INVENTORY MANAGEMENT MODELS

A Comprehensive Study Guide

When and Why to Use Each Model

Chapter 20: Inventory Management
Operations and Supply Chain Management

Quiz 2 Preparation Material

Introduction: Why Inventory Models Matter

Inventory management is one of the most critical operational decisions a company makes. Choosing the wrong model can mean millions of dollars in wasted stock or lost sales. In a job interview, you need to be able to explain not just what each model is, but when and why a company would use it. This guide is designed to give you that understanding.

Every inventory decision comes down to two fundamental questions: (1) When should an order be placed? and (2) How large should the order be? The models in this guide answer these questions differently depending on the business situation.

The Big Picture: How to Choose a Model

Is this a one-time purchase or ongoing replenishment? If one-time, use a Single-Period Model.

If ongoing: Can you continuously monitor inventory levels? If yes, consider a Fixed-Order Quantity (Q) Model.

If you review inventory on a schedule (weekly, monthly), use a Fixed-Time Period (P) Model.

Does your supplier offer quantity discounts? Layer on a Price-Break Model.

Which items deserve the most attention? Use ABC Classification to prioritize.

1. Single-Period Inventory Models (The Newsvendor Problem)

What Is It?

A single-period model is used when you are making a one-time purchasing decision for an item that cannot be sold at full price after the selling period ends. You place one order before the season, and there is no opportunity for replenishment. This is sometimes called the "newsvendor problem" because it mirrors the decision a newspaper vendor makes each morning: order too many papers and you waste money on unsold copies; order too few and you lose potential profit.

When to Use It

Use a single-period model whenever all of the following conditions are true:

- You are placing a single order before a selling season (no replenishment).
- Unsold items lose most or all of their value after the period (perishable or time-sensitive).
- You must balance the risk of ordering too many (overage cost) versus too few (underage cost).

Key Costs

Underage cost (Cu): The cost per unit of demand you underestimated. This is typically lost profit: Revenue per unit minus Cost per unit.

Overage cost (Co): The cost per unit of demand you overestimated. This is typically wasted investment: Cost per unit minus Salvage value per unit.

The Core Formula

Service Level = Cu / (Cu + Co)

This tells you the probability your stocking quantity should cover. A higher service level means stocking more to avoid shortages.

Continuous Demand vs. Discrete Demand

Within the single-period model, the approach you use depends on the nature of the demand data:

Continuous Demand

Use this when demand can be described by a smooth probability distribution (typically a normal distribution). Demand could theoretically be any value within a range, and you have enough historical data or expertise to estimate a mean and standard deviation.

Solution Steps: (1) Calculate Cu and Co. (2) Compute the service level = Cu / (Cu + Co). (3) Find the Z-value from the normal distribution corresponding to that service level. (4) Calculate optimal order quantity: $Q^* = \mu + Z \times \sigma$.

Discrete Demand

Use this when demand comes in specific, countable increments and you have a probability distribution for each possible demand level. This is common when dealing with small quantities or when historical data gives you exact probabilities for specific demand values.

Solution Steps: (1) Calculate Cu and Co. (2) Compute the service level = Cu / (Cu + Co). (3) Build a cumulative probability table. (4) Find Q* where the cumulative probability equals or first exceeds the service level.

Feature	Continuous Demand	Discrete Demand
Demand pattern	Any value in a range (e.g., 85.3 units)	Specific whole numbers (e.g., 0, 1, 2, 3...)
Distribution	Normal distribution (μ, σ)	Probability table for each value
Typical data source	Large sample of historical data	Small sample or expert judgment
Solution method	Z-table / NORMSINV	Cumulative probability table
Formula for Q*	Q* = μ + Zσ	First Q where P(D ≤ Q) ≥ service level

Real-World Examples by Industry

Continuous Demand Examples

Retail – Zara (Fashion): Zara orders a seasonal clothing line before the season. Demand for a trendy jacket follows a roughly normal distribution based on past similar styles. Unsold jackets go to clearance at steep discounts. Zara uses a continuous single-period approach because demand data from thousands of stores approximates a smooth distribution.

Grocery – Whole Foods (Perishables): A Whole Foods store orders fresh strawberries each morning. Historical sales data shows demand is approximately normally distributed with a known mean and standard deviation. Unsold berries are discarded or donated at a loss. The continuous model determines the optimal daily order.

Media – Newspaper Publisher: The classic newsvendor: a newspaper prints copies before knowing exact demand. Based on years of circulation data, demand follows a normal curve. Unsold papers become worthless after the day. This is the textbook continuous demand example.

Events – Super Bowl Merchandise: The NFL orders commemorative Super Bowl merchandise for both teams before the game. After the game, losing-team merchandise has almost no domestic value. With large volumes and historical event data, demand can be modeled continuously.

Discrete Demand Examples

Airlines – Delta, United (Overbooking): Airlines routinely overbook flights because some passengers will not show up. Historical no-show data gives exact probabilities: P(0 no-shows) = 0.05, P(1 no-show) = 0.10, etc. The airline uses a discrete single-period model to decide exactly

how many extra seats to sell. The underage cost is an empty seat (lost revenue), and the overage cost is bumping a passenger (compensation + goodwill loss).

Hotels – Marriott (Overbooking): Marriott overbooks hotel rooms using similar logic. They track no-show rates as discrete probabilities and determine the optimal number of extra reservations to accept each night.

Bakery – Local Bakery (Custom Cakes): A small bakery decides how many specialty cakes to bake for a holiday weekend. Demand data is limited to a handful of observations: P(sell 5) = 0.20, P(sell 6) = 0.30, and so on. The discrete model finds the profit-maximizing quantity.

Retail – Concert T-Shirt Vendor: A vendor at a Taylor Swift concert must decide how many souvenir t-shirts to stock. They have data from past concerts showing discrete demand probabilities. Leftover shirts have minimal resale value.

Interview Tip: Continuous vs. Discrete

If an interviewer asks when to use continuous vs. discrete demand, explain: Use continuous when you have large-volume demand data that fits a bell curve (normal distribution). Use discrete when you have small-sample or count-based data with specific probabilities for each demand level. The underlying math differs, but the logic is the same: balance the cost of ordering too much against ordering too little.

2. Multi-Period Inventory Models

Multi-period models are used when an item will be purchased repeatedly and the goal is to maintain it in stock on an ongoing basis. Unlike single-period models, replenishment is possible and expected. There are two major types, and the key distinction is what triggers the order.

2A. Fixed-Order Quantity Models (Q-Model / EOQ Model)

In a fixed-order quantity model, you order the same quantity every time, but the timing of orders varies. An order is placed when inventory drops to a predetermined reorder point (R). This is an event-triggered, perpetual system—meaning you must continuously monitor inventory levels.

Stable Demand (Basic EOQ)

When demand is constant and predictable, you use the basic Economic Order Quantity (EOQ) model. The EOQ formula finds the order quantity that minimizes the total of ordering costs and holding costs.

Key Assumptions: Demand is known and constant over time. Lead time is constant. No quantity discounts. Ordering cost and holding cost are known and fixed. No stockouts allowed.

EOQ Formula

$$EOQ = \sqrt{(2DS / H)}$$

Where D = Annual demand, S = Setup/ordering cost per order, H = Annual holding cost per unit.

Reorder Point (R) = d × L (where d = average daily demand, L = lead time in days)

Average inventory = Q/2

Amazon Fulfillment Centers: For stable, high-volume items like AA batteries or bottled water, Amazon uses a system very similar to EOQ. Demand is predictable, lead times from suppliers are reliable, and automated warehouse systems continuously track inventory levels. When stock hits the reorder point, a fixed quantity is ordered.

Walmart – Staple Goods: For staple products like Tide detergent or Coca-Cola, Walmart's demand is extremely stable and predictable. Their sophisticated inventory systems continuously monitor levels and trigger replenishment orders of fixed quantities.

Toyota Manufacturing (Fasteners & Standard Parts): Toyota uses EOQ-type models for standard fasteners, bolts, and other commodity parts where demand is driven by a steady production schedule and consumption is highly predictable.

Unstable Demand (EOQ with Safety Stock)

When demand fluctuates or lead times are variable, you still use the EOQ for order quantity, but you add safety stock to the reorder point to buffer against uncertainty. The higher the desired service level, the more safety stock you carry.

Reorder Point with Safety Stock

$$R = \bar{d}L + z\sigma L$$

Where $\bar{d}L$ = average demand during lead time, z = number of standard deviations for desired service level, σL = standard deviation of demand during lead time.

The order quantity (EOQ) stays the same—only the reorder point changes to include safety stock.

Apple – iPhone Accessories: Demand for iPhone cases fluctuates based on new product launches, seasonal trends, and marketing campaigns. Apple's supply chain uses safety stock at distribution centers to ensure popular accessories remain available during demand spikes while still using EOQ-based ordering.

CVS Pharmacy – Cold Medicine: Demand for cold and flu medicine is seasonal and unpredictable. CVS uses safety stock to buffer against surges during flu season. Their inventory system continuously monitors stock and triggers orders when the reorder point (which includes safety stock) is reached.

Nike – Popular Shoe Models: Demand for trendy models like Air Jordans can spike unpredictably due to social media trends or celebrity endorsements. Nike's distribution centers maintain safety stock for high-variability items while using standard EOQ quantities for replenishment.

2B. Fixed-Time Period Models (P-Model / Periodic Review)

In a fixed-time period model, inventory is checked and orders are placed at regular, fixed intervals (e.g., every week, every month). The order quantity varies each period depending on how much inventory has been used since the last review. This is a time-triggered system.

P-Model Order Quantity

$$q = \bar{d}(T + L) + z\sigma(T+L) – I$$

Where T = review period, L = lead time, $\bar{d}$ = average demand rate, I = inventory on hand at review time.

Order enough to cover demand through the NEXT review period plus lead time, minus what you already have.

Key Difference from Q-Model: The P-model generally requires higher safety stock because there is risk of stockout during the entire review period plus lead time, whereas the Q-model only faces stockout risk during lead time.

Coca-Cola Route Deliveries: Coca-Cola delivery drivers visit convenience stores and restaurants on a fixed weekly schedule. During each visit, they check inventory levels and restock to bring inventory up to a target level. This is a classic P-model application because the vendor visit schedule determines when orders happen.

Vending Machine Operators: Vending companies service machines on predetermined schedules (e.g., every Tuesday). At each visit, they count remaining inventory and refill to capacity. The order quantity varies every time, but the timing is fixed.

Office Depot – Office Supplies to Businesses: Many businesses receive office supply deliveries on a fixed schedule (e.g., the first Monday of each month). The order varies based on what was consumed, but the review period stays consistent.

Hospital Pharmaceutical Inventory: Many hospital pharmacy systems review medication inventory at fixed intervals (daily for critical drugs, weekly for routine supplies) and place orders to replenish to target levels.

Q-Model vs. P-Model: Side-by-Side Comparison

Feature	Q-Model (Fixed-Order Quantity)	P-Model (Fixed-Time Period)
What is fixed?	Order quantity (Q)	Review period (T)
What varies?	When the order is placed	How much is ordered
Trigger	Event-triggered (inventory hits R)	Time-triggered (calendar)
Monitoring	Continuous (perpetual system)	Periodic (only at review)
Safety stock	Lower (covers lead time only)	Higher (covers review period + lead time)
Best for	High-value items (A items), items needing tight control	Items from same supplier, routine delivery schedules
Real example	Amazon auto-replenishment for staples	Coca-Cola route delivery trucks

3. Price-Break Models (Quantity Discounts)

Price-break models extend the EOQ framework to account for suppliers offering lower unit prices for larger order quantities. The decision becomes: Is the savings from the lower price worth the extra cost of carrying more inventory?

When to Use It

Use a price-break model whenever a supplier offers tiered pricing—different unit costs at different order quantity thresholds. The total cost now includes item cost (which changes with quantity) in addition to ordering and holding costs.

Procedure for Price-Break Models

1. Starting with the LOWEST unit price, compute the EOQ for each price range.
2. Check if the EOQ is feasible (falls within its price range).
3. If the lowest-price EOQ is feasible, it is optimal.
4. If not, compare total cost at each price break point (minimum quantity for that discount) with the total cost at the feasible EOQ. Choose the quantity with the lowest total cost.

Important: Holding cost often depends on unit price (e.g., H = iC where i is a percentage), so H changes at each price level.

Real-World Examples

Costco – Bulk Purchasing: Costco's entire business model is built on price-break logic. Customers buy larger quantities (a 48-pack of paper towels vs. a 6-pack) at a lower unit cost. For the customer, the trade-off is storage space and capital tied up. For Costco's own procurement, they negotiate volume discounts from manufacturers like Procter & Gamble.

Tesla – Battery Cell Procurement: Tesla negotiates significant price breaks with battery manufacturers like Panasonic and CATL. Ordering 10 million cells might cost $80/kWh vs. $95/kWh for 1 million cells. Tesla must weigh the savings against the carrying cost of storing massive battery inventories.

Starbucks – Coffee Bean Sourcing: Starbucks purchases coffee beans from suppliers around the world. Larger orders from a single farm or cooperative typically come with volume discounts. However, coffee has shelf-life considerations and storage costs, making the price-break analysis critical.

Restaurant Chains – Sysco/US Foods: Chain restaurants like Chipotle or McDonald's get better pricing from food distributors when ordering above certain thresholds. A Chipotle location must decide: order 500 lbs of chicken at $3.20/lb or 1,000 lbs at $2.85/lb? The price-break model answers this.

4. ABC Classification System

Not all inventory items deserve the same level of attention. ABC classification is a prioritization method that ranks items by their dollar volume (annual demand multiplied by unit cost) to determine how much management effort each item should receive.

Class	% of Items	% of Dollar Volume	Control Level
A	~15–20%	~70–80%	Tight control: frequent reviews, accurate records, careful forecasting
B	~30–35%	~15–25%	Moderate control: regular reviews, good records
C	~50%	~5–10%	Loose control: simple systems, order in large quantities, minimal review

Why It Matters

ABC classification determines which inventory model to use for each item. Class A items justify the cost of continuous monitoring (Q-model with safety stock). Class C items may only need periodic review (P-model) or simple two-bin systems. This approach ensures you invest management time where it yields the greatest financial return.

Real-World Examples

Apple – Retail Stores: A items would include iPhones and MacBooks (few SKUs but enormous dollar volume—tracked in real time). B items might include AirPods and accessories (moderate volume, regular monitoring). C items include cables, adapters, and cases (many SKUs, low individual value—ordered in bulk with simple reorder rules).

Hospital Supply Chain: A items: surgical implants, specialized medications (high cost, tightly controlled). B items: surgical gloves, IV tubing (moderate cost, standard ordering). C items: bandages, gauze pads, tongue depressors (low cost, ordered in bulk).

Amazon Warehouse: A items: high-value electronics (laptops, tablets) stored in secure areas with real-time tracking. B items: mid-range products (kitchen appliances, books). C items: low-value items (pens, small accessories) managed with simpler systems.

5. Inventory Accuracy and Cycle Counting

Inventory Accuracy

Inventory accuracy measures how well physical inventory counts match what the computer system shows. If your records say you have 100 units but you actually have 87, your system cannot make good ordering decisions. Every inventory model depends on accurate data to function properly.

Cycle Counting

Cycle counting is a technique where small portions of inventory are counted on a frequent, rotating basis rather than shutting down operations for a massive annual count. This approach catches errors quickly and keeps records accurate throughout the year.

When to Cycle Count

- When records show low or zero balance on hand.
- When records show a positive balance but a backorder exists.
- After a specified level of activity (e.g., after every 100 transactions).
- Based on the importance of the item (A items counted more frequently than C items).

Connecting to ABC Classification

ABC classification directly guides cycle counting frequency and accuracy tolerances:

Class	Count Frequency	Accuracy Tolerance	Rationale
A	Monthly or more	±0.2%	High dollar value; errors are costly
B	Quarterly	±1%	Moderate value; reasonable oversight
C	Annually or semi-annually	±5%	Low value; tight control not cost-effective

Real-World Examples

Walmart: Walmart uses continuous cycle counting across its 4,700+ U.S. stores. High-value electronics are counted more frequently than low-value consumables. Their inventory accuracy directly affects their ability to offer "in-stock guarantee" programs.

FedEx/UPS – Package Tracking: While not traditional inventory, package tracking is a form of inventory accuracy. Every scan creates a record that must match physical reality. FedEx scans packages at every handoff point—a form of continuous cycle counting.

Summary: Choosing the Right Model

The following decision framework summarizes when to use each inventory model. In an interview, being able to walk through this logic demonstrates that you understand the practical application, not just the formulas.

Situation	Model	Real-World Example
One-time order, demand is a smooth bell curve	Single-Period, Continuous	Zara orders a seasonal dress line
One-time order, demand has specific probabilities	Single-Period, Discrete	Delta Airlines decides overbooking level
Ongoing replenishment, stable predictable demand	EOQ (Basic Q-Model)	Walmart restocks Tide detergent
Ongoing replenishment, demand fluctuates	EOQ with Safety Stock	CVS restocks flu medicine in winter
Inventory checked on a schedule, not continuously	Fixed-Time Period (P-Model)	Coca-Cola driver refills store cooler weekly
Supplier offers lower price for larger orders	Price-Break Model	Costco negotiates bulk pricing from P&G
Need to prioritize which items get the most attention	ABC Classification	Apple tracks iPhones tightly, cables loosely
Need to keep inventory records accurate	Cycle Counting	Walmart counts A items monthly, C items yearly

Final Interview Tip

When discussing inventory in an interview, always frame your answer around the BUSINESS CONTEXT first. Start by describing the nature of the product and demand, then explain which model fits and why. For example: "For a perishable product with a single selling season, I would use a single-period model because there is no replenishment opportunity, and the key trade-off is between overstocking and understocking." This shows you think like a supply chain professional, not someone who just memorized formulas.