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CERTIFIED IN LOGISTICS,
TRANSPORTATION AND DISTRIBUTION

MODULE 5:
INVENTORY MANAGEMENT

APICS

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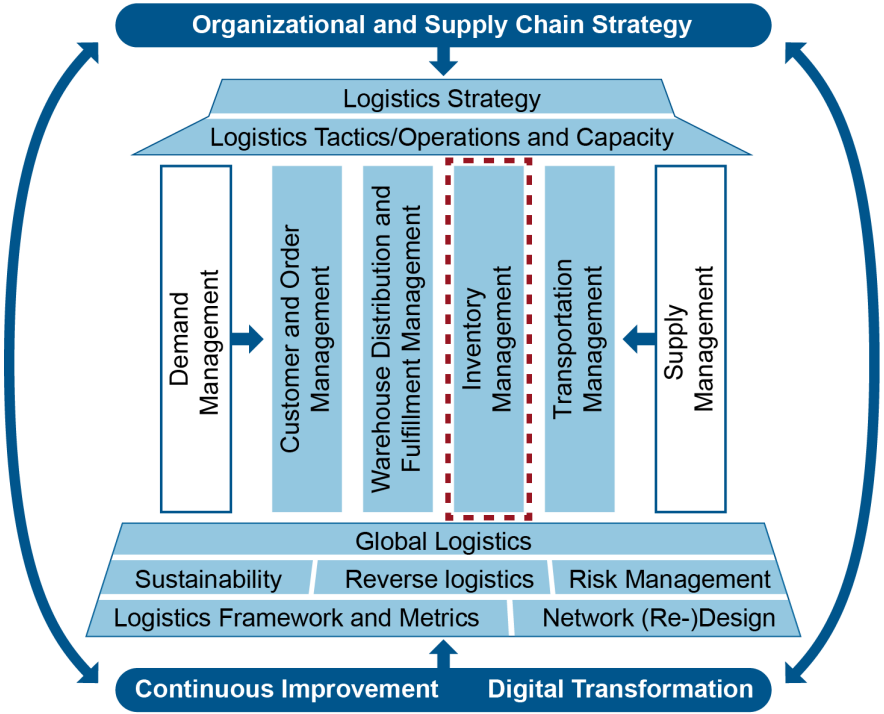
Module 5 Overview



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MODULE 5, SECTION A: UNDERSTAND INVENTORY MANAGEMENT FUNDAMENTALS

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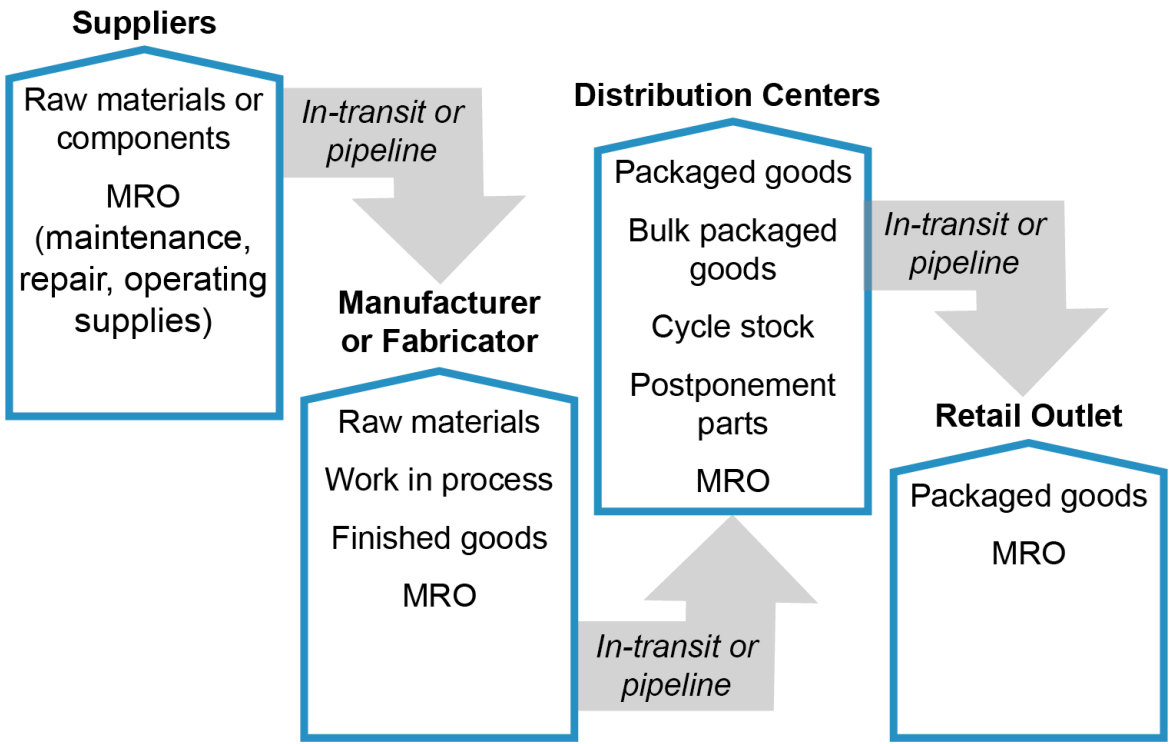
Inventory in the Supply Chain

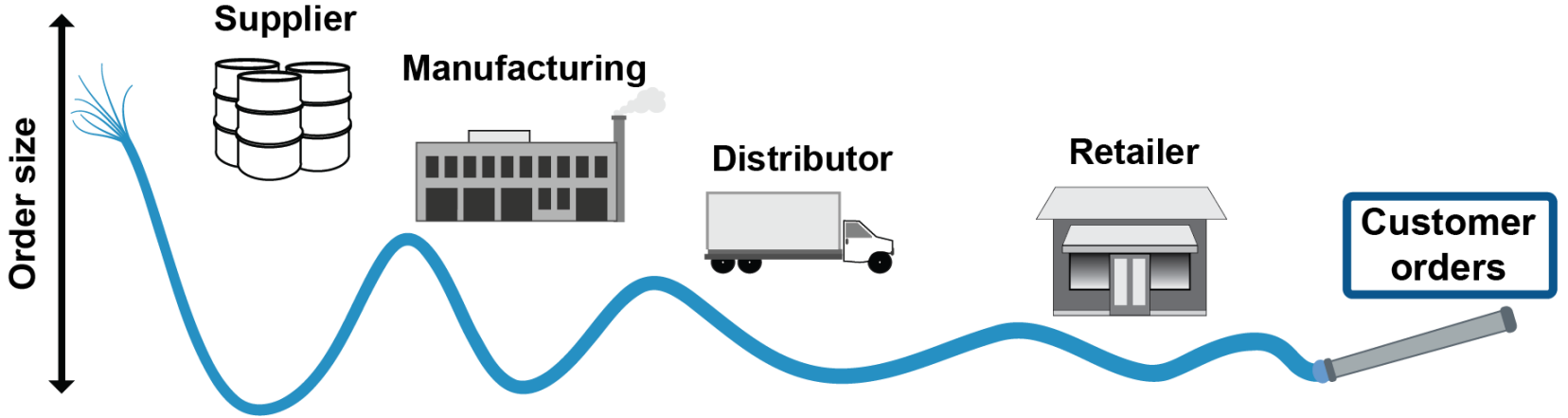
Inventory to support

- Production
- Supporting activities
- Customer service
- Channel distribution



Bullwhip Effect

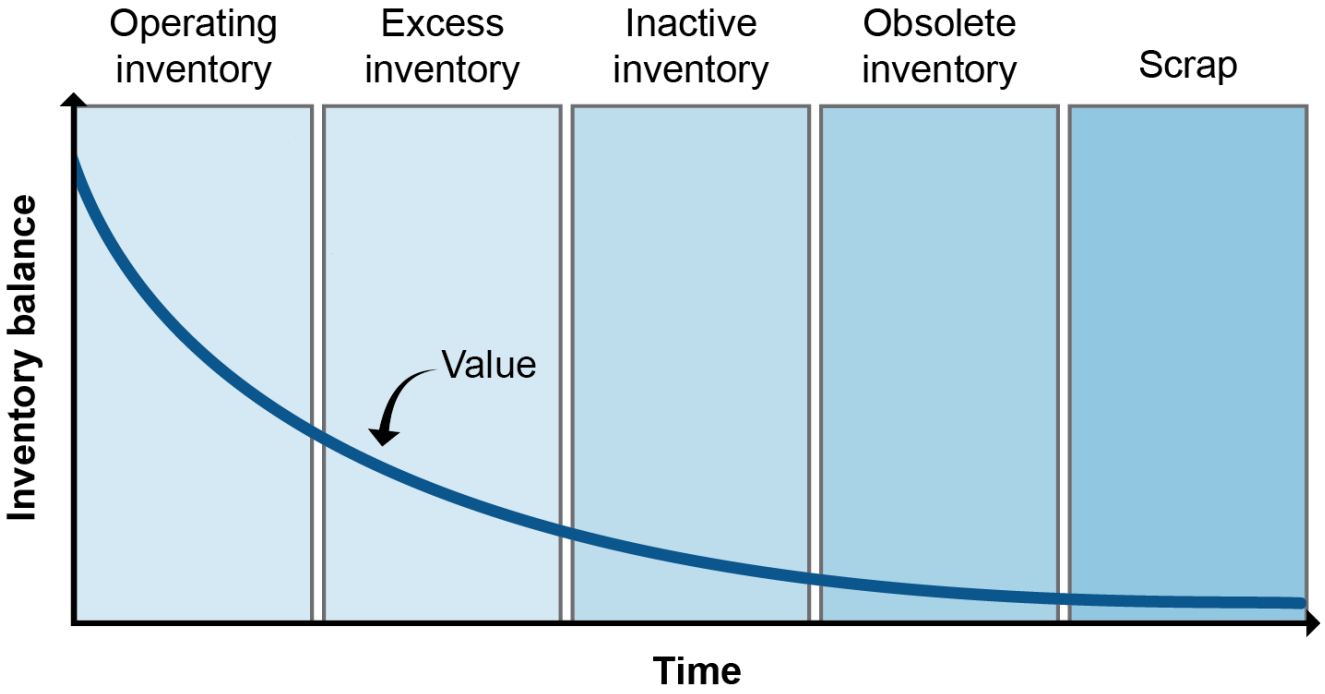
- Caused by lack of communication among supply chain partners of consumer demand, plus supply variability
- Primarily impacts make-to-stock environments



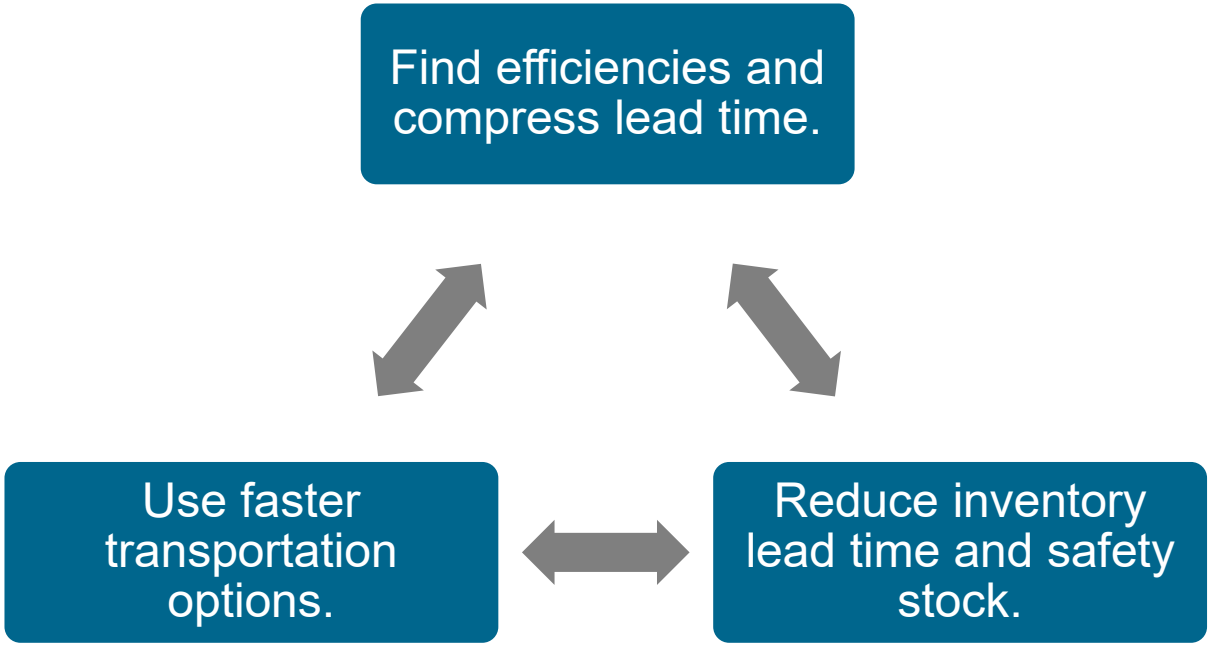
Stakeholder Perceptions of Inventory

Business leaders	Cost that may limit investments in new opportunities and growth.
Financial managers	Keep value of inventory low as it affects business financials.
Operations managers	Inventory is key to output; long production runs reduce production costs.
Sales and marketing	Enough inventory to satisfy demand.
Consumers	Right product in the right amount at the right time.

Inventory and Time

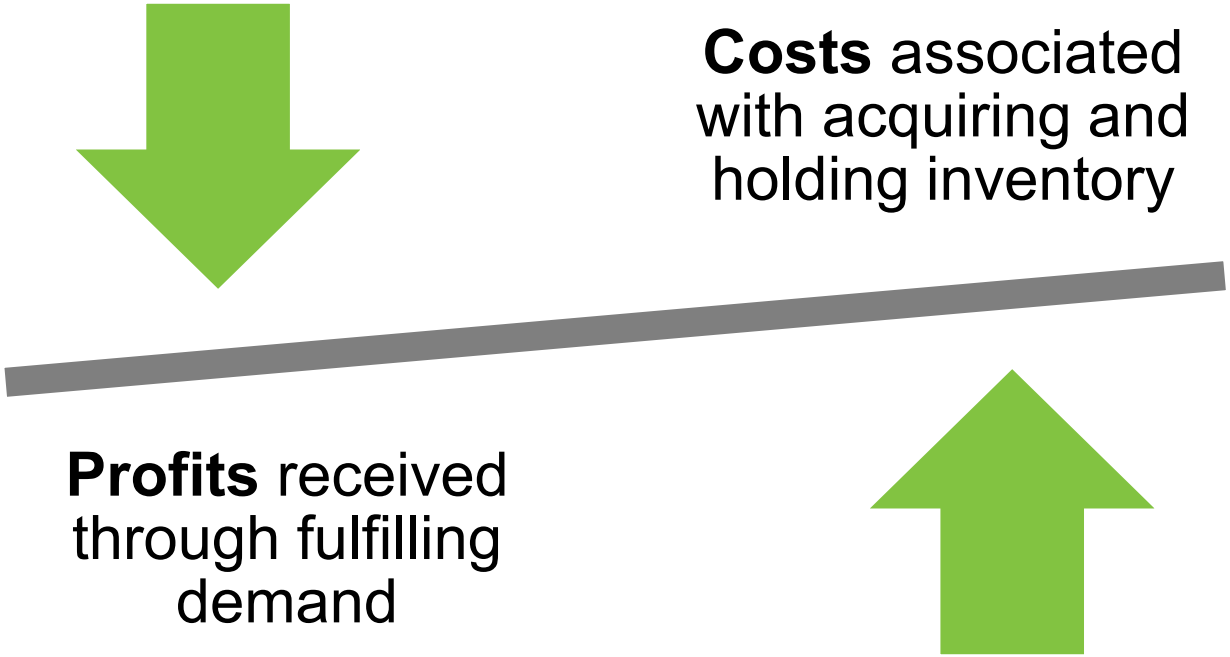


Faster Inventory Turns Means Less Cash Investment



Define Functions of Inventory and Related Strategies

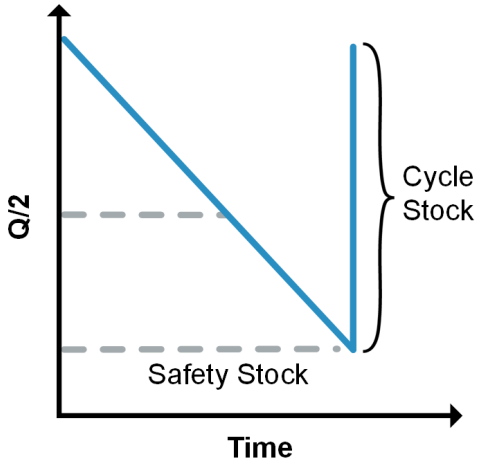
Demand Fulfillment



Cycle and Pipeline Stock

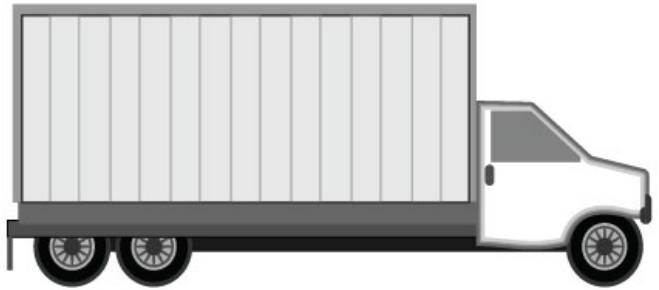
Cycle stock

Amount of inventory required to satisfy normal demand

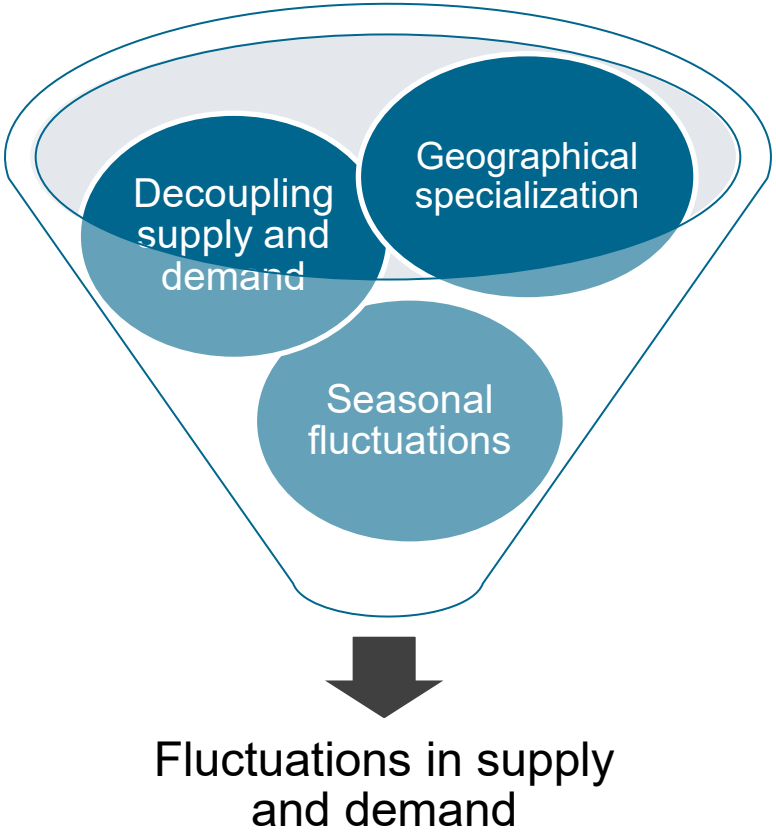


Pipeline stock

Amount of inventory in the transportation network and distribution system



Define Functions of Inventory and Related Strategies

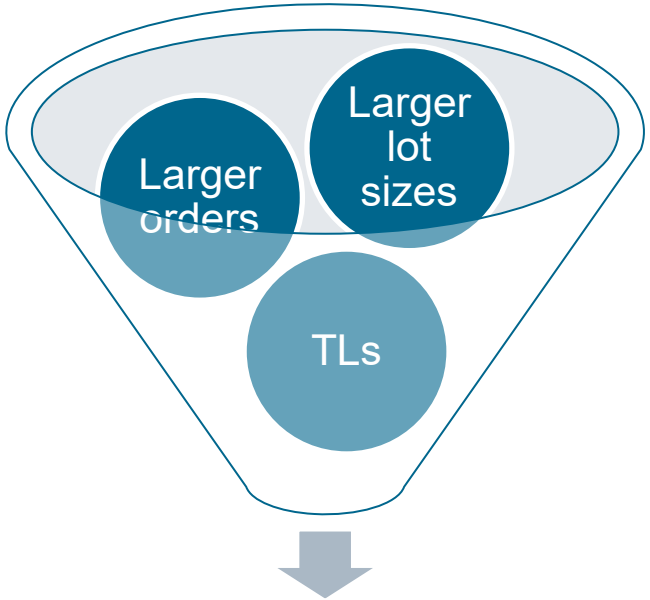


Define Functions of Inventory and Related Strategies

Safety Stock, Safety Lead Time, and Hedge Inventory

- Safety lead time: get before real need date
- Hedge inventory: buffer against uncertain events

Cost Savings from Economies of Scale



Lower cost per unit by distributing fixed costs over larger quantity.

Inventory Management Strategies

- Minimize: MTO, postpone, share demand
- Standard service level for all or tiered service level
- Maximize inventory profitability
- Meet budget constraints
- Maximize economies of scale
- Maximize transportation capacity utilization
- Liquidate inactive

Digital Transformation for Better Inventory Management

Digital Transformation/Industry 4.0

- High level of supply chain maturity
- Capabilities with technology enablers
- Control towers
- Real-time forecasting and analytics

Internet of Things (IOT)

- Sensors report on status
  - In vehicles, payloads, warehouse systems, reusable assets
- Location
- Temperature

Inventory management systems (IMS)

- Integrate
- Control
- Visualize
- AI-enabled forecasting

Robotics

- Reduce inventory cost by reducing labor
- Higher fixed cost

Barcoding/RFID

Barcodes

- Machine-readable code: manufacturer and SKU
- Examples:
  - 1D: UPC, GS1 DataBar
  - 2D: QR code
- Goal: all POS accept 2D

RFID

- Smart chips to identify and locate units
  - Case, pallet
- Signals automatically picked up by readers/interrogators.

RFID Tag Types

Passive tag

- Does not send out data
- Not self-powered
- Reader temporarily powers tag
- Can transmit data at short range
- Cheap if purchased in bulk

Semipassive tag

- Tag sends out data
- Self-powered
- Widens range by harnessing power from reader

Active tag

- Broadcasts information
- Has power source
- Can transmit data to reader at long ranges
- Most expensive type
- For containers or pallets

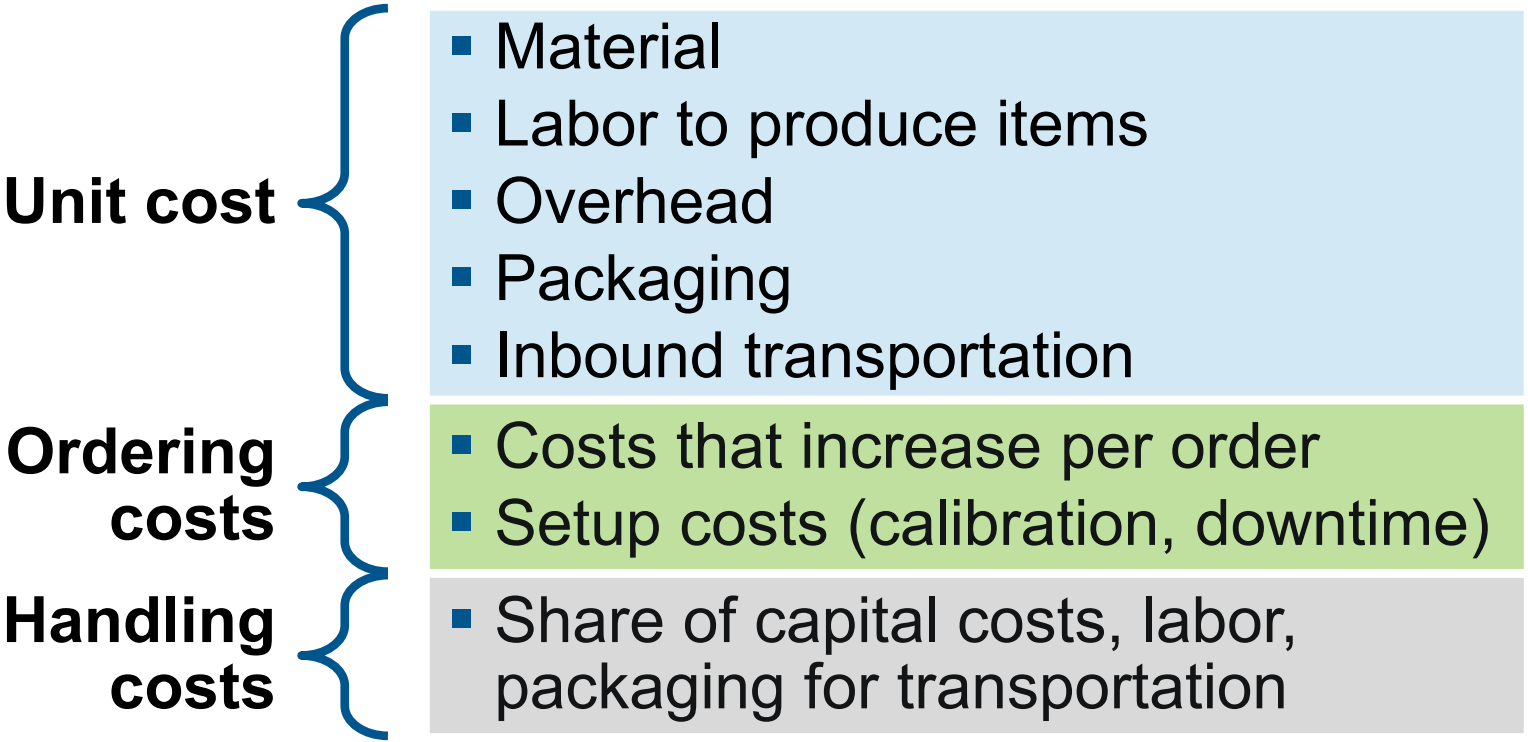
Understand the Costs of Inventory

Inventory Costs

Acquisition Costs	Carrying Costs	Stockout Costs
▪ Unit cost – Overhead costs ▪ Ordering cost – External orders – Internal setup costs ▪ Handling cost	▪ Capital cost ▪ Storage ▪ Insurance ▪ Taxes ▪ In-transit cost	▪ Immediate loss of revenue ▪ Damaged customer relations ▪ Damaged business reputation ▪ Lost future revenue

Understand the Costs of Inventory

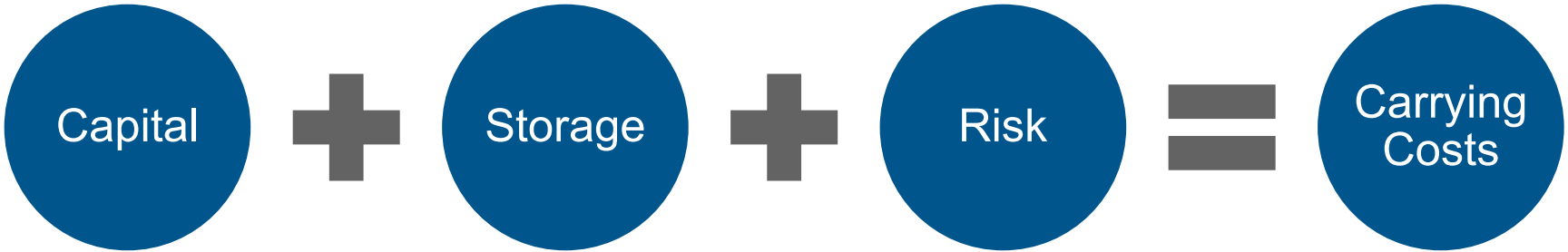
Acquisition Costs



Understand the Costs of Inventory

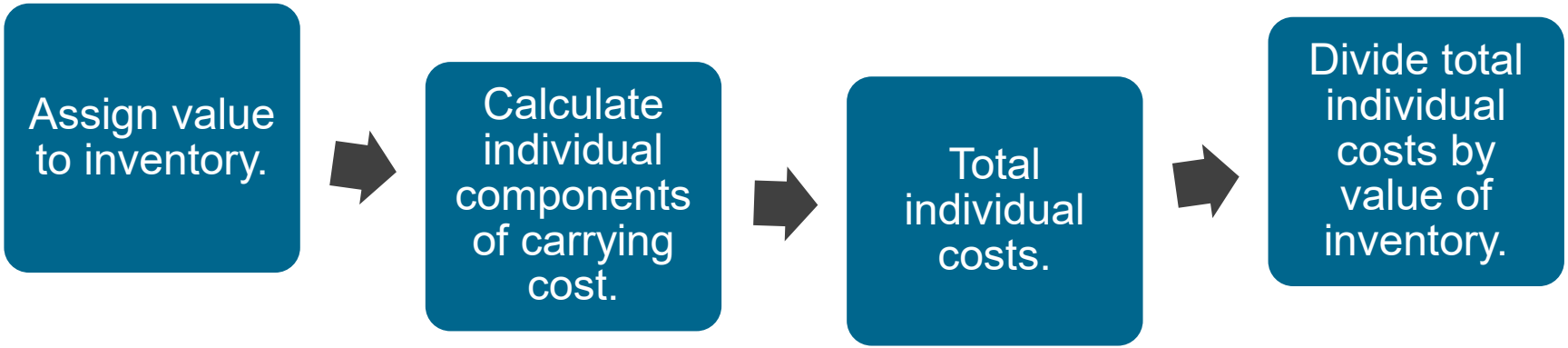
Carrying Costs

"The cost of holding inventory, usually defined as a percentage of the dollar value of inventory per unit of time (generally one year)."



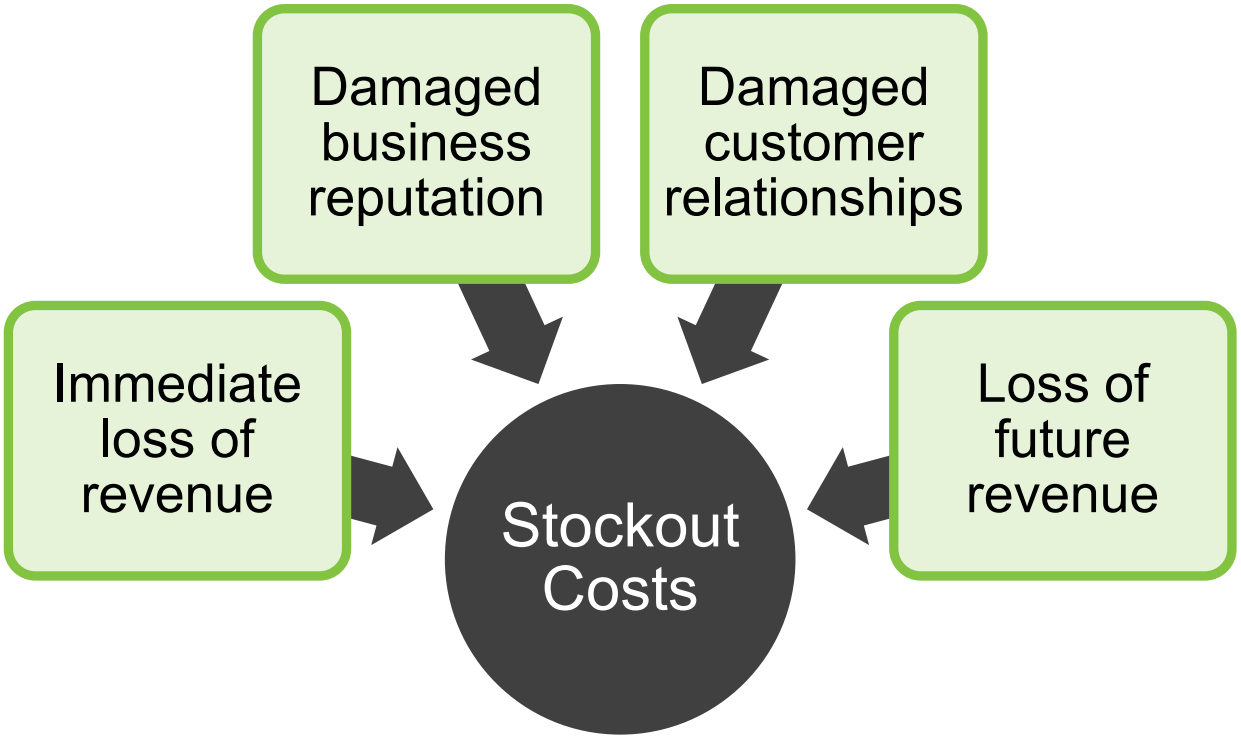
Calculating Carrying Cost

Carrying cost is shown as a percentage of the value of inventory.



Understand the Costs of Inventory

Stockout Costs



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MODULE 5, SECTION B: DEVELOP INVENTORY STRATEGY AND POLICY AND IMPLEMENT INVENTORY CONTROL

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Determine When and How Much to Order

Demand Types

Independent demand

- Finished goods
- Forecasted
- Inventory approaches
  - Fixed order quantity
  - Fixed order period

Dependent demand

- Components or kits
- Calculated
- Approaches
  - MRP for components
  - DRP for kits

Dual demand

- Independent: Service parts
- Dependent: Components

Determine When and How Much to Order

When to Order: Order Point

$$\text{Order Point} = \text{Anticipated Demand (D)} \times \text{Lead Time (L)}$$

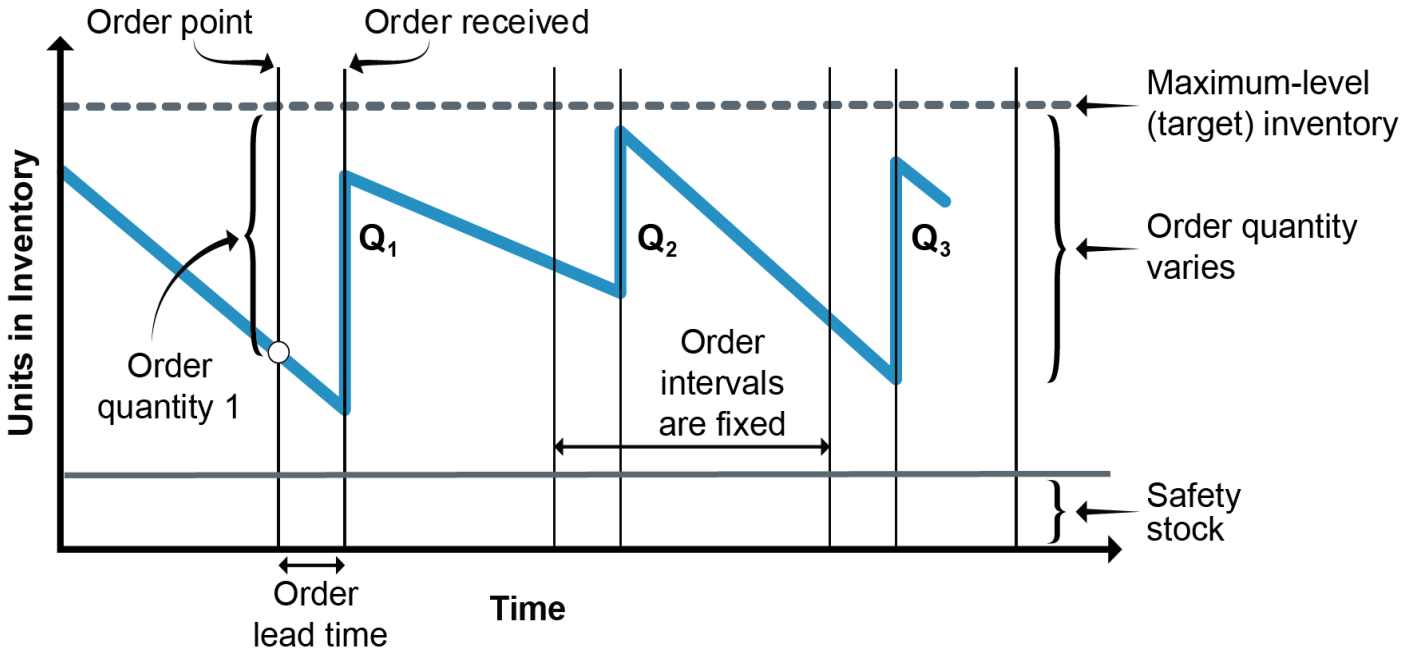
Demand:

- Historical data
- Forecasts
- Analysis of current trends

Lead time:

- Inventory review
- Prepare and submit orders
- Supplier reviews and processes
- Transit time
- Receipt, check, and stock

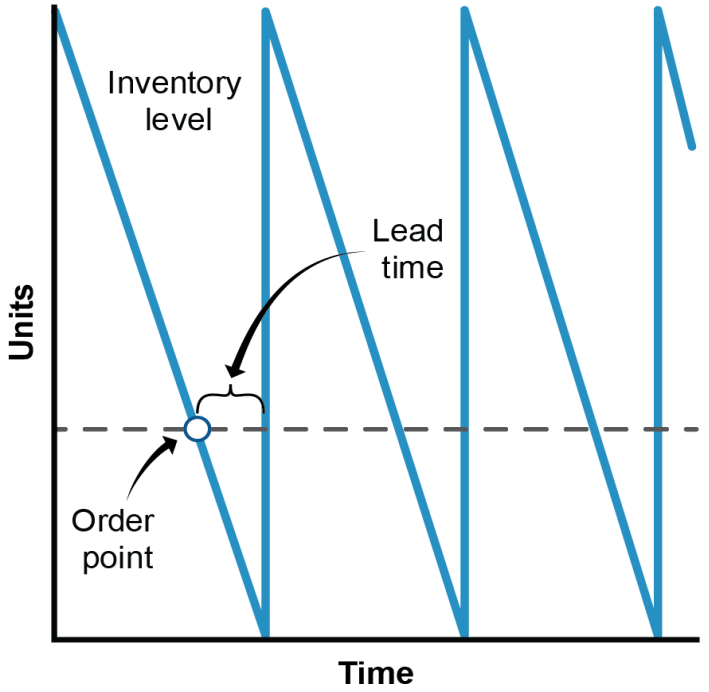
When to Order: Fixed Order Period



Source: *APICS Certified Supply Chain Professional Learning System, Version 4.0*

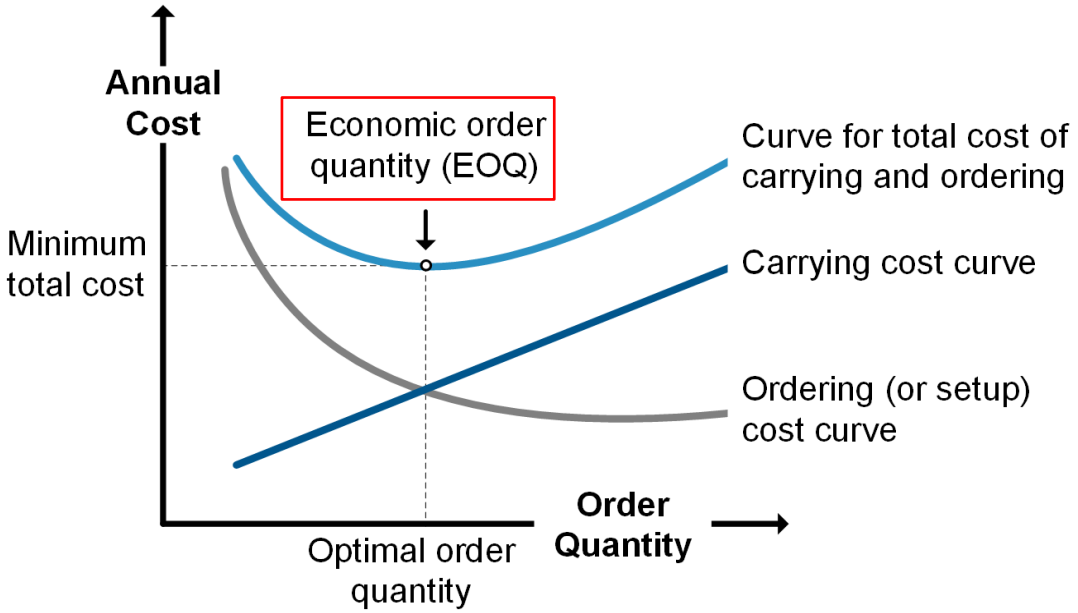
How Much to Order: Fixed Order Quantity

- Quantity of order remains the same.
- Uses an order point to trigger replenishment.
- Time between orders (order period) may vary.



Determine When and How Much to Order

Economic Order Quantity (EOQ)



Source: *APICS Certified Supply Chain Professional Learning System, Version 4.0*

$$EOQ = \sqrt{\frac{2AS}{IC}}$$

Where:

- A = Annual usage in units
- S = Ordering (or setup) costs in a currency amount
- I = Annual carrying cost rate
- C = Unit cost

Determine When and How Much to Order

EOQ versus Period Order Quantity (POQ)

Using EOQ of 298 units:

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	SUM
Net Requirements	50	80	100	100	80	60	0	70	90	100	100	150	200	1,180
Planned Order Receipt	298			298					298			298		1,192
Ending Inventory	248	168	68	266	186	126	126	56	264	164	64	212	12	1,960

Using POQ of 3 weeks: POQ's Ideal Number of Periods = $\frac{\text{EOQ}}{\text{Average Usage per Period}} = \frac{298}{100} \cong 3$

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	SUM
Net Requirements	50	80	100	100	80	60	0	70	90	100	100	150	200	1,180
Planned Order Receipt	230			240				260			450			1,180
Ending Inventory	180	100	0	140	60	0	0	190	100	0	350	200	0	1,320

Order period can vary

Determine When and How Much to Order

How Much: Target Inventory (Min-Max Systems)

- Type of order point replenishment system
- Hybrid approach to inventory control
- Variable order quantity

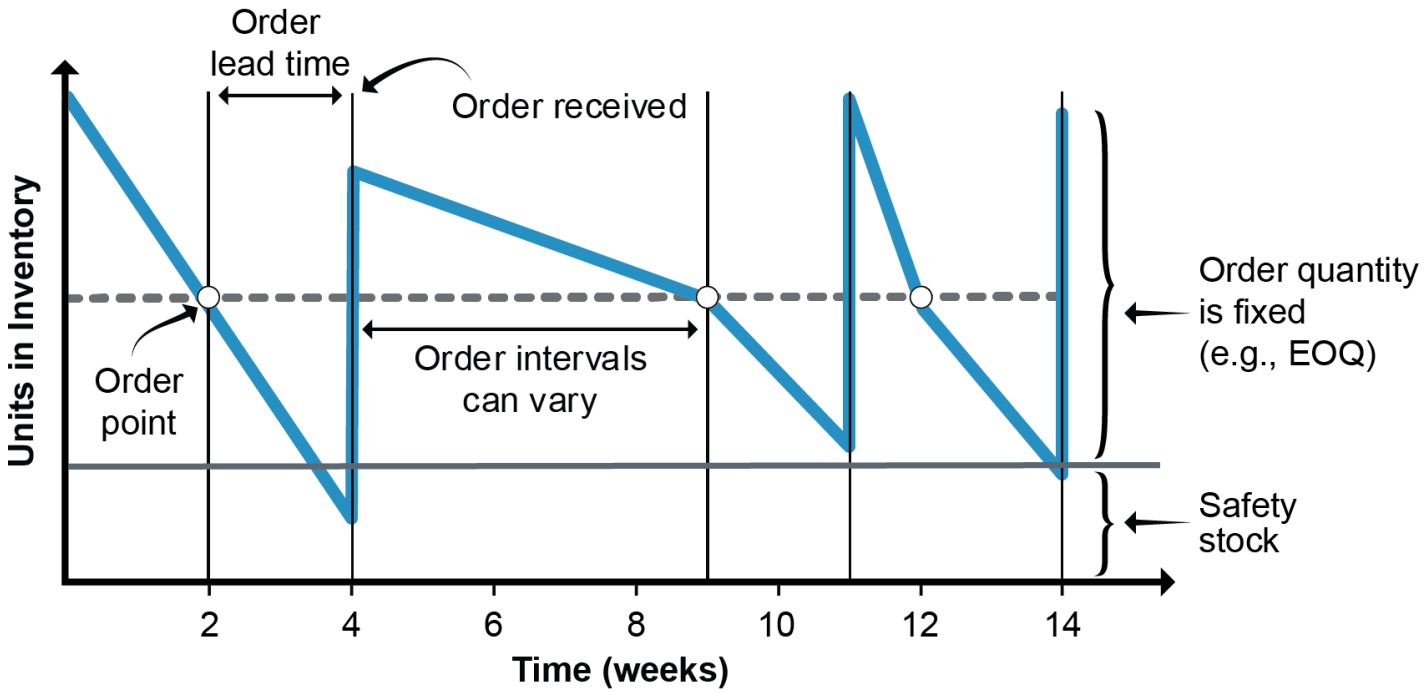
- Minimum (min) is the order point.
- Maximum (max) is the order up to inventory target level.

Determine When and How Much to Order

Just in Time (JIT) with Kanban

- Aims at reducing waste
- Works to reduce uncertainty of what to produce or what and how much to order
- Kanban: standard containers or lot sizes pulled on demand signal

Effect of Uncertainty on Reorder Frequency



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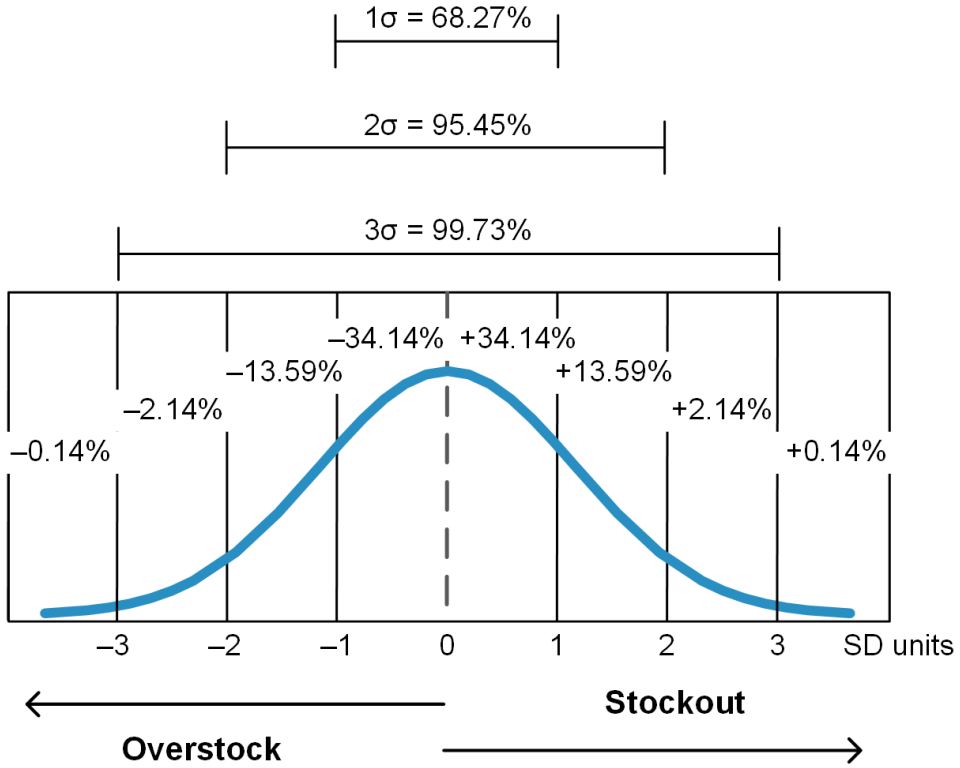
Standard Deviations in a Normal Distribution

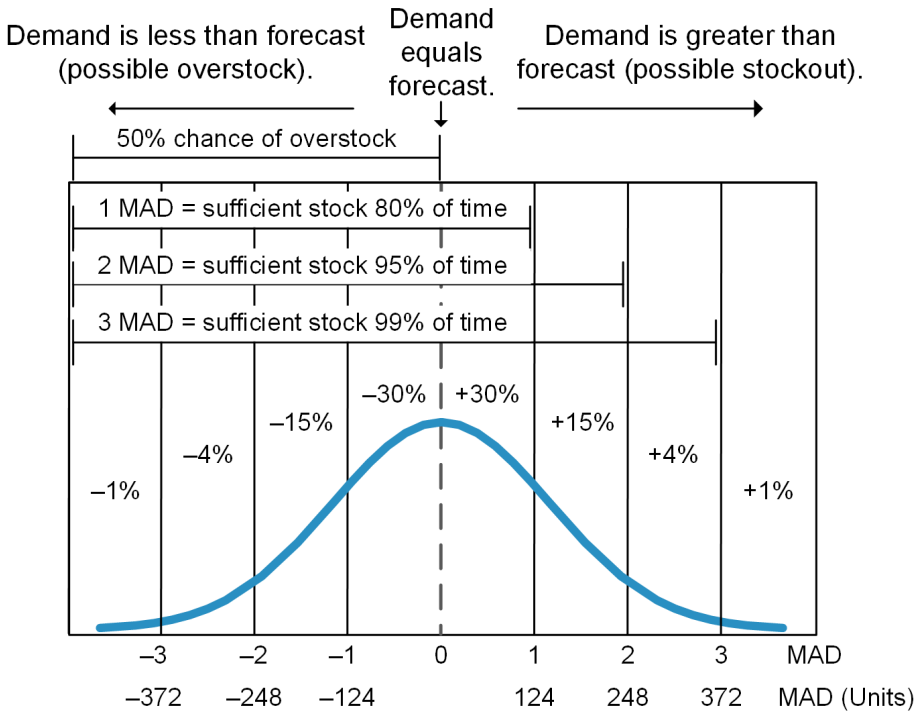


Calculating Standard Deviation in Units

- This example: *n* = 10-week period
- If a using a complete set of data, use *n*
- If using a sample to represent the whole, use *n* – 1

Week	Forecast	Actual	Absolute Deviation	Actual – Mean	(Actual – Mean) Squared
1	1,000	1,100	100	24	576
2	1,000	950	50	–126	15,876
3	1,000	1,150	150	74	5,476
4	1,000	1,400	400	324	104,976
5	1,000	1,000	0	–76	5,776
6	1,000	900	100	–176	30,976
7	1,000	920	80	–156	24,336
8	1,000	1,300	300	224	50,176
9	1,000	990	10	–86	7,396
10	1,000	1,050	50	–26	676
Sum		10,760	1,240		246,240
Mean		1,076			
Sum of (Actual – Mean)^2/*n* – 1					27,360
Standard deviation (square root of line above)					165.4

Mean Absolute Deviation



Week	Forecast	Actual	Absolute Deviation
1	1,000	1,100	100
2	1,000	950	50
3	1,000	1,150	150
4	1,000	1,400	400
5	1,000	1,000	0
6	1,000	900	100
7	1,000	920	80
8	1,000	1,300	300
9	1,000	990	10
10	1,000	1,050	50
Sum			1,240
Mean absolute deviation (sum absolute deviation/*n*)			124

Calculating Safety Stock from Service Level

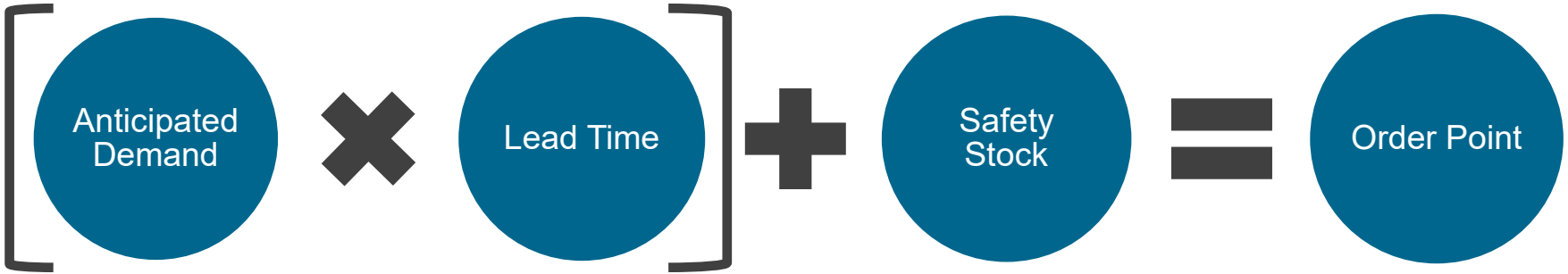
- Safety factor table:
- For example, for 90% service level:
  - 165.4 SD in units x 1.28 = 211.7 units ~ 212 units
  - 124 MAD in units x 1.60 = 198.4 units ~ 199 units

Percentile Customer Service Level	SD Units × Factor Below	MAD Units × Factor Below
85.00	1.04	1.30
89.44	1.25	1.56
90.00	1.28	1.60
93.32	1.50	1.88
95.00	1.65	2.06
97.72	2.00	2.50
98.00	2.05	2.56

Calculating Safety Stock: Order Point

Demand during the lead time (DDLT) = Anticipated Demand × Lead Time

DDLT + Safety Stock = Order Point



Other Safety Stock/Safety Lead Time Methods

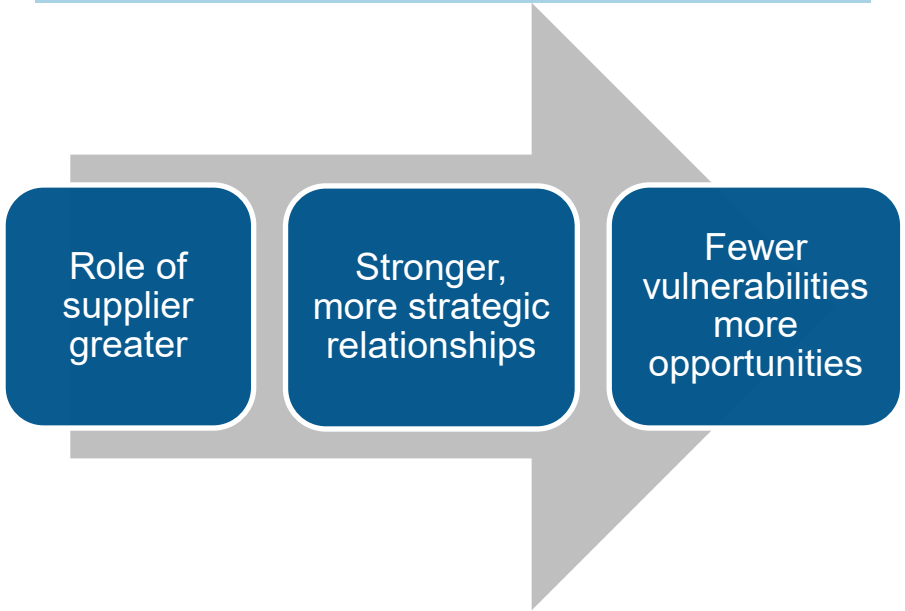
- Based on order cycle time (OCT) and OCT variability
  - Uses OCT, SD of OCT, and desired service level
  - Lower safety stock need: reduce OCT or OCT variability
- Safety lead time: SD of lead time, adjust by safety factor

Stockout cost validation example for safety stock:

- 60% backorders x $100 per backorder
- + 15% lost sales x $500 lost profit
- + 5% lost customers x $25,000 lost lifetime revenue
- = $60 + $75 + $1,250 = $1,385

Vendor-Managed Inventory (VMI) and Consignment

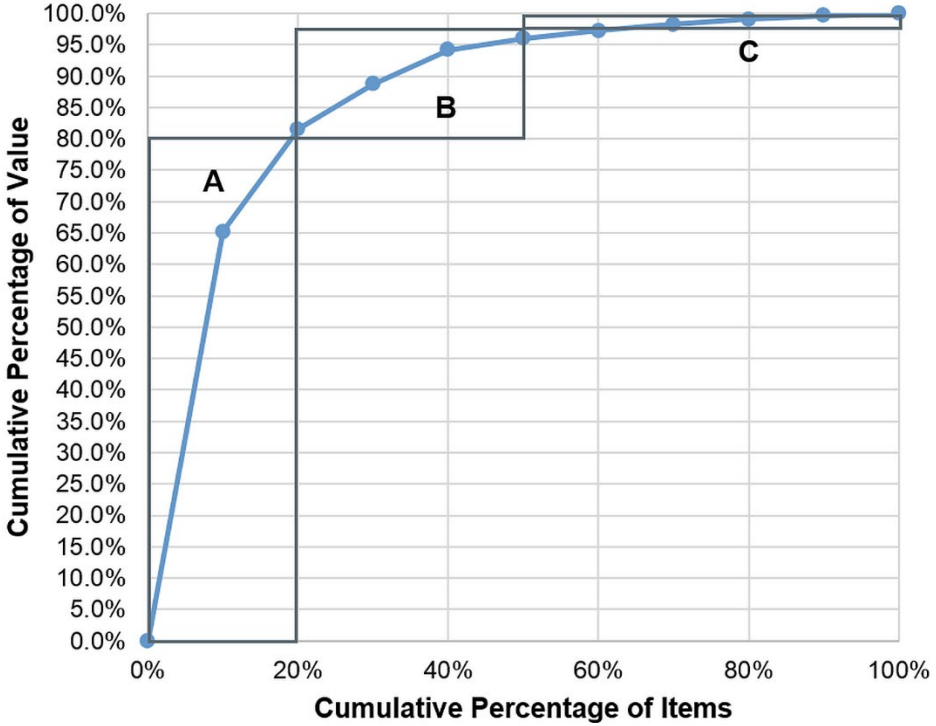
VMI



Consignment

- Customer does not own goods upon receipt
- Pays only when withdrawn
- Advantage to buyer = avoids investing capital in stock.
- Advantage to seller = guarantees seller's products (vs. competitors) are used in process.

ABC Analysis of Inventory



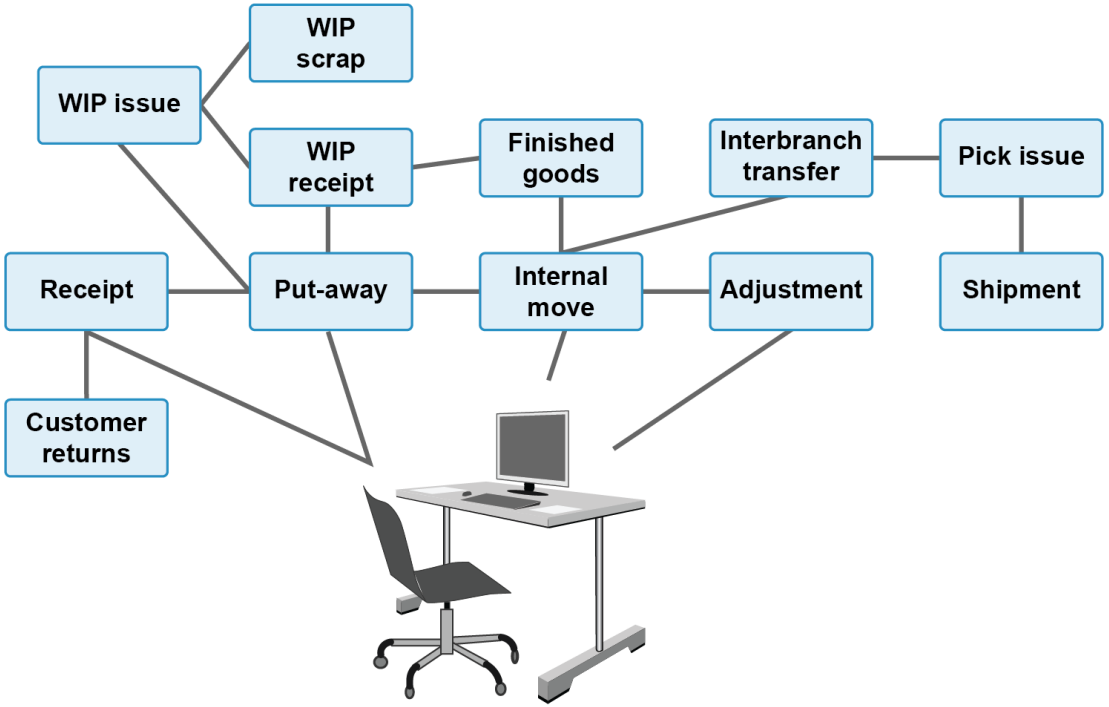
ABC Analysis by Revenue

Item Code	Annual Revenue	% Annual Revenue	% Cumulative Revenue	% Items	ABC Class
01A	40,000	40.0	40.0	9	A
14V	30,000	30.0	70.0	16	A
78Y	10,000	10.0	**80.0**	20	A
98H	6,000	6.0	86.0	36	B
09P	5,000	5.0	91.0	45	B
65T	4,000	4.0	**95.0**	55	B
23W	3,000	3.0	98.0	64	C
12Q	800	0.8	98.8	73	C
99M	700	0.7	99.5	82	C
88B	500	0.5	**100.0**	96	C
04Z	0	0.0	**100.0**	100	D
TOTAL	**US$100,000**	**100%**			

Dead stock (D) or slow-moving, inactive, or new with no sales history:

- No sales during 12-month period

Inventory Transaction Points



Source: David F. Ross. *Distribution Planning and Control—Managing in the Era of Supply Chain Management.* Used with permission.

Inventory Review Approaches

Periodic inventory review

- Checked at designated intervals to see if order points have been triggered.

Continuous inventory review

Checked whenever:

- A change in inventory level occurs.
- Order point is reached.
- Restocking order released.

Inventory Auditing

GOAL: To measure, confirm, and improve, if necessary, inventory accuracy.

Approaches to cycle counting:

- ABC classification
- Zone method
- Just-before-order replenishment
- Demand order pick

Inventory Control Metrics

- **Days' Inventory Outstanding** (**DIO**) = $\frac{\text{Inventory on Hand}}{\text{Average Daily Use}}$
- **Weeks of Supply** = $\frac{\text{Inventory on Hand}}{\text{Average Weekly Use}}$

Inventory Reduction Methods and Benefits

Methods	Benefits
▪ More accurate forecasting ▪ Reducing usage and lead times ▪ Recalculating order quantities ▪ Reducing safety stocks ▪ ABC classification ▪ Cycle counting ▪ Monitoring deliveries ▪ VMI or consignment	Reduction in carrying cost Reduction in risk of excess inventory Reduction in risk of obsolete inventory Increase in available cash

Calculating Inventory Turnover Rate (Variants)

Inventory Turnover =

- $$\frac{\text{COGS}}{\text{Average Inventory Valued at Cost During Period}}$$
- $$\frac{\text{Sales Revenue}}{\text{Average Inventory Valued at Selling Price During Period}}$$
- $$\frac{\text{Units Sold}}{\text{Average Unit Inventory During Period}}$$