels is understanding the probability distribution of lead-time usage, which combines variations in lead time and demand rate. If safety stock is set too low, shortages will occur frequently. Conversely, setting it too high eliminates the risk of stock-outs but increases holding costs. Typically, safety stock is set to achieve a predetermined probability that stock-outs will not occur.

Example of Lead-Time Usage:

Consider a scenario where the first replenishment order arrives after a lead time of (t_1), with a demand rate of (d_1). The second order takes longer, (t_2), with a higher demand rate, (d_2). The third order cycle may show various inventory profiles depending on different conditions of lead-time usage and demand rate. By analyzing these scenarios, businesses can determine the appropriate safety stock level to maintain a balance between service level and inventory costs.

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Continuous and Periodic Review in Inventory Management

In inventory management, determining when to place replenishment orders can be approached through continuous or periodic review systems. Each method has its own advantages and trade-offs, depending on the operational environment and the nature of demand.

Continuous Review Approach:

The continuous review approach involves constantly monitoring the stock level of each item and placing an order as soon as the stock reaches its re-order level. This method ensures that the order size (Q) remains constant, typically set at the optimum economic order quantity (EOQ). The main advantage of this approach is that it allows for precise control over inventory levels, minimizing the risk of stock-outs. However, it can be time-consuming, especially in environments with frequent stock withdrawals. In modern settings with computerized inventory systems, this is less of an issue unless there are inaccuracies in the records.

Periodic Review Approach:

The periodic review approach simplifies the process by placing orders at fixed, regular intervals rather than at a specific re-order level. For example, inventory levels might be reviewed at the end of each month, and orders are placed to replenish stock to a predetermined maximum level (Qm). This method sacrifices the use of a fixed order quantity, potentially leading to less optimal inventory levels. However, it reduces the need for constant monitoring, making it easier to manage in environments with many items.

Calculating the Time Interval:

The time interval between orders in a periodic review system is often calculated using the EOQ model, even though demand is uncertain. For instance, if the annual demand for an item is 2,000 units, the cost of placing an order is €25, and the holding cost is €0.50 per item per year, the EOQ is calculated as follows:

$$[\ \mathrm{EOQ} = \sqrt{\frac{2\times 2{,}000\times 25}{0.50}} = 447]$$

The optimal time interval ((t_f)) between orders is:

$$[\ t_f = \frac{\mathrm{EOQ}}{D} = \frac{447}{2{,}000}\ \text{years} = 2.68\ \text{months}\ ]$$

Despite the assumption of constant demand, uncertainties in demand and lead time are accounted for by setting Qm to cover the desired probability of stock-outs during the period $(t_f + \text{lead time})$.

Two-Bin and Three-Bin Systems:

In continuous review systems, keeping track of inventory levels is crucial, especially when managing a large number of items. Simple methods like the two-bin and three-bin systems can help signal when the re-order point has been reached.

- **Two-Bin System:** This system involves using two bins to manage inventory. The first bin contains the working stock, while the second bin holds the re-order point quantity plus the safety stock. As items are used from the first bin, the second bin remains untouched until the first bin is empty. When the first bin is depleted,

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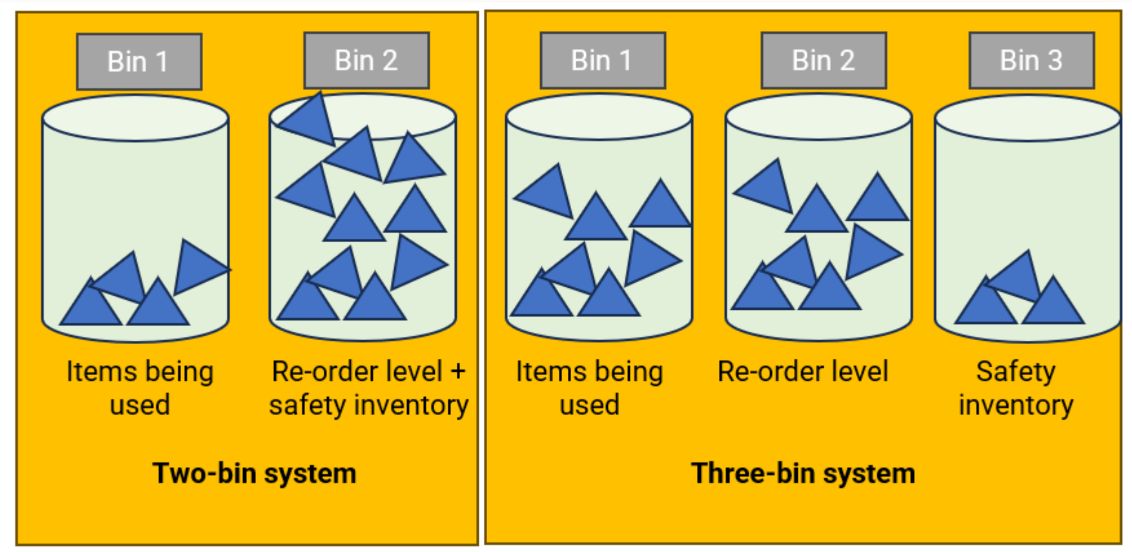
it signals that it's time to place a new order for the re-order quantity. This system is straightforward and effective for ensuring timely reordering.

- **Three-Bin System:** In some cases, a third bin is added to store the safety inventory separately. This setup makes it clear when demand exceeds expectations, as the third bin is only used when the safety stock is needed. The three-bin system provides an additional layer of visibility into inventory levels and helps manage unexpected demand surges.

These bin systems do not necessarily require physical bins. In retail operations, for example, the second "bin" quantity might be stored upside-down behind or under the first "bin" quantity. Orders are then placed when the upside-down items are reached, providing a simple yet effective visual cue for reordering.



Controlling Inventory: Strategies and Systems

Managing inventory effectively involves more than just applying theoretical models, as real-world stock management is often far more complex. With thousands of items in stock, sourced from numerous suppliers, and serving potentially tens of thousands of customers, inventory control becomes a dynamic and intricate task. To manage this complexity, operations managers need to focus on two key strategies:

1. **Prioritization of Stocked Items:** Managers must differentiate between various stocked items to apply the appropriate level of control based on each item's significance. This means identifying which items are critical to operations and require more stringent monitoring and control, versus those that are less critical and can be managed with less oversight.
2. **Investment in Information Systems:** Implementing a robust information-processing system is crucial for handling the specific inventory control needs of the organization. Such systems can help track inventory levels, manage supplier relationships, forecast demand, and streamline the ordering process, thereby enhancing the overall efficiency and effectiveness of inventory management.

By focusing on these strategies, operations managers can better navigate the complexities of inventory control and ensure that stock levels are optimized to meet customer demand while minimizing costs.

Inventory Prioritization – The ABC System

In any inventory system with multiple stocked items, certain items hold more significance for the organization than others. For instance, some items may have a high usage rate, meaning that running out of them could lead to customer dissatisfaction. Other items might be of high value, making it costly to maintain excessive inventory levels. A common method to differentiate between stock items is to rank them based on their usage value, which is calculated by multiplying their usage rate by their individual value. Items with a high usage value require more stringent control, while those with lower usage values can be managed with less intensity.

Typically, a small percentage of the total inventory items will account for a large portion of the total usage value, a concept known as the Pareto principle or the 80/20 rule. This principle suggests that around 80% of an operation's sales are generated by just 20% of the stocked item types. The Pareto principle is also applied in other areas of operations management. In inventory management, it helps classify items based on their usage value:

- **Class A Items:** These are the top 20% of items with high usage value, accounting for approximately 80% of the total usage value. They require the most careful management.
- **Class B Items:** These items have a medium usage value, typically representing the next 30% of items, and account for about 10% of the total usage value.
- **Class C Items:** These are low usage value items, which, although they make up about 50% of the total item types in stock, only contribute to around 10% of the total usage value.

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ABC inventory control enables managers to focus their efforts on managing the most critical stock items effectively.

While annual usage and value are the most common criteria for determining stock classification, other factors can also influence the classification of an item:

- **Impact of Stock-Out:** Items that could cause significant delays or disruptions to operations or customers if unavailable might be given higher priority.
- **Supply Uncertainty:** Items with unpredictable or inconsistent supply, even if low in value, may require more attention.
- **Risk of Obsolescence or Deterioration:** Items at risk of losing value due to becoming obsolete or deteriorating may need additional monitoring and care.

Some more sophisticated stock classification systems incorporate these criteria by assigning an A, B, C classification for each factor. For instance, a part might be categorized as A/B/A, indicating it is a Class A item by value, a Class B item by the consequence of stock-out, and a Class A item by obsolescence risk.

Example in the Context of European Automotive Industry: EuroAuto Parts Distributor

EuroAuto, a European automotive parts distributor, manages 20 different components in stock, each varying in annual usage and cost per item. The distributor has ranked these stock items based on their annual usage value, with the total annual usage value reaching €5,569,000. This allows for the calculation of each item's annual usage value as a percentage of the total, leading to a cumulative total of the usage value. The distributor can then plot the cumulative percentage of all stocked items against the cumulative percentage of their value. For example, the part with stock number A/703 is the highest-value part, accounting for 25.14% of the total inventory value, yet it represents only 5% of the total number of items stocked. This item, along with the next highest-value item (D/012), comprises only 10% of the total number of items stocked but accounts for 47.37% of the stock's value.

The distributor has classified the first four part numbers (20% of the range) as Class A items, which will be closely and frequently monitored in terms of usage and ordering. Small improvements in order quantities or safety stocks for these items could lead to significant savings. The next six part numbers, C/375 through A/138 (30% of the range), are categorized as Class B items, with slightly less effort devoted to their control. All other items are classified as Class C items, whose stocking policy is reviewed only occasionally.

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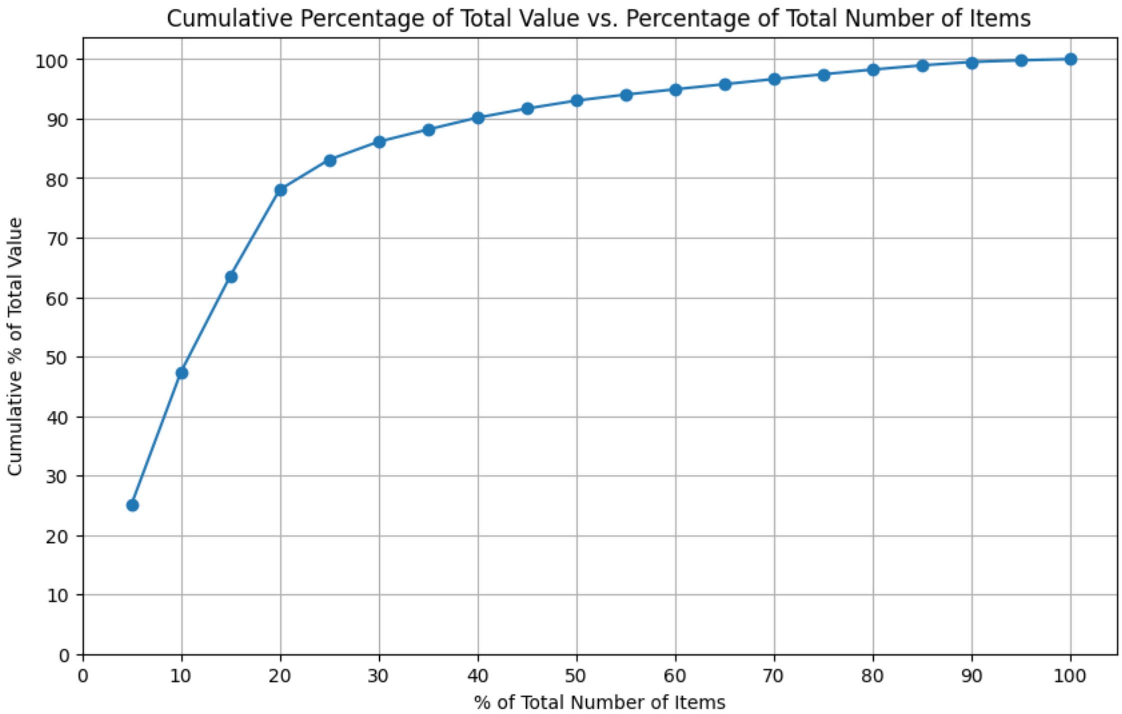
Stock no.	Usage (items/year)	Cost (€/item)	Usage value (€000/year)	% of total value	Cumulative of total value
A/703	700	20.00	1400	25.14	25.14
D/012	450	2.75	1238	22.23	47.37
A/135	1	0.90	900	16.16	63.53
C/732	95	8.50	808	14.51	78.04
C/375	520	0.54	281	5.05	83.09
A/500	73	2.30	168	3.02	86.11
D/111	520	0.22	114	2.05	88.16
D/231	170	0.65	111	1.99	90.15
E/781	250	0.34	85	1.53	91.68
A/138	250	0.30	75	1.34	93.02
D/175	400	0.14	56	1.01	94.03
E/001	80	0.63	50	0.89	94.92
C/150	230	0.21	48	0.86	95.78
F/030	400	0.12	48	0.86	96.64
D/703	500	0.09	45	0.81	97.45
D/535	50	0.88	44	0.79	98.24
C/541	70	0.57	40	0.71	98.95
A/260	50	0.64	32	0.57	99.52
B/141	50	0.32	16	0.28	99.80
D/021	20	0.50	10	0.20	100.00
Total			5,569	10000	



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Evaluating Inventory

In our ABC classification example, we utilized the financial worth of each item's annual consumption as a metric for inventory usage. This monetary value can also serve as a gauge for the total inventory level at any given moment. This involves counting the quantity of each item in stock, multiplying it by its cost (typically the purchase price), and then adding up the values of all stored items. This approach provides a useful measure of the financial commitment an operation has in its inventories, but it doesn't indicate how significant that investment is compared to the overall throughput of the operation. To assess this, we need to compare the total stock quantity against its usage rate.

There are two methods to achieve this. The first method calculates how long the inventory would last under normal demand conditions if it were not restocked. This is often referred to as the stock's "cover period," which could be expressed in weeks, days, months, or years. The second method determines how frequently the stock is completely used up within a specific timeframe, typically a year. This is known as the stock turnover rate, or simply "stock turn," and it is the inverse of the stock cover period mentioned earlier.

EuroAuto Parts Distributor

EuroAuto, a European automotive parts distributor, maintains an inventory of three types of automotive components: Component A, Component B, and Component C. The current stock levels are 500 units of Component A, 300 units of Component B, and 200 units of Component C. The table below outlines the quantity of each component in stock, their cost per unit, and the annual demand for each component.

Item	Average number in stock	Cost per item (€)	Annual demand
Component A	500	3.00	2000
Component B	300	4.00	1500
Component C	200	5.00	1000

Total Value of Stock

The total value of the stock is calculated as follows:

$$\text{Total value} = \sum(average\ cost\ level\ x\ \ cost\ per\ item) = (500 \times 3) + (300 \times 4) + (200 \times 5) = €3{,}700$$

Stock Cover

The stock cover provided by each component, assuming 50 sales weeks per year, is calculated as:

- Component A Stock Cover:
  $$\frac{\text{Stock}}{\text{Demand}} = \frac{500}{2{,}000} \times 50 = 12.5 \text{ weeks}$$
- Component B Stock Cover:
  $$\frac{\text{Stock}}{\text{Demand}} = \frac{300}{1{,}500} \times 50 = 10 \text{ weeks}$$

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- Component C Stock Cover:
$\frac{\text{Stock}}{\text{Demand}} = \frac{200}{1{,}000} \times 50 = 10 \text{ weeks}$

Stock Turn
The stock turn for each component is calculated as:

- Component A Stock Turn:
$\frac{\text{Demand}}{\text{Stock}} = \frac{2{,}000}{500} = 4 \text{ times/year}$
- Component B Stock Turn:

  $\frac{\text{Demand}}{\text{Stock}} = \frac{1{,}500}{300} = 5 \text{ times/year}$
- Component C Stock Turn:
$\frac{\text{Demand}}{\text{Stock}} = \frac{1{,}000}{200} = 5 \text{ times/year}$

Average Stock Cover and Stock Turn
To determine the average stock cover or stock turn for the entire inventory, we weight the individual measures by their demand levels as a proportion of the total demand (4,500 units). The calculations are as follows:

- **Average Stock Cover:**
$$\left(12{,}5 \times \frac{2{,}000}{4{,}500}\right) + \left(10 \times \frac{1{,}500}{4{,}500}\right) + \left(10 \times \frac{1{,}000}{4{,}000}\right) = 11.11 \text{ times/year}$$
- **Average Stock Turn:**

$$\left(4 \times \frac{2{,}000}{4{,}500}\right) + \left(5 \times \frac{1{,}500}{4{,}500}\right) + \left(5 \times \frac{1{,}000}{4{,}500}\right) = 4.56 \text{ times/year}$$

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