Garment Production Management

Week 12

Inventory management

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Recap-previous week

- Capacity and workforce planning concepts
- Capacity planning strategies
- Workforce planning

Lecture Learning Outcomes

1. Understand inventory management concepts
2. Analyze types of inventory
3. Evaluate inventory management models

Session outline

- Inventory management concepts
- Types of inventory
- Inventory costs
- Inventory planning and control models

Introduction to inventory management

- Inventory management is the structural backbone that keeps capacity and workforce planning grounded
- Capacity planning tells what you *can* produce
- inventory management tells what you *should* hold
  - To keep production flowing efficiently
  - Avoid locking up too much working capital

Types of inventory

- **Inventory can be classified based on:**
  1. Inventory stage in production cycle
     - Raw Materials
     - Work-in-Process (WIP)
     - Finished Goods
     - Maintenance, Repair, and Operations (MRO)
  2. Functional purpose within the facility
     - Cycle stock
     - Safety stock
     - Pipeline (transit) inventory

Types of inventory

Inventory stage in production cycle

- Raw Materials:
  - ❖ Unprocessed items or components waiting to enter the production line
  - ❖ It keeps optimal balance protects from supply chain delays
  - ❖ It ties up initial capital
- Work-in-Process (WIP):
  - Goods currently on the production floor in various stages of completion
  - High WIP is usually a red flag indicating line imbalances, bottlenecks, or poor capacity coordination

Types of inventory

Inventory stage in production cycle

- Finished Goods:
  - Completed products ready for distribution or sale
- Maintenance, repair, and operations (MRO):
  - Supplies required to keep the facility running
    - ❖ lubricants, machine spare parts, needles, or tools
  - Not part of the final product but prevent from downtime

Types of inventory

Functional purpose within the facility

- Cycle stock: The inventory expected to be used during a given period between routine replenishments
- Safety stock: Buffer stock held to protect against uncertainties in demand or lead time
- Pipeline (transit) inventory: Inventory that has been ordered or shipped but has not yet arrived at the facility

Inventory cost

- Every item held on a shelf comes with a hidden price tag
- Effective control models balance these three primary, competing cost categories
- Total inventory cost is the sum of three components
  1. Holding costs (carrying costs)
  2. Ordering costs (Set up costs)
  3. Shortage costs (Stockout costs)

Inventory cost

Holding (carrying) cost (H or Ch):

- The cost of keeping inventory on hand over time
- E.g. warehouse space rental, utilities, insurance, security, material handling,
- Opportunity cost: the return could have been earned if that capital was invested elsewhere
- It also includes obsolescence and spoilage
  - E.g. fabric degrading, items going out of style
- Usually expressed as a percentage of the inventory value per year (typically 15–25%)

Inventory cost

Ordering or set up cost (S or Co)

- The fixed cost incurred every time you place an order with a supplier or change over a production line for a new run
- E.g. administrative paperwork, shipping fees, inspection labor, and machine downtime during changeovers

Shortage (Stockout) Costs

- The cost incurred when demand cannot be met because inventory is depleted
- E.g. immediate lost sales, expedited shipping fees to rush an emergency order, and the long-term erosion of customer goodwill

Objectives of inventory management

- Ensuring operational continuity
  - Continuous production flow
  - Decoupling production stages
  - Protecting against uncertainty
- Optimizing financial performance
  - Minimizing capital tied up
  - Reducing carrying costs
  - Achieving economies of scale
- Customer service & market responsiveness
  - Order fulfillment speed
  - Maintaining service levels
  - Smoothing seasonal fluctuations

Inventory management models

Economic Order Quantity (EOQ)

- An optimal batch size that minimizes the total ordering and holding inventory cost
- Order too little, and pay high per-unit ordering costs too often
- Order too much, and pay high storage and carrying costs
- An economic order quantity (EOQ) finds the balance
- Only applied for non-seasonal basic items with stable, predictable demand
- E.g. plain white t-shirts, black socks, basic undergarments, uniform fabrics
- Not useful for trendy or seasonal fashion because it assumes static demand

Inventory planning & control models

- Inventory planning and control models help to minimize total costs
- Operations managers use mathematical models to answer classic questions
  - When to order? (Reorder level or point or time)
  - How much to order? (Quantity)
- **Economic Order Quantity (EOQ) Model**
  - The classic EOQ model finds the perfect sweet spot where annual holding costs exactly equal annual ordering costs, minimizing the total cost curve

$$EOQ = \sqrt{\frac{2DS}{H}}$$

D= Annual demand(units); S=ordering or setup cist per order; H=Holding cost per unit per year

Inventory planning & control models

- **Economic Production Quantity (EPQ) Model**
  - Also known as the **Production Order Quantity** model
  - Adapts the EOQ for situations where inventory is consumed while it is still being produced on a line, rather than arriving in one complete bulk shipment

$$EPQ = \sqrt{\frac{2DS}{H(1-\frac{d}{p})}}$$

D= Annual demand(units); S=ordering or setup cist per order; H=Holding cost per unit per year

p= daily production rate; d=daily demand rate (p>d)

Inventory planning & control models

- **Continuous review (Q) system**
  - In a Q system, inventory levels are tracked continuously
  - When physical stock drops to a predetermined reorder point (ROP), a fixed order quantity (Q, often calculated via EOQ) is automatically triggered
  - ROP=(d*L)+SS

d= average daily demand; L=lead time in days; SS=safety stock (calculated based on desired service level and demand variability)

Inventory management models

ABC Analysis (Pareto-Based)

- Not all inventory is equal and the model treat each class differently
- A-items are small fraction of stock keeping units (SKUs) e.g. 20% but generates 80% revenue
- B-items moves steadily and C-items are slow, cheap, or both
- Applicable for large product catalogs with hundreds or thousands of SKUs
- Decide items priority (e.g. premium storage locations, frequent cycle counts, and transferred to back corners)
- Essential for prioritizing management attention when resources are limited.

Inventory control

- **Selective Inventory Control: ABC Analysis**
  - Not all inventory items deserve the same amount of managerial focus
  - ABC Analysis applies Pareto's 80/20 rule to classify inventory based on annual dollar usage
  - Class A items (tight control):
    - ~ 15–20% of physical items
    - Represent **70–80%** of total inventory value
    - Require continuous review, precise records, and frequent supplier collaboration

Inventory control

- **Selective Inventory Control: ABC Analysis**
  - Class B items (Moderate control):
    - ~30% of items, representing **15–20%** of value
    - Managed with periodic tracking and standard models
  - Class C items (Loose control):
    - ~50% of items, but only **5–10%** of value
    - Kept in bulk (e.g., basic fasteners, bulk chemicals, sewing needles)
    - Managed with simple systems like a Two-Bin system, where reaching the second bin triggers a reorder.

Inventory management models

The Newsboy Model (Single-Period):

- It calculates the optimal order quantity for a product with uncertain demand and no second chance to reorder
- Applicable for seasonal collections (e.g., winter jackets, summer dresses)
- holiday-specific apparel (Christmas sweaters, Halloween costumes)
- Ultra-trendy items that will be irrelevant next month
- Used when leftover inventory has little to no residual value

Inventory management models

Newsvendor (single-period) model

- Best for seasonal or trendy fashion items (e.g., holiday sweater)
- Balances risk of overstocking vs. understocking for one selling season
- Determines optimal order quantity under uncertain demand
- Minimizes expected total cost of leftovers and lost sales
- Widely used for fast fashion collections with short lifecycles

AI & SMART technology driven models

- Markov Decision Process (MDP) is used for color selection
    - Learns consumer color preference shifts
- Genetic Algorithm (GA) optimizes order quantities under variable raw material costs
- Reduces total inventory costs by using evolutionary search
- Heuristic models combine demand forecasting, assortment planning, and capacity constraints
- Dynamic pricing models adjust prices in real-time based on inventory levels and demand

Industry implemented strategies

- Seller Just-in-Time (SJIT): Suppliers hold inventory until order placed (e.g., Myntra)
- Reduces warehousing costs and dead stock risk for e-commerce platforms
- Quick Response (QR): Small initial batches, rapid replenishment of winning designs
- Zara pioneered QR – minimizes large forecasting errors
- Fashion ERP software automates reorder points and centralizes real-time analytics

How to choose the right model

- Seasonal/trendy items with high uncertainty → Newsvendor Model
- Managing many colors/SKUs across channels → MDP or Software-Driven Management
- High warehousing costs and slow turns → SJIT or Quick Response
- Fluctuating raw material costs → Genetic Algorithm Model
- Basic staples with predictable demand → Economic Order Quantity (EOQ)

Inventory management models

- Garment inventory faces short product life cycles and seasonal demand
- High demand volatility due to changing fashion trends
- Balancing overstock and understock costs is the main challenge
- Multiple SKUs (colors, sizes) across distributed locations
- Technologies including AI, IoT, RFID enables real-time inventory visibility

Assumptions in traditional models

- Demand is assumed to be known and constant (not true for fashion items)
- Lead times are fixed and reliable (often disrupted in global garment supply chains)
- No quantity discounts or price variations (contradicts bulk fabric purchasing)
- Infinite or unlimited production capacity (unrealistic for seasonal peaks)
- No stockouts or backorders allowed (fashion brands deliberately create scarcity)

Violations of assumptions

Real world cases in garment industry

- Demand is highly seasonal, trend-driven, and unpredictable
- Lead times vary due to fabric delays, shipping disruptions, customs holds
- Bulk fabric discounts incentivize over-ordering raw materials
- Production capacity is limited by sewing line availability and labor
- Stockouts are common and sometimes scarcity is created intentionally

Adjusting inventory models to realities

- Use probabilistic demand forecasts instead of fixed numbers
- Build safety stock buffers for long and variable lead times
- Apply quantity discount models (EOQ with price breaks) for fabric purchases
- Implement capacity-constrained production planning (finite loading)
- Accept calculated stockouts for high-margin trendy items using News vendor logic

Inventory management models

First-In, First-Out (FIFO)

- The oldest stock or the first to arrive must be the first to sell
- It is less a model and more a fundamental discipline
- Applicable for every garment business without exception
- Especially critical for trend-sensitive apparel, seasonal collections, and any product with a perceived expiry date (e.g., formal wear that goes out of style)
- Essential for physical retail racks and warehouse bin organization

Inventory management models

Just-in-Time (JIT) / Seller-JIT

- Produce or ship nothing until a customer actually places an order
- This reactive model transforms inventory from an asset you hold into a product you chase
- Warehouse becomes a pass-through point rather than a storage facility
- Applicable for E-commerce fulfillment centers and marketplace partnerships (e.g., Sellers ship only after an order is received)
- Test-and-reorder strategies for new designs where demand is validated with a small initial batch before committing to larger production

Inventory management models

Multi-Echelon Inventory Optimization

- Inventory exists at multiple nodes in the supply chain network (supplier, in transit, central warehouse, at regional distribution centers, and finally at retail stores)
- Optimizing each node separately creates inefficiency hence optimize the entire network simultaneously
- This model is applicable for :
  - Omnichannel brands selling both online and through physical stores
  - Large retail chains with multiple warehouses and store locations
  - Any business where a single product served from multiple sources (e.g., ship-from-store, buy-online-pick-up-in-store)

Inventory management models

Dynamic pricing & inventory model

- Price and inventory are not separate decisions
- Optimal price should drop
- This model sets the price path (e.g., full price → 20% off → 50% off → clearance) with replenishment decisions
- Maximizing profit from short lifecycle products where time destroys value
- Use it for seasonal fashion, end-of-season clearance planning pricing decisions
- Decide when to mark down and by how much before the product becomes worthless

Inventory management models

Lean / Agile (Responsive) Inventory

- Speed is more important to efficiency
- Do not place one large order months in advance rather small, frequent orders and replenish based on what is actually selling
- Requires flexible suppliers capable to deliver in shorter lead times and smaller batch sizes
- Applicable for fast-fashion retailers (Zara, Shein) streetwear brands with weekly drops
- Essential for high demand volatility and cost of being wrong (dead stock) is higher than cost of being less efficient

Inventory management models

Forecast-driven models (with AI/ML)

- Historical sales data, when fed into machine learning algorithms, can reveal patterns invisible to the human eye
- Seasonality, weather impacts, social media trends, even the effect of a competitor's promotion
- These models predict future demand at the granular level of size, color, and location
- Applicable for brands of any size seeking to focus on data-driven decisions
- Valuable for companies with deep sales history and multiple channels
- The output feeds directly into replenishment automation systems

Inventory management models

Stochastic (probabilistic) models:

- The future is not a single number rather a range of possibilities
- Demand might be 100 or 300 units
- Lead times might be 2 weeks or 6 weeks
- The model accepts randomness as a fact and uses probability distributions to set safety stock levels and reorder points accordingly
- Applicable in high-uncertainty environments:
  - Luxury goods with unpredictable hype driven by influencer posts
  - Supply chains exposed to disruptions (port delays, raw material shortages)
  - Any scenario where average demand is a misleading and dangerous metrics

Inventory management models

Monte Carlo Simulation Models

- Run thousands of what-if scenarios in a computer
- E.g. what if demand is 30% higher than expected? What if the shipment is delayed by three weeks? The output is not a single answer but a probability distribution of outcomes (e.g., 85% chance we sell out, 15% chance we have dead stock)
- Applicable for strategic planning for high-stakes decisions
  - Launching a completely new product line with no historical data
  - Placing large pre-season buys for a major collection
  - Evaluating the financial risk of different ordering strategies before committing real money

Strategies of inventory management

To manage this complexity, successful retailers and manufacturers use a combination of strategic approaches:

- **Real-Time, Omnichannel Tracking**
  - Investing in a centralized system that syncs inventory across physical stores, online shops, and warehouses is foundational
  - Ensures stock levels are accurate, prevent overselling and allowing features like "buy online, return in-store," which improves the customer experience.
  - Barcode scanning automates this tracking, reducing the manual errors common with paper systems

Strategies of inventory management

- **Smart stock control (ABC Analysis & FIFO)**
  - ABC Analysis helps prioritize items based on their sales value
  - FIFO (First-In, First-Out) is critical for a trend-driven industry
- **Data-driven forecasting and automation**
  - AI-driven demand forecasting is used to analyze past sales and current trends
  - Helps predict demand at the specific size and color level

Strategies of inventory management

Optimize warehouse layout

- Organize space using hierarchical categorization (style > color > size) and place high-velocity items near packing stations
- For premium goods, consider hanging storage to preserve garment quality and reduce handling time

Leverage demand forecasting

- Analyze past sales data at the variant level (e.g., specific size/color combinations), not just top-line product categories
- Avoids ordering equal quantities across all sizes while sales are skewed towards some sizes (e.g. M and L)

Strategies of inventory management

Use automation for replenishment

- Automated systems can generate purchase orders based on predefined reorder point
- Ensures popular items are restocked proactively without manual intervention
- It reduces the risk of both stockouts and excess inventory

Strengthen supplier relationships

- Develop flexible partnerships that allow for shorter, more frequent orders
- It is a test and reorder strategy
- It allows to place a small initial buy, measure sales velocity, and quickly reorder what is selling best
- It reduce exposure to dead stock

Strategies of inventory management

Optimize the returns process

- Speed is everything in reverse logistics
- A returned item should be quickly inspected, graded, and either restocked, marked down, or donated
- Implement an exchange-first return flow to retain revenue and move returned inventory back into sellable status as fast as possible

Benefits of inventory management for garment industry

- From Cost Center to Profit Driver
- Inventory is cash in physical form – manage it or lose it
- Fashion faces unique pressures (perishable trends, long supply chains, thin margins)
- Mastering inventory management separates profitable brands from failed ones
- Responsible functions are Finance, Operations, and Merchandising teams

Benefits of inventory management for garment industry

- It is a Make-or-Break for garment business
- The high-stakes trade-off
  - Stockouts (too little): Lost sales, angry customers, wasted marketing spend
  - Impact: Up to 30% of revenue lost on bestselling items
  - Overstock (Too Much): Forced markdowns, high holding costs, cash tied up
  - Impact: Destroys gross margins by 10-40% per season
- Having exactly the right product, in the right place, at the right time
- A 10% improvement in inventory turnover can boost net profit by 2-5%

Benefits of inventory management for garment industry

Protecting Profitability & Cash Flow

- Inventory as a Financial Asset
- Cash conversion cycle (CCC): Inventory management directly controls how long cash is trapped
  - Longer cycle = more financing needs, less liquidity.
- Markdown Prevention: Better forecasting reduces the need for deep discounts.
  - In practice over $70-140 billion in unsold stock is discounted or destroyed annually
- Holding cost reduction: Lower inventory levels reduce warehouse rent, insurance, and labor
- Supplier payment health: Selling stock faster frees cash to pay suppliers on time for better terms

Benefits of inventory management for garment industry

Managing trend Perishability & Brand Value

- Unique risk factors in garment businesses are:
  - Trend velocity: A hot style can become obsolete in 4-6 weeks (fast fashion) or one season (contemporary)
  - Seasonality: Unsold winter coats lose 50-70% of value by March
  - Brand protection:
    - Luxury brands: Overstock forces discount outlets, destroying exclusivity
    - Sustainable brands: Excess inventory contradicts eco-promises, causing backlash
    - Fast fashion: Stockouts break the promise of new arrivals
  - Compliance risk: New EU laws ban destroying unsold textiles – poor management becomes illegal

Benefits of inventory management for garment industry

Strategic Levers & Best Practices

How inventory management helps success?

- Demand Forecasting: Use data & AI to predict sales, not gut feeling
- Agile Replenishment: Small batch production + frequent reorders vs. one massive order
- Omnichannel Visibility: One real-time view of stock across stores, warehouses, and online
- Slow Fashion Models: Made-to-order, pre-orders, or capsule drops to eliminate overproduction risk
- Key Metric to Track: Inventory turnover ratio = COGS ÷ Average Inventory (Higher = healthier)
- Final Takeaway: Treat inventory as a dynamic, perishable asset – not static storage.

Automation and AI in inventory management

Automated storage and retrieval systems (AS/RS):

- These robotic systems can reduce human picking tasks by **40% to 70%**
- They allow for vertical storage and complex retrieval logic
- Enables strategies like **Last-In-First-Out (LIFO)** for flash sales or pulling specific batches for quality control

AI & Machine Learning:

- Artificial intelligence can analyze vast datasets to:
  - Predict demand with higher accuracy
  - Dynamically adjust pricing to move slow inventory
  - Suggest optimal inventory allocation across stores to maximize sell-through rates

Benefit of automation and AI in inventory management

Effective inventory management in the garment industry is about

- Balancing the art of fashion with the science of data
- Encourage proactive processes than reactive approach for inventory adjustment
- Technology-driven strategies can:
  - Reduce waste
  - Delight customers
  - Make inventory strategic asset than a liability

Summary

- Holding costs, ordering costs, and shortage costs must be balanced to reduce total inventory cost
- Match the inventory management model to the product type
  - Use EOQ for stable basics (plain tees, socks)
  - Newsboy for seasonal/trendy items,
  - JIT for e-commerce and test-and-reorder strategies
- Prioritize using ABC Analysis for different value inventories
- Enable inventory management responsiveness with technology
- Balance the art of fashion with the science of data
- Effective inventory management turns inventory from a liability into a strategic asset

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Thank You !

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