

# CPIM

CERTIFIED IN PLANNING  
AND INVENTORY MANAGEMENT

## MODULE 3: DEMAND

## Demand

- Section A: Demand Management
- Section B: Sources of Demand/Forecasting
- Section C: Forecast Performance

# CPIM

CERTIFIED IN PLANNING  
AND INVENTORY MANAGEMENT

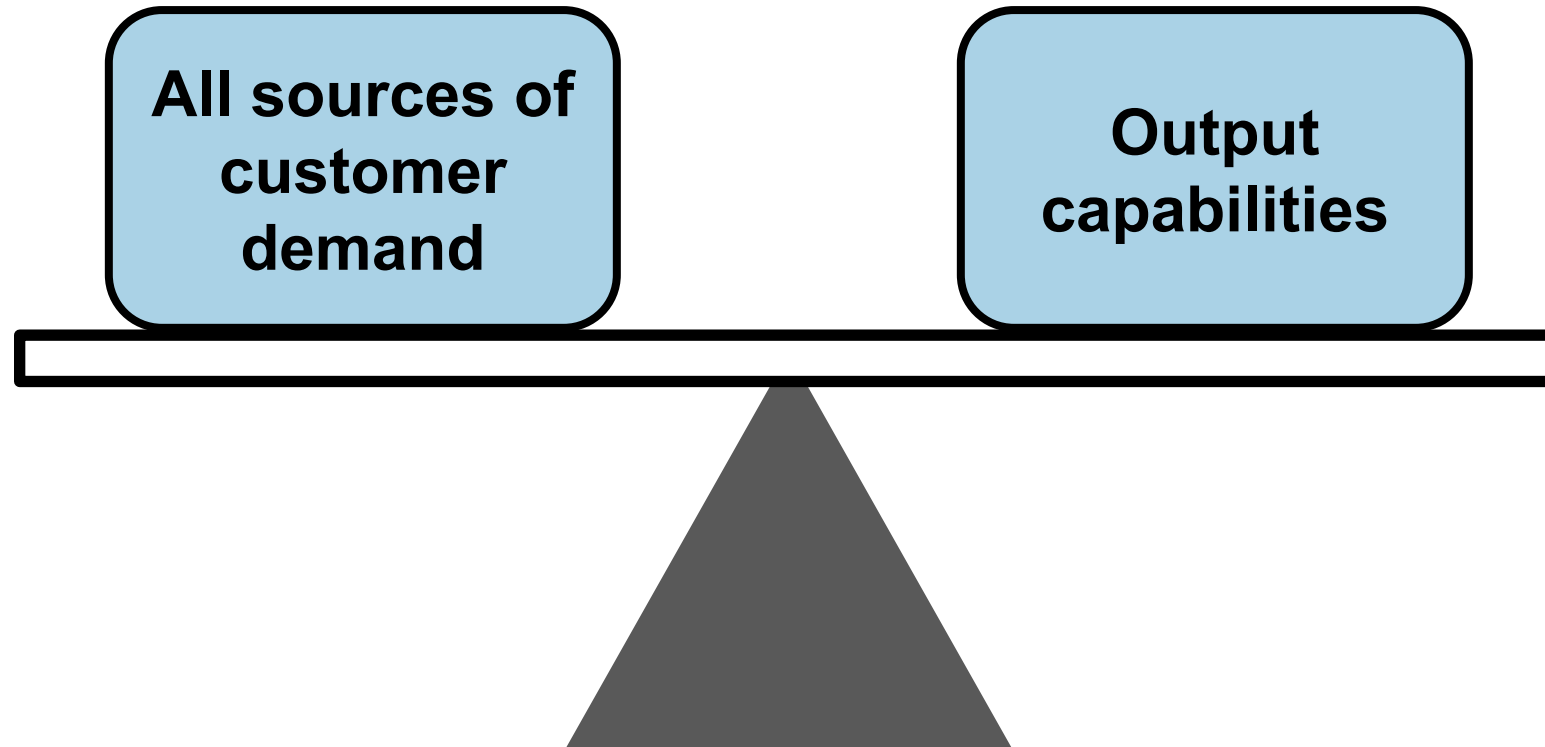
## SECTION A: DEMAND MANAGEMENT

## Section A Learning Objectives

- Demand-side activities in MPC
- Demand planning: planning, communicating, influencing, and prioritizing demand
- Principles of and inputs to demand management
- Seven “rights”
- Customer segmentation and customer relationship management
- Setting customer service policies, safety stock levels, and performance targets
- Measuring order delivery performance
- Influencing demand to align with supply
- Marketing promotions and promotion life cycle
- Quality function deployment, voice of the customer, modular design, design for...
- Product configuration and changes

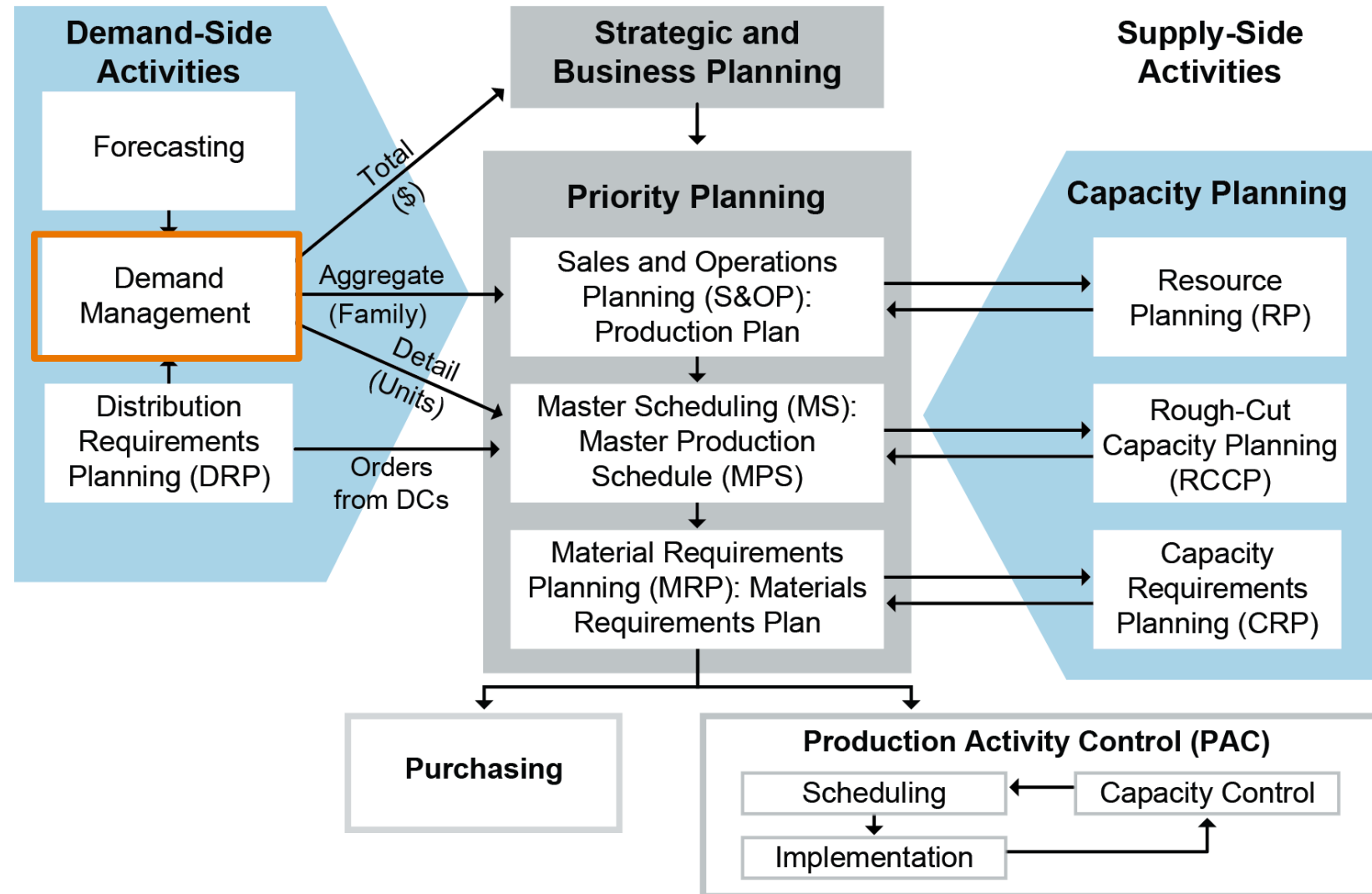
# Demand Management Overview

## S&OP and Master Scheduling Balance Demand



# Demand Management Overview

## Demand Management in Manufacturing Planning and Control



## Demand Management Activities

- Forecasting
  - Identifying market trends and patterns
- Identifying and reconciling demand sources
  - Customer segments
  - Unmet demands
  - Special requests
  - Items with erratic demand
- Distinguishing
  - Forecast versus manufacturing plans
  - Independent versus dependent demand
- New products/features
- Customer service levels and safety stock
- Order entry
- Communications

## Data Reliability

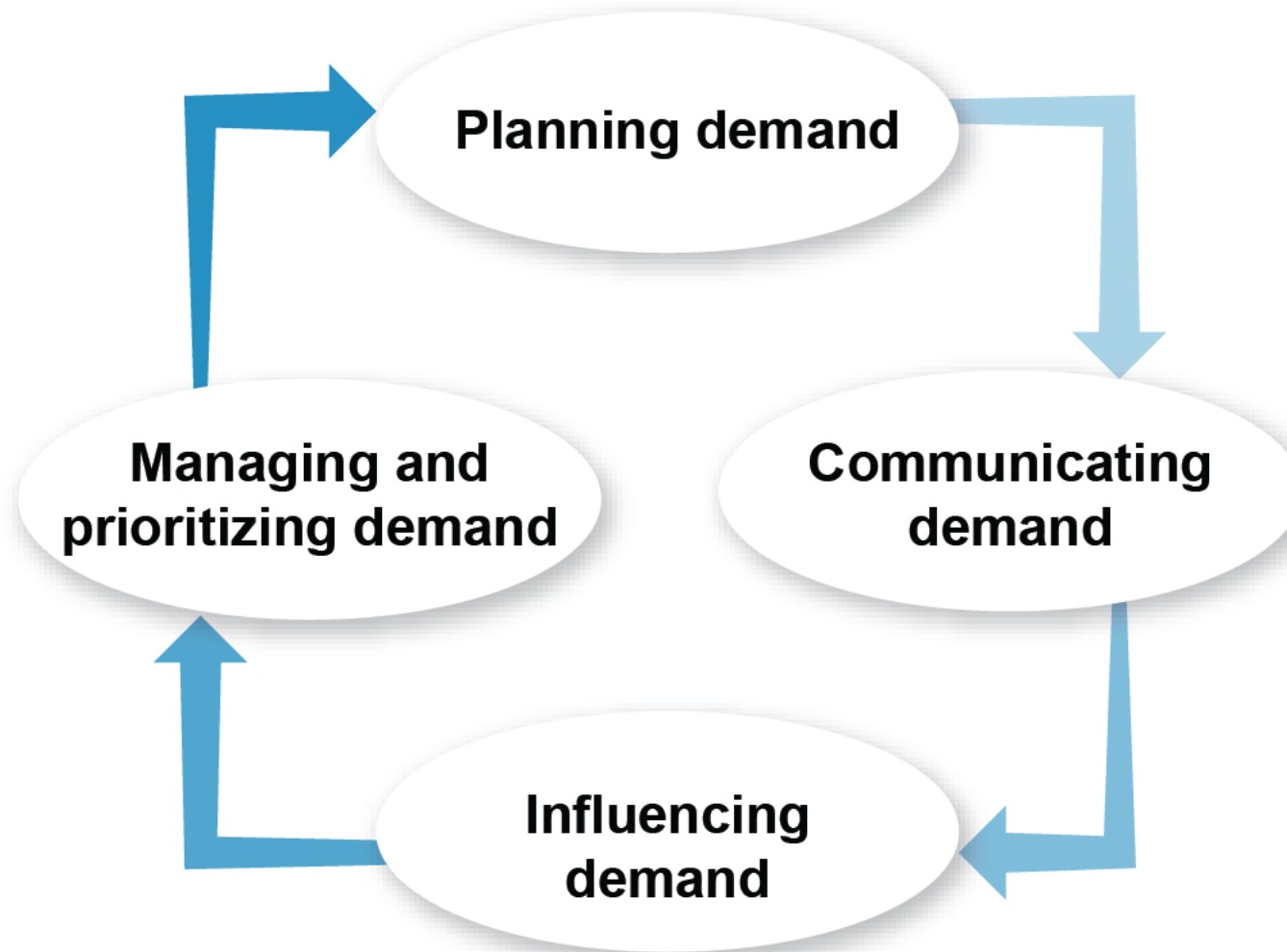
### Forecasts are

- Not accurate (prediction)
- More on target the larger the group measured
- Best when used with a forecast error measuring technique
- More accurate the shorter the time period.

### Inputs, calculations, and outputs checked for

- Errors in inputs, e.g., mixed units of measure, gaps, or exceeding minimum or maximum values
- Calculation errors: wrong formula or formula errors
- Unusual or unexpected trends needing investigation

## Demand Management Process



## Identifying Market or Customer Segments

- Groups similar in specific ways relevant to marketing
  - Who, where, when, why, what, how many?
- Market segmentation: Broad categories
  - Customer segmentation: Refinement based on attributes
- Intermediate versus ultimate customers
- Internal versus external customers

## Market and Customer Segmentation

“The practice of dividing a customer base into groups that are similar in specific ways relevant to marketing.”

### Customer Value Proposition

- What the customer will and will not pay for

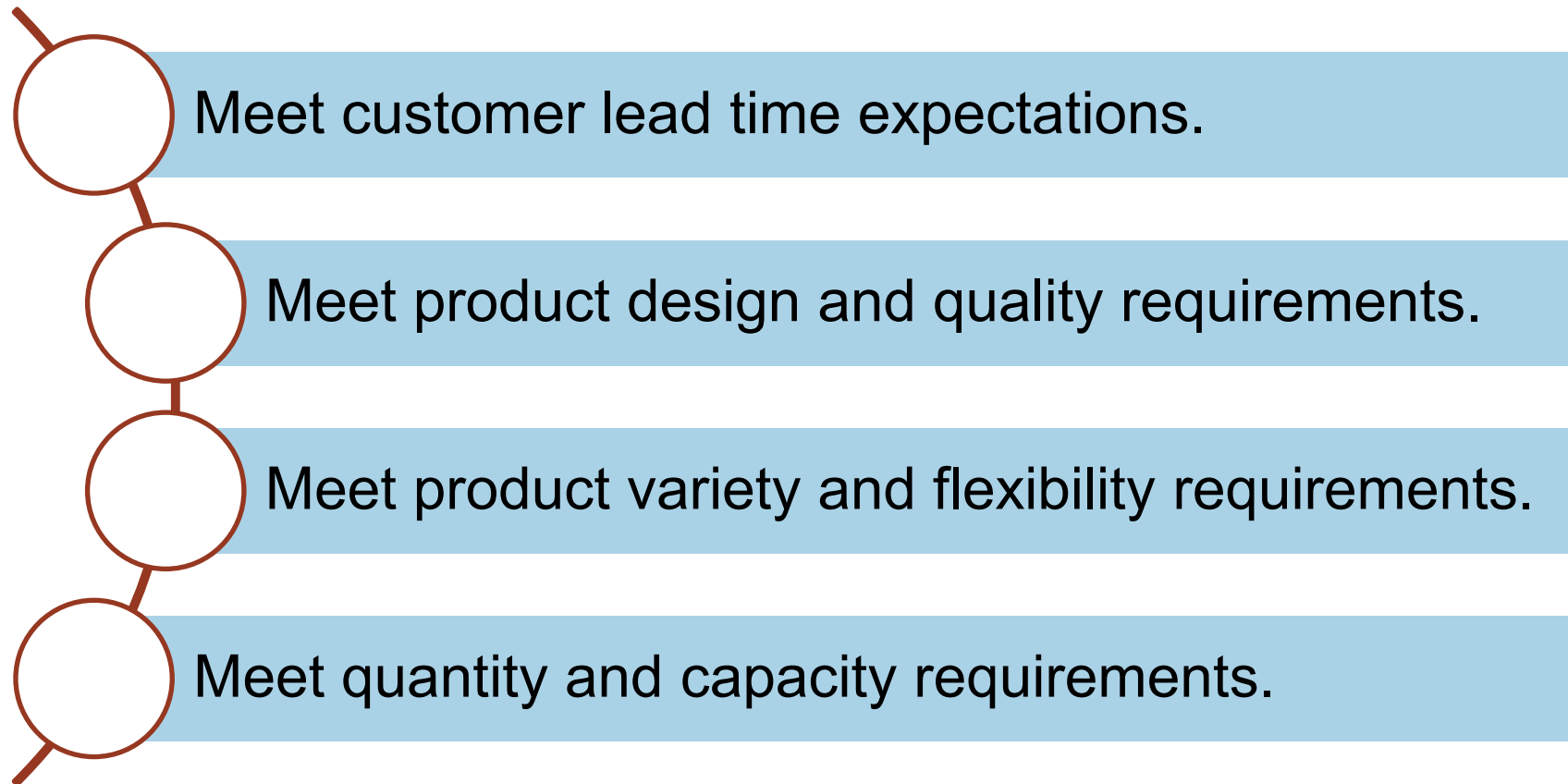
### Customer Experience

- The voice of the customer
- How the customer uses the products

### Value of Customer Segment

- Cost of acquiring and keeping customers
- Relative value of customer segments

## Local Strategic Design Principles for Customers

- 
- Meet customer lead time expectations.
  - Meet product design and quality requirements.
  - Meet product variety and flexibility requirements.
  - Meet quantity and capacity requirements.

# Customer Segments and Strategic Objectives

## Generic Performance Objectives at the Functional Level

Category	Description	Tradeoff
Speed	Time to market, lead times, output, and/or delivery	Fast equipment may be less flexible; speed has a cost.
Dependability	Promise fulfillment, on-time delivery, product durability	Unused or redundant capacity adds flexibility and disruption resilience but at a cost.
Flexibility	Agility to ramp up or down in volume or change production mix without significant disruption	Flexibility can reduce economies of scale; specialized vs. generalized.
Quality	Fitness for use, product attributes, compliance with specifications	Tighter specification limits may limit speed or flexibility; lower long-term cost.
Cost	Goods at lowest price relative to competition, return on capital, business viability	Competitive price is qualifier; lowest price limits priorities.

# Customer Segments and Strategic Objectives

## Performance Objective Choices Exercise

Performance Objectives	Low-Cost Provider Strategy	Differentiation Strategy
Quality		X
Speed	X	
Dependability		X
Flexibility		X
Cost	X	

1. Explain your choice of key performance objectives for a low-cost provider strategy.
2. Explain your choice of key performance objectives for a differentiation strategy.

## Objectives of Supply Chain Management Discussion

1. Describe at least two types of quality that are critical to supply chain responsiveness, and explain why.
2. What are two types of performance characteristics that relate to the performance objective of speed?
3. How does the dependability performance objective relate to cost?
4. What is the relationship between the performance objective of flexibility and a competitive strategy based on innovation and differentiation?
5. Name two types of cost reductions that are critical to a low-cost provider strategy.

## Defining Customers and Product-Service Parameters

### Which customer segments?

- Industrial
- Consumer
  - Market segments
- Institutional
- Government

### How will we reach them?

- Sales channels

### What products/services?

- Product positioning
- Number of lines
- Price/market share/profit
- Quality
- Brand name or generic
- Packaging
- Returns policy

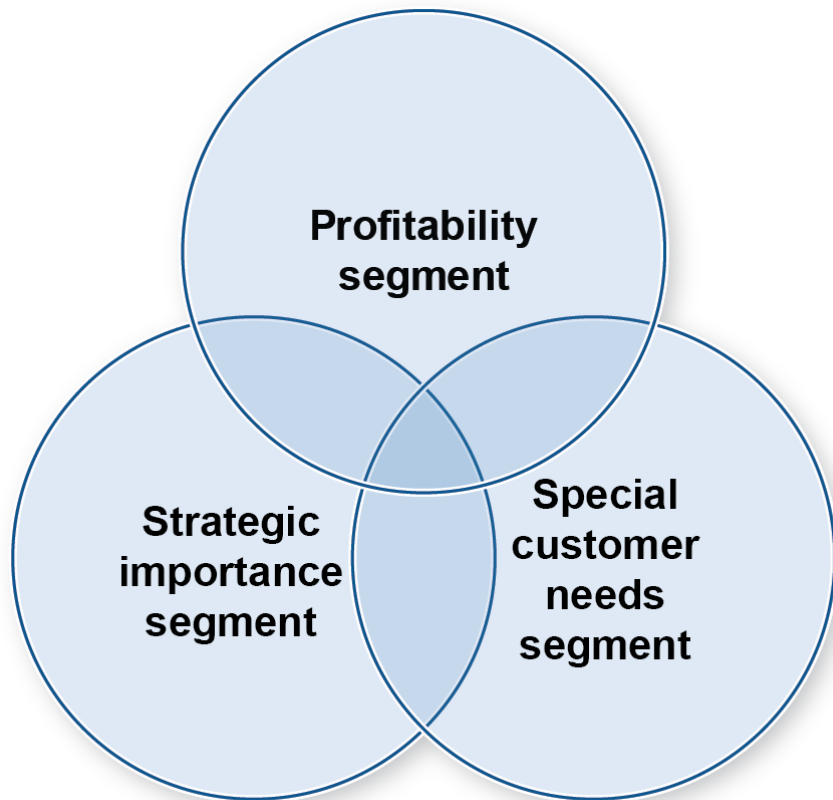
Manufacturing environment,  
process type, and layout choices

Product and  
service design

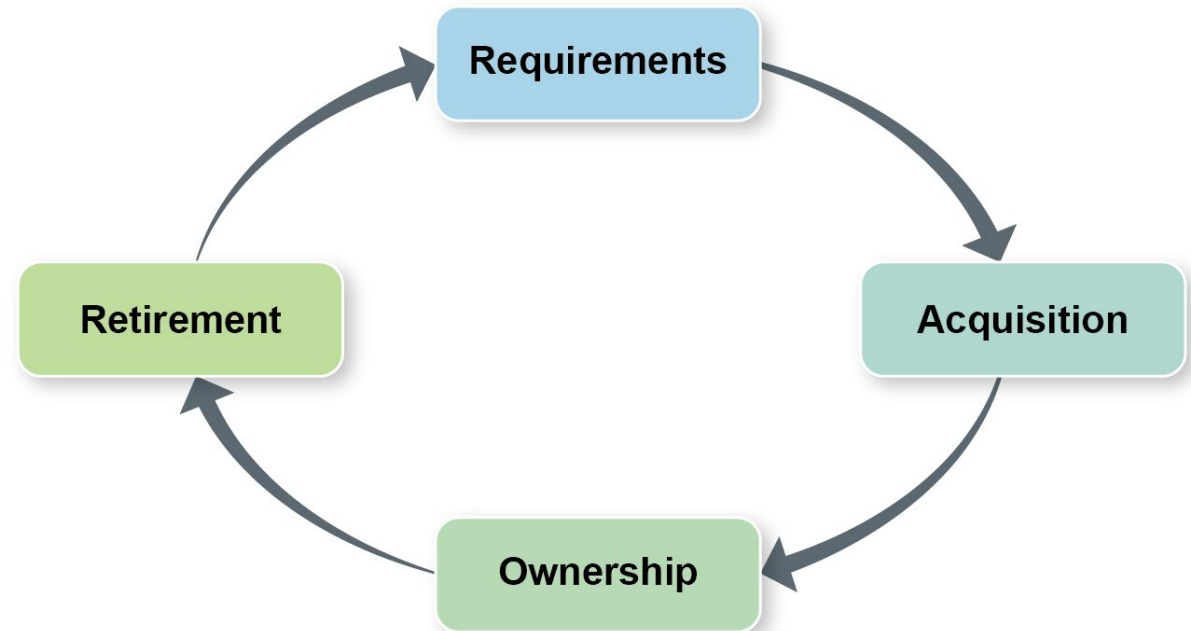
# Customer Relationship Management

## CRM: Philosophy of Putting the Customer First

### Criteria for customer segmentation



### Customer service life cycle



## The “Rights” of Customer Service

- The customer is always right.
- Customer-oriented organizations balance
  - Customer needs and wants
  - Organization’s strategic and business objectives.

### The seven “rights” of customer service

- Right customers
- Right goods and services
- Right price
- Right quality
- Right quantity
- Right time
- Right place

## Customer Service

Cycle Steps	Examples of Key Activities
Customer inquiry, order	Request price and availability.
Order entry	<ul style="list-style-type: none"><li>▪ Check price and inventory available-to-promise.</li><li>▪ Configure as necessary.</li><li>▪ Promise and send order confirmation to customer.</li><li>▪ Create sales order in system.</li><li>▪ Reserve or allocate items to specific sales orders.</li></ul>
Shipping and delivery	<ul style="list-style-type: none"><li>▪ Consolidate and route shipments.</li><li>▪ Prepare pick lists.</li><li>▪ Prepare bills of lading and packing slips.</li><li>▪ Send advanced shipping notices.</li></ul>
Invoicing	<ul style="list-style-type: none"><li>▪ Prepare invoices.</li><li>▪ Transmit electronically or by other means.</li></ul>

## Order Promising

### **Available-to-promise (ATP)**

- Response to customer order inquiries

### **Capable-to-promise (CTP)**

- Committing orders against available capacity and inventory
- Multiple supply sites
- Uses finite scheduling model
- Considers constraints
- Less expediting needed

### **Abnormal demand**

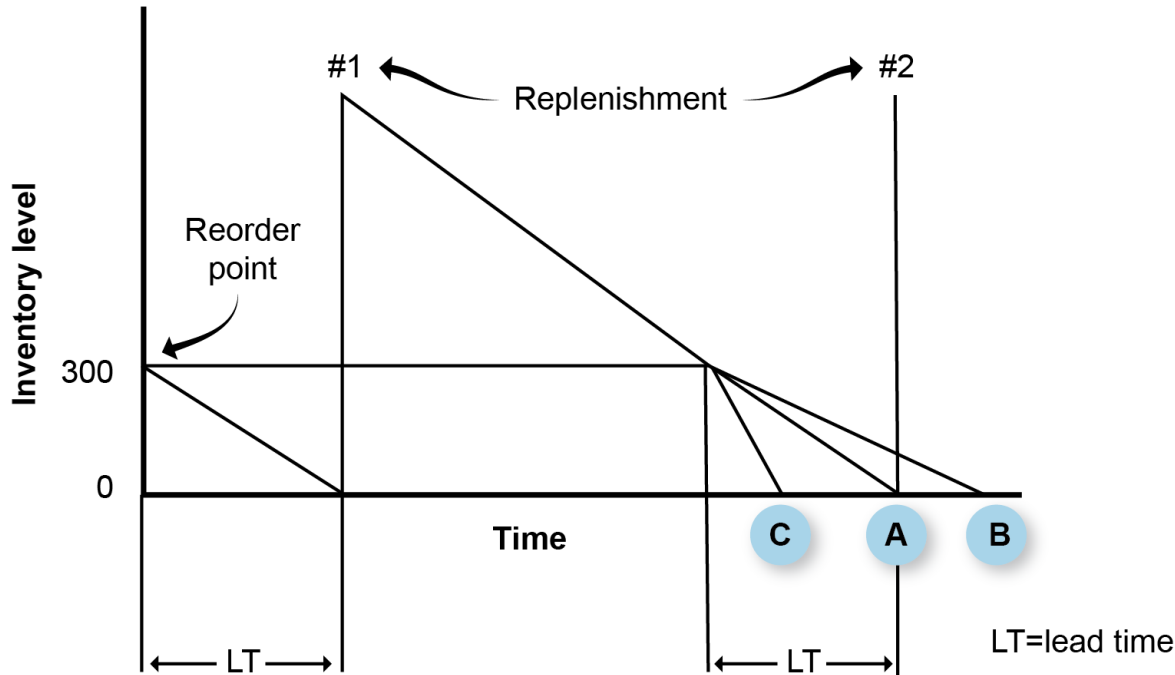
- Demand in any period that is outside the limits established by management policy

## Customer Service Policies

- Customer focus
- Service levels
- Performance measurement
- Systems support
- Customer interface
- Culture
- Top management support
- Integration with strategic goals

# Customer Service Methods

## Safety Stock



Additional inventory to prevent customer dissatisfaction and loss of revenue caused by demand and supply uncertainty

Point A: Zero inventory level is reached at replenishment; no stockout.

Point B: Zero inventory level is not reached before replenishment occurs; no stockout.

Point C: Zero inventory level is reached before replenishment; stockout!

## Internal Communications

### Communication among processes/subprocesses

- S&OP
- CRM
- Master scheduling
- Demand management
- Order management
- Order visibility

### Patterns and preferences

- Purchasing patterns
- Shipping preferences

### Visibility data sources

- Transaction records
- Sales representatives
- Field service representatives
- Market intelligence

## Differences in Communications by Environment

	<b>MTO/ETO</b>	<b>ATO</b>	<b>MTS</b>
<b>S&amp;OP</b>	Engineering detail and demand forecasts	Product family mix and demand forecasts	Demand forecasts
<b>MPS</b>	Final configurations	Actual demand and mix forecasts	Actual demand
<b>Customers</b>	Delivery date and design status	Delivery date and configuration issues	Next inventory replenishment

## Customer Value and Service Metrics

### **Satisfaction rankings**

- Most common tool used to measure customer satisfaction is surveys.

### **Lifetime customer value**

- Decrease marketing cost.
- Easier to satisfy over time.
- Opportunity for additional revenue and profit.

### **Service levels by segment**

- Level of service and organizational commitment to attaining that level varies by segment.

## Order Delivery Performance Metrics

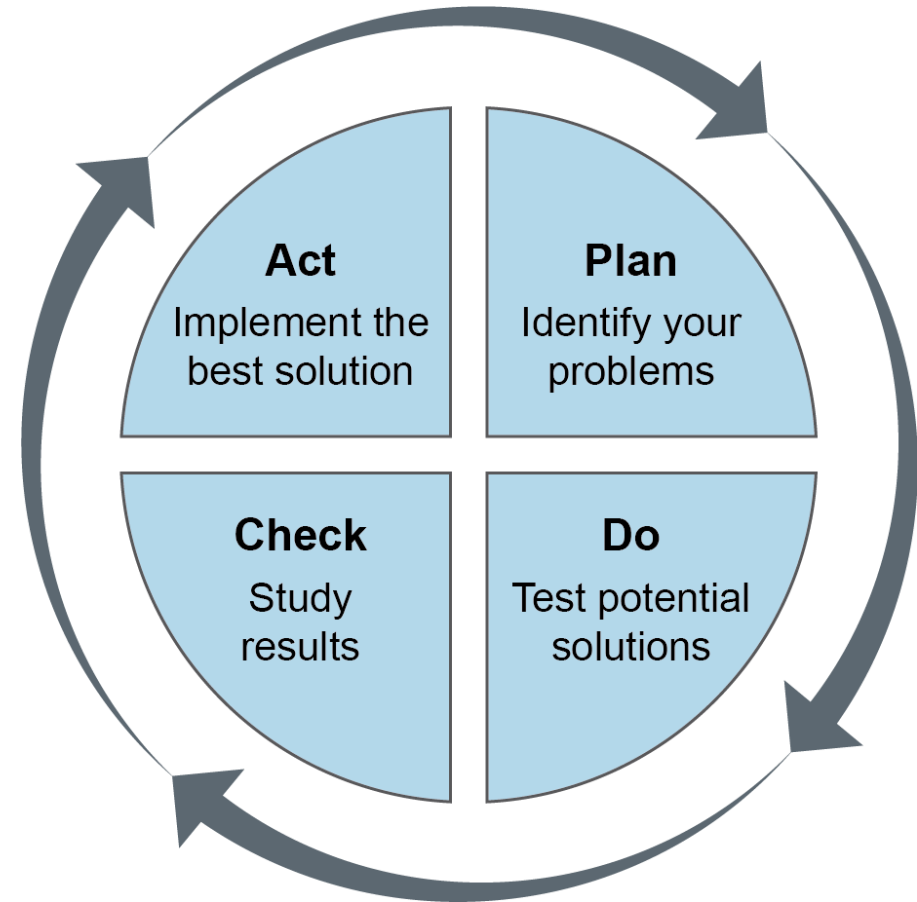
### Additional metrics

- Manufacturing or retail environment impact on delivery performance
- Cash-to-cash cycle time
- Return on supply chain fixed assets

Attribute	Metrics
<b>Reliability</b>	<ul style="list-style-type: none"><li>▪ Perfect order fulfillment</li><li>▪ Delivered on time</li><li>▪ Delivered in full</li><li>▪ Correct condition</li><li>▪ Correct place</li></ul>
<b>Responsiveness</b>	<ul style="list-style-type: none"><li>▪ Order fulfillment cycle time</li><li>▪ Order entry time</li><li>▪ Dwell time for future dated orders</li><li>▪ Make, distribute, transport time</li></ul>
<b>Agility</b>	<ul style="list-style-type: none"><li>▪ Upside supply chain flexibility</li><li>▪ Upside supply chain adaptability</li><li>▪ Downside supply chain adaptability</li><li>▪ Overall value at risk</li></ul>
<b>Cost</b>	<ul style="list-style-type: none"><li>▪ Supply chain management cost</li><li>▪ Total cost to serve</li></ul>

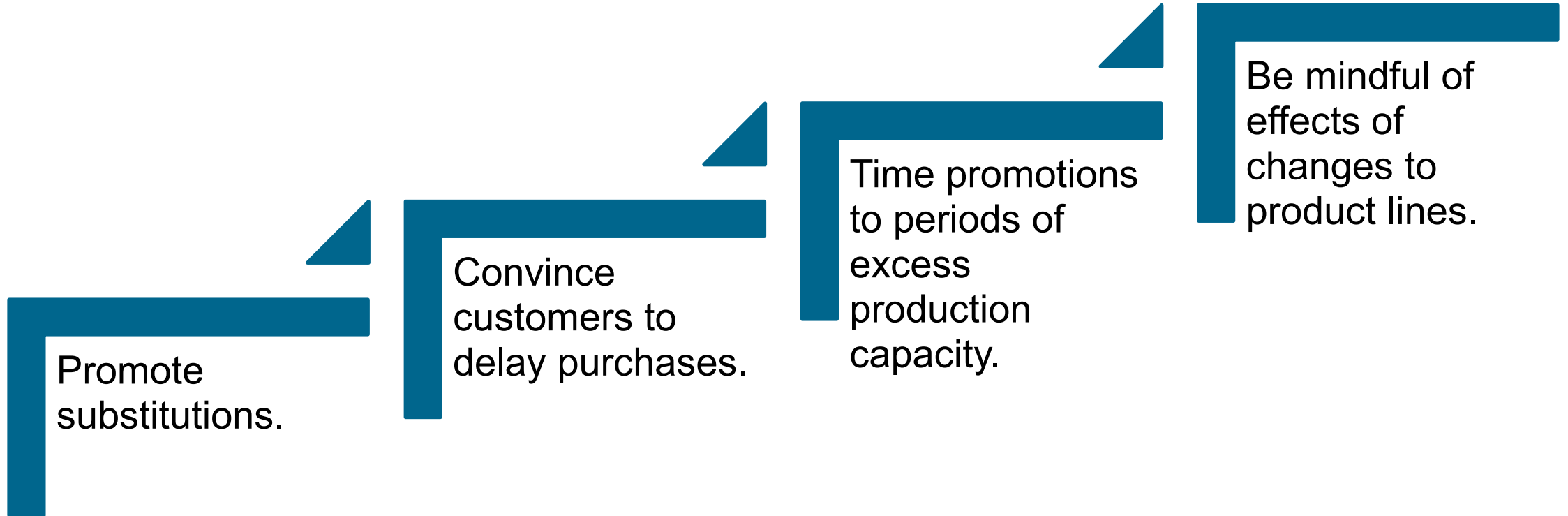
## Using PDCA for Planning and Influencing Demand

- **Plan**
  - Develop budget, schedule, tasks, and targets.
- **Do**
  - Launch, manage, and retire products.
- **Check**
  - Review and analyze performance.
- **Act**
  - Address variances, replan.



# Influencing Demand and Product Designs

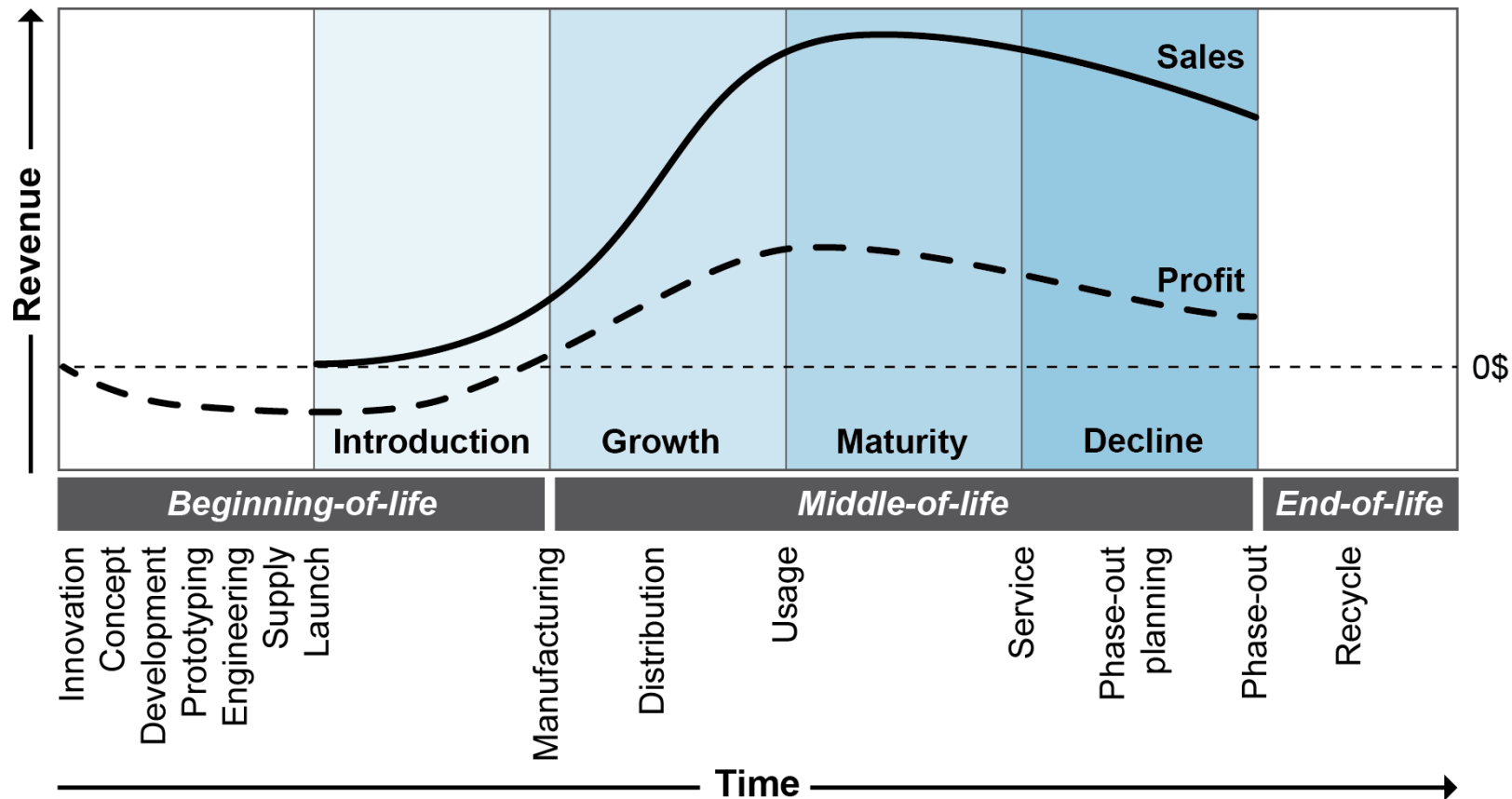
## Prioritizing Demand



# Influencing Demand and Product Designs

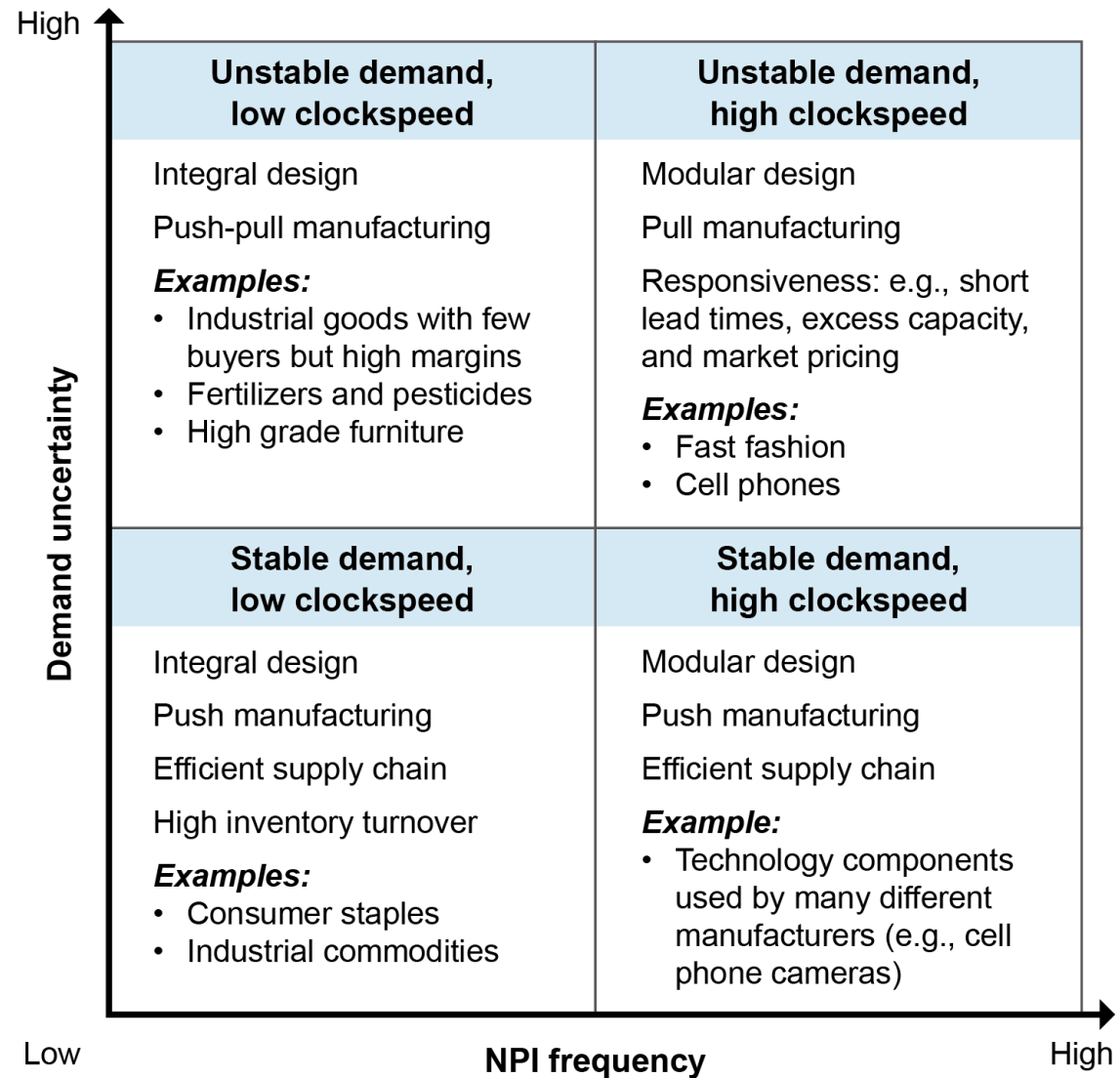
## Product Lifecycle Management

PLM is also used to track life cycles of individual lots or units.

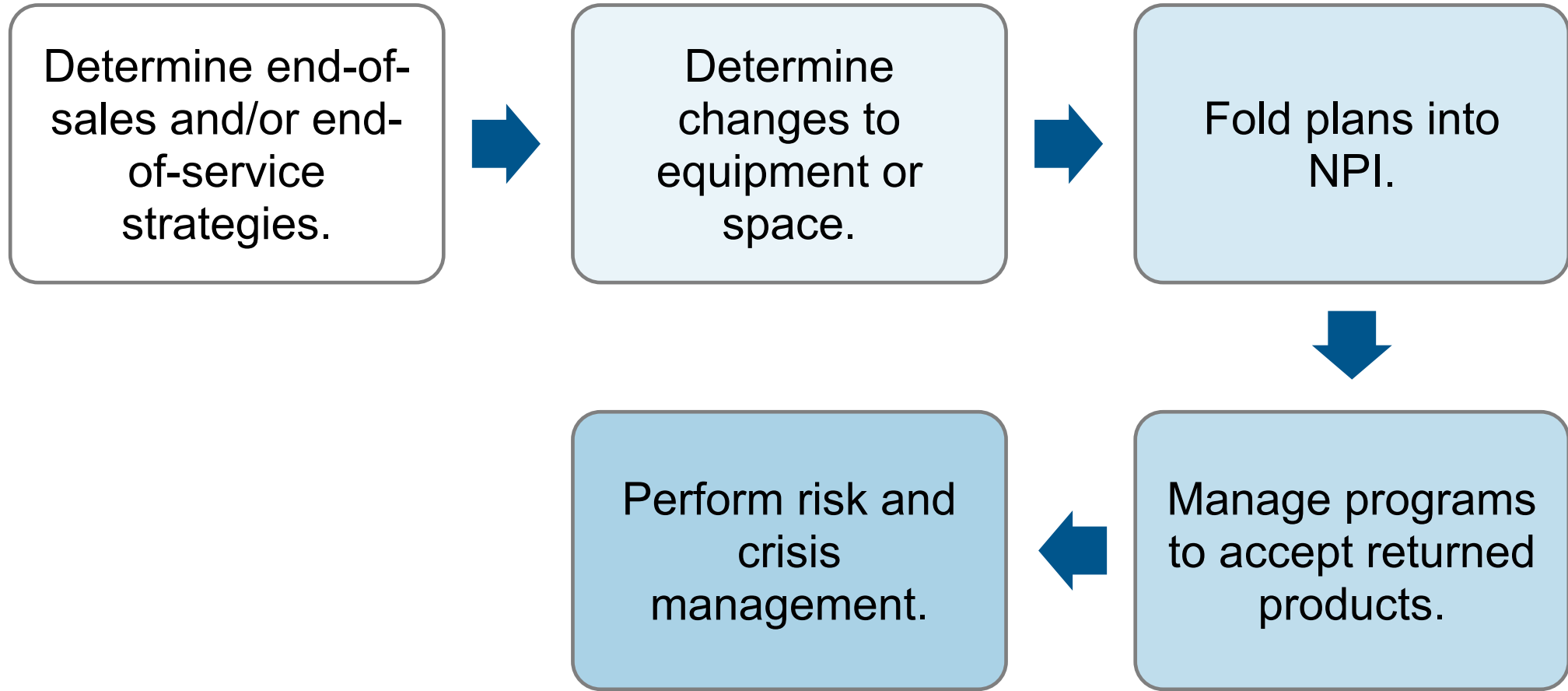


# Influencing Demand and Product Designs

## NPI Frequency versus Demand Uncertainty



## End-of-Life Plan Elements



## Influencing Product Designs

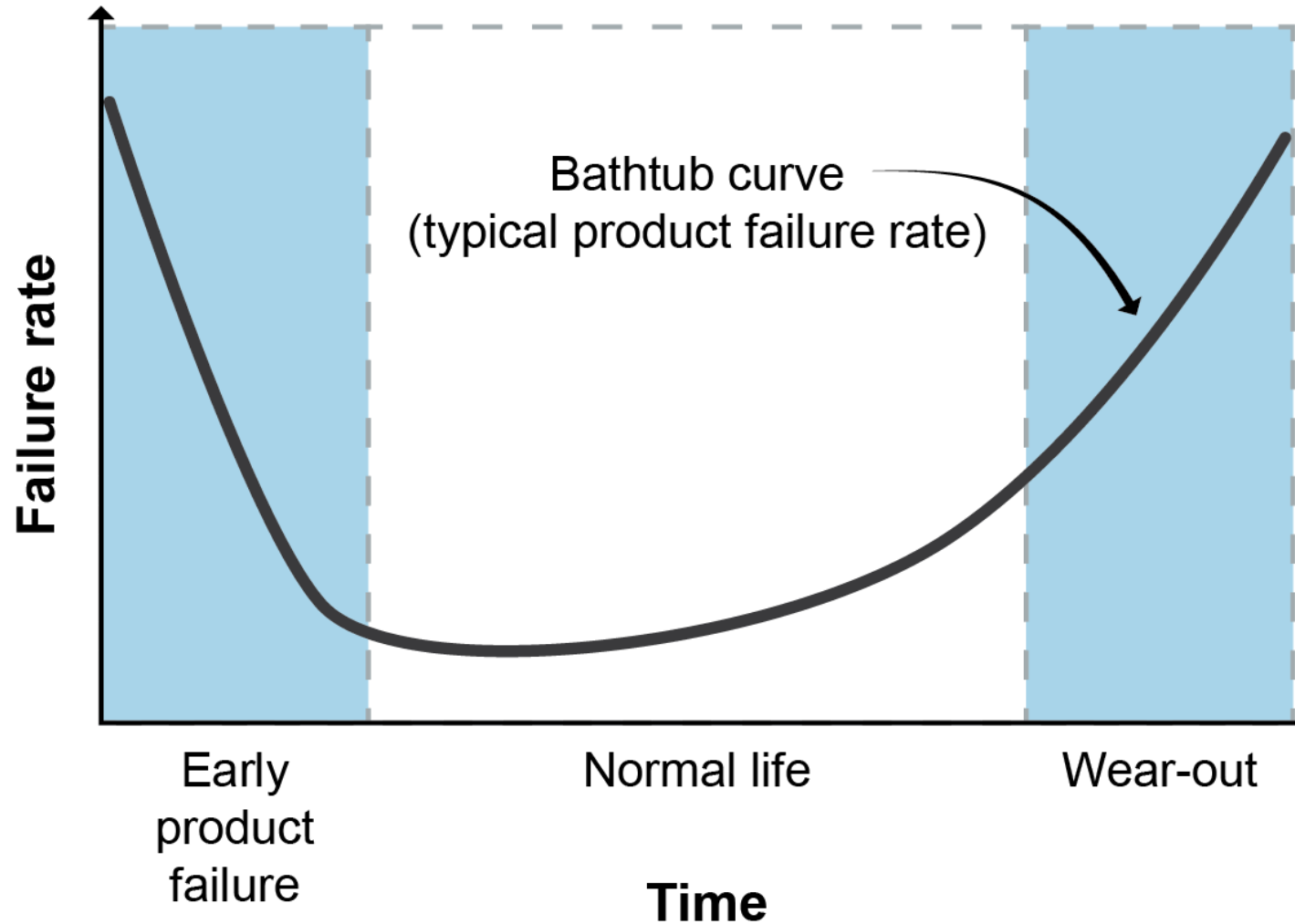
### Quality function deployment

- Capture the voice of the customer.
- Use multidisciplinary teams.
- Improve planning.

### Participative design/engineering (concurrent engineering)

- Meet internal/external customer needs.
- Consider all inputs together for fewer product/process design changes.
- Compress time from concept to introduction.
- Prevent quality and reliability problems.
- Reduce cost.

## Bathtub Curve



## Design for Manufacturability and Maintainability

### Tradeoffs

- Reliability vs. maintainability
- Modular vs. nonmodular construction
- Repair vs. disposal
- Built-in vs. external test equipment
- Person vs. machine



# Influencing Demand and Product Designs

## Identifying Engineering Changes

Type of Change	Product Issue/Reason for Change	Action Required
Mandatory	<ul style="list-style-type: none"><li>Failure to function</li><li>Safety issue</li><li>Legal compliance</li></ul>	<ul style="list-style-type: none"><li>Immediate</li><li>Engineering change notice</li><li>Design review board process</li></ul>
Phased-in/ optional	<ul style="list-style-type: none"><li>Product improvement or correction</li><li>Adapting product or manufacturing process to new life cycle phase</li><li>Customer request</li><li>Cost reduction</li><li>Process improvement</li></ul>	<ul style="list-style-type: none"><li>Phase-out or modification of existing products</li><li>Review of options for effectivity date</li><li>Engineering change notice</li><li>Design review board process</li></ul>

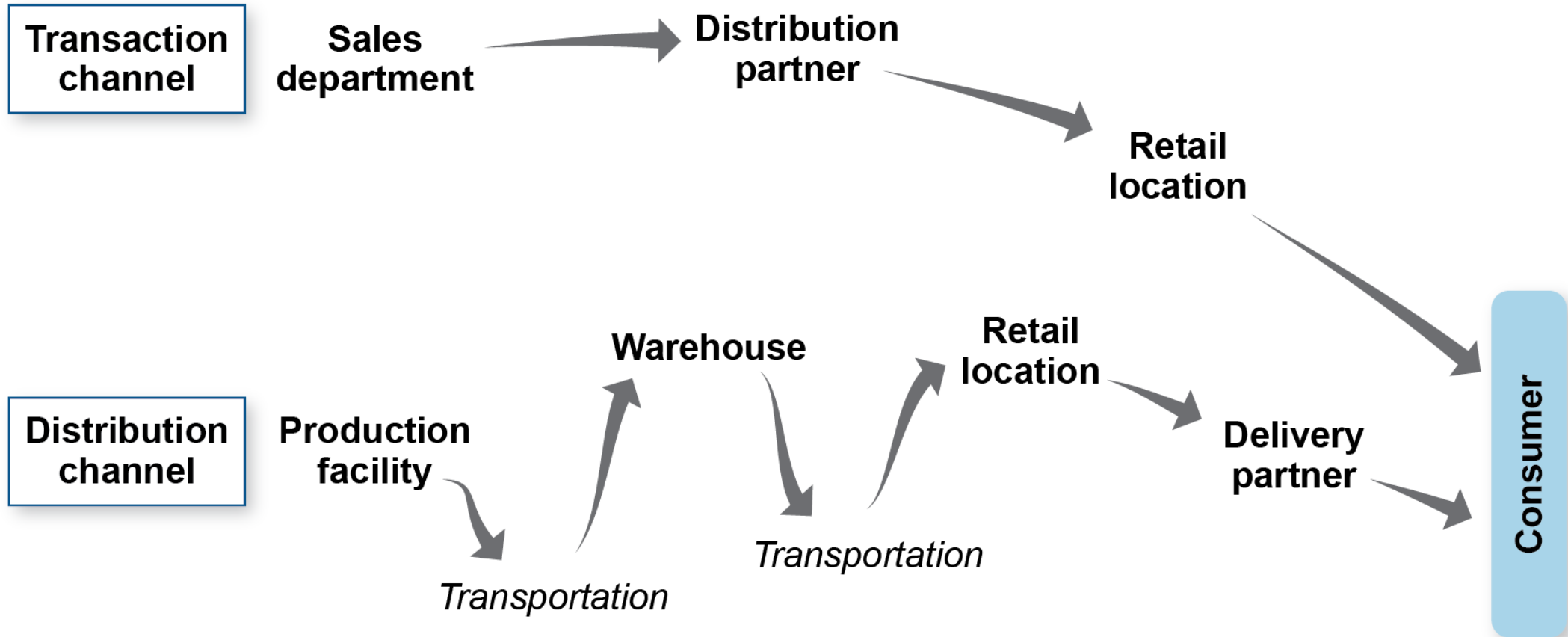
# **CPIM** CERTIFIED IN PLANNING AND INVENTORY MANAGEMENT

## **SECTION B: SOURCES OF DEMAND/ FORECASTING**

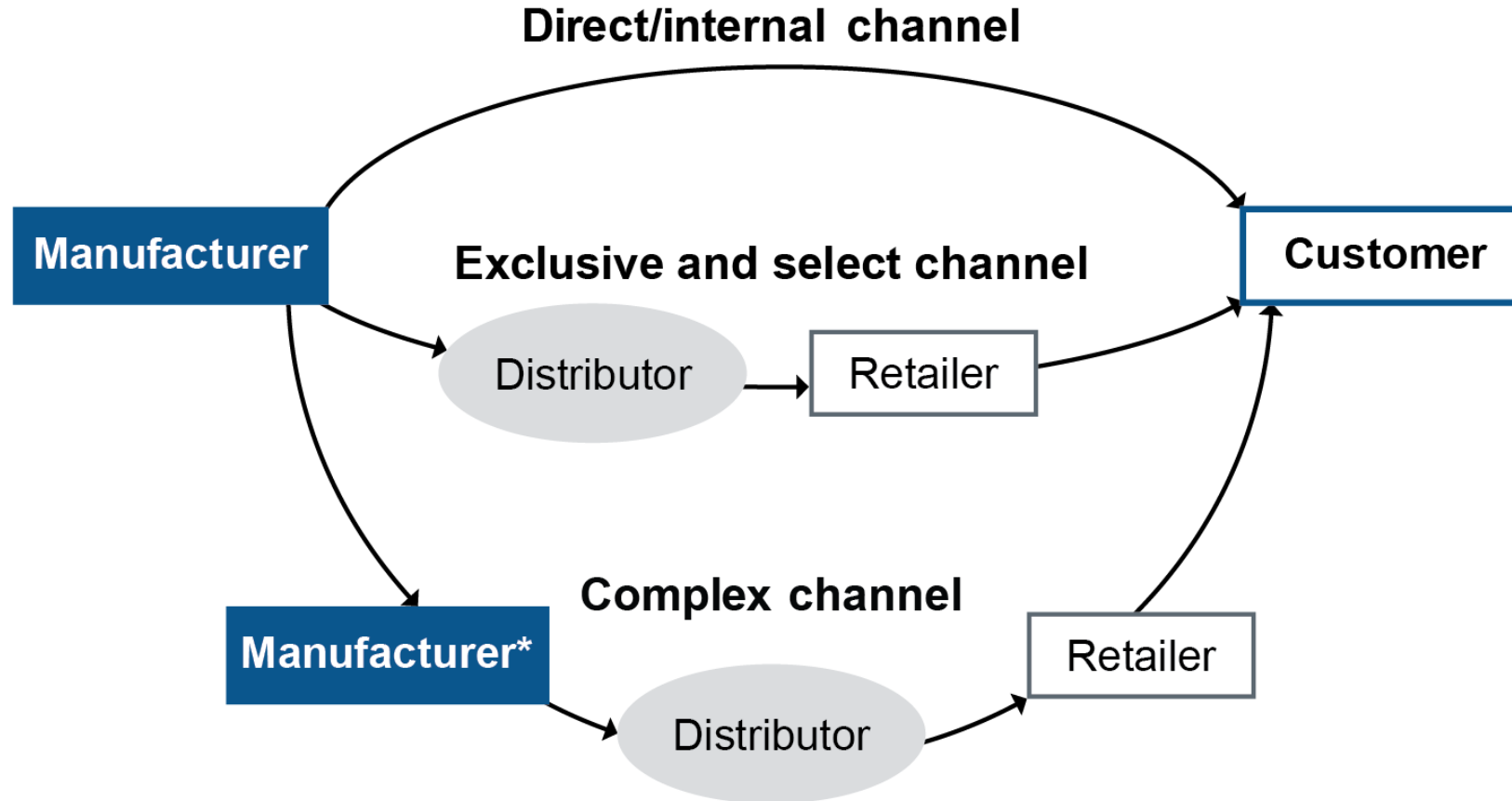
## Section B Learning Objectives

- Sources of demand in master scheduling, including B2B and B2C
- Direct/internal; exclusive and select; and complex distribution channels
- Dependent and independent demand
- Key forecasting principles
- Forecast horizon and interval
- Forecasting process
- Qualitative and quantitative (extrinsic and intrinsic) forecasting methods
- Forecasting method pros and cons and selection criteria

## Distribution and Transaction Channels



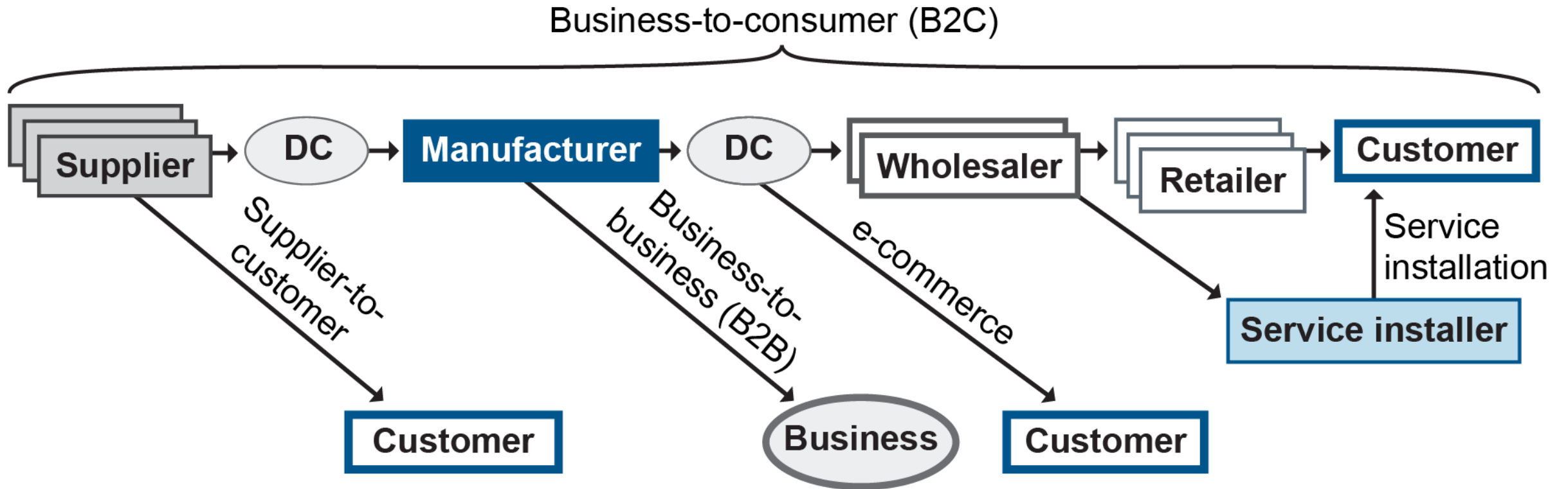
## Distribution Channels



\* Regional distribution centers owned by manufacturer

# Demand Channels and Sources

## Distribution Channels



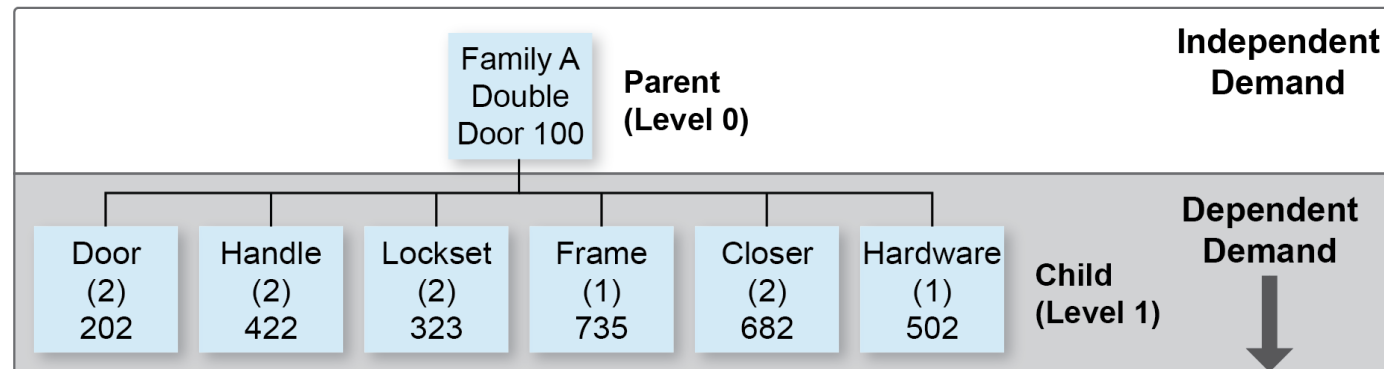
## Dependent versus Independent Demand

### Independent

- Demand for an item unrelated to the demand for other items
- Forecasted

### Dependent

- Demand that is directly related to or derived from bill-of-material structure for other items or end products
- Calculated, not forecasted



## Item Forecasts: Sources of Forecast Data

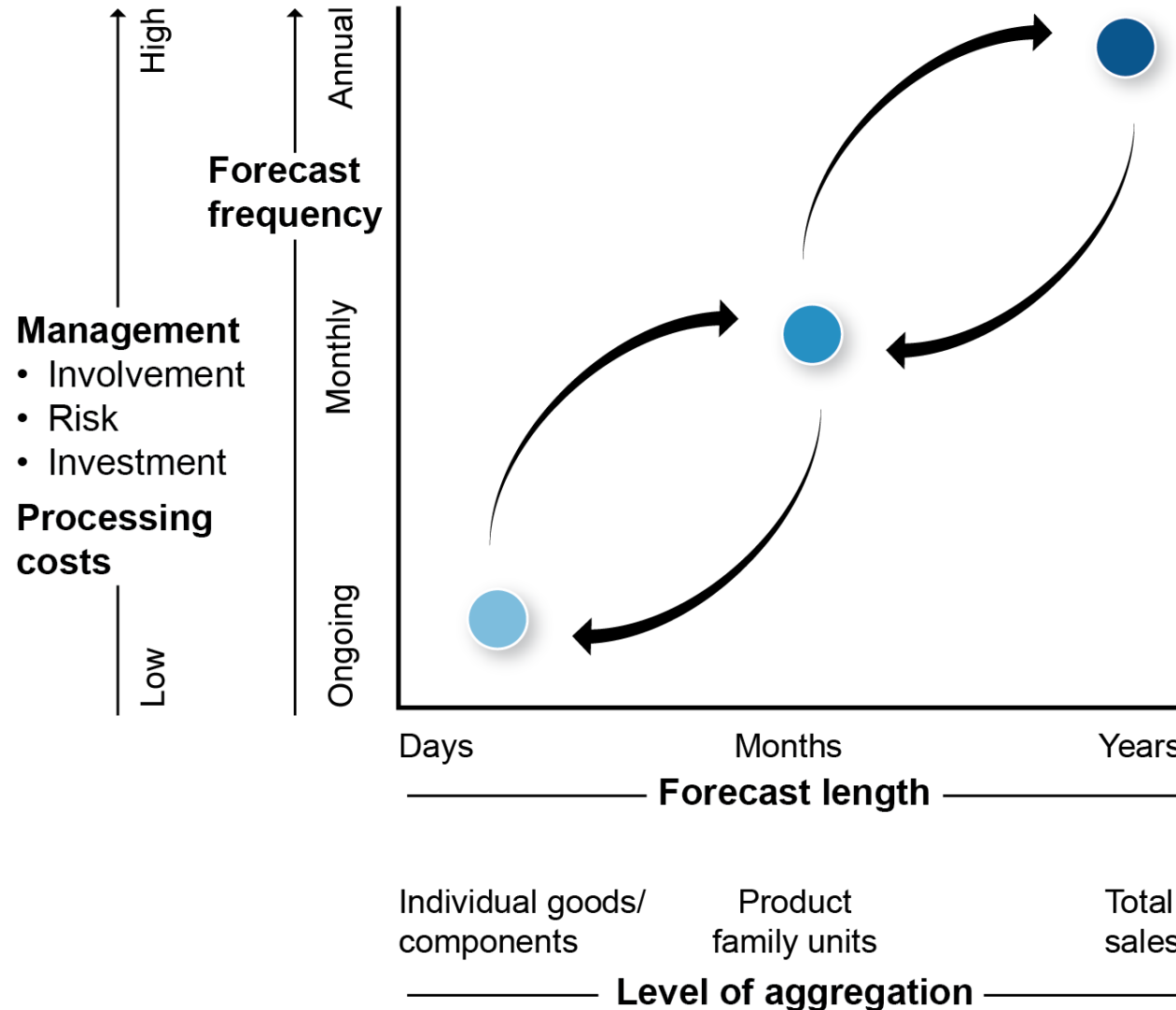
Source	Demand Inputs
Demand management	<ul style="list-style-type: none"><li>▪ Channel family-level forecasts disaggregated to mix level, then end-item level at lowest level stocking points.</li><li>▪ Item forecasts for lowest level stocking points (using time series analysis, etc.) rolled up regionally to systemwide total for master scheduling.</li></ul>
Sales	<ul style="list-style-type: none"><li>▪ Sales force estimates for inventory storage locations.</li><li>▪ Replenishment needs for vendor-managed inventory.</li></ul>
Marketing	<ul style="list-style-type: none"><li>▪ Promotions that will cause demand spikes.</li></ul>
CRM	<ul style="list-style-type: none"><li>▪ Customer orders pending release to supplier.</li><li>▪ Changes in ordering patterns.</li></ul>
DCs and customers	<ul style="list-style-type: none"><li>▪ Reports of special events that will cause demand spikes.</li><li>▪ Recent anomalous purchases.</li></ul>

## Forecasting Principles

- Forecasts are wrong most of the time.
- Forecast not complete without reliability/error metrics.
- Avoid forecasting: Use actual demand if able. Actual demand:
  - “Composed of customer orders or allocations of items, ingredients, or raw materials to production or distribution.”
  - Consumes the forecast.
- Aggregate demand to degree possible. Can aggregate:
  - Products (families)
  - Geographic areas
  - Time.
- Forecasts are more accurate in near term than long term.
- Match type to need:
  - Simpler is better.
  - Monitor routinely for appropriateness and quality.

# Forecasting Overview and Selection

## Creating and Using a Forecast



### Strategic planning

Forecasting techniques

- Management judgment
- Economic growth models
- Regression

### S&OP

Forecasting techniques

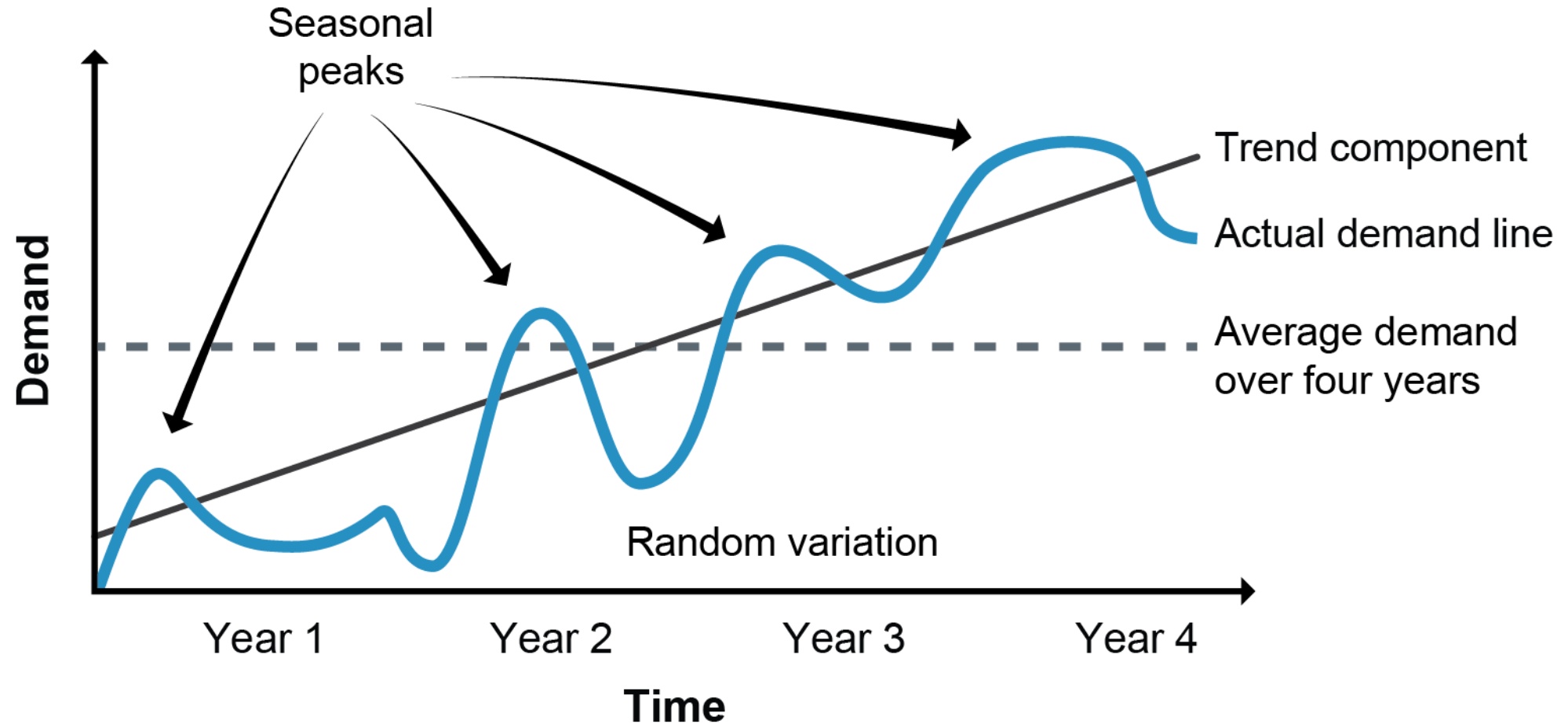
- Aggregation of detailed forecasts
- Customer plans
- Regression

### Master production scheduling & control

Forecasting techniques

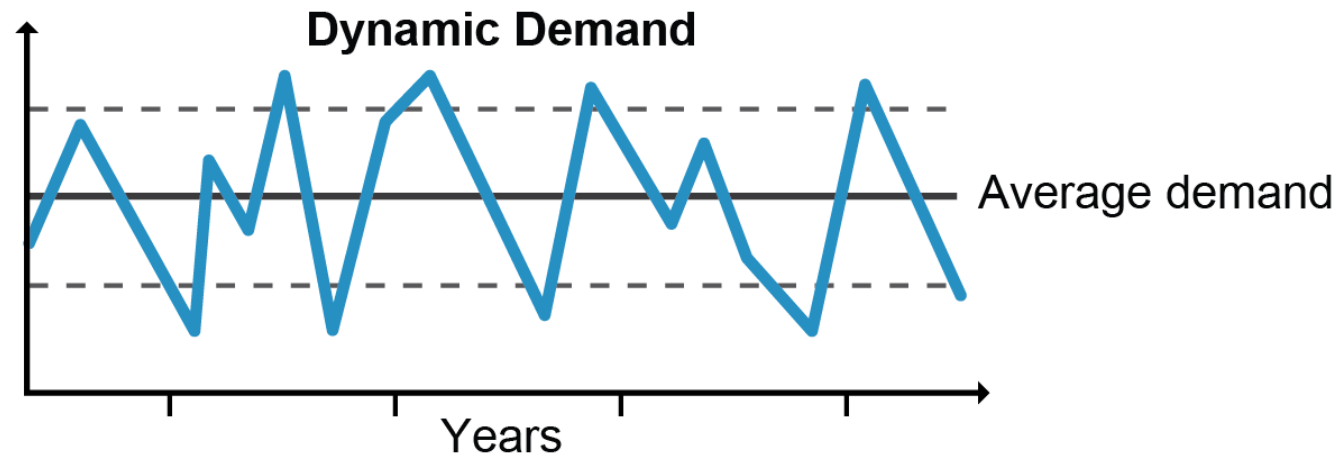
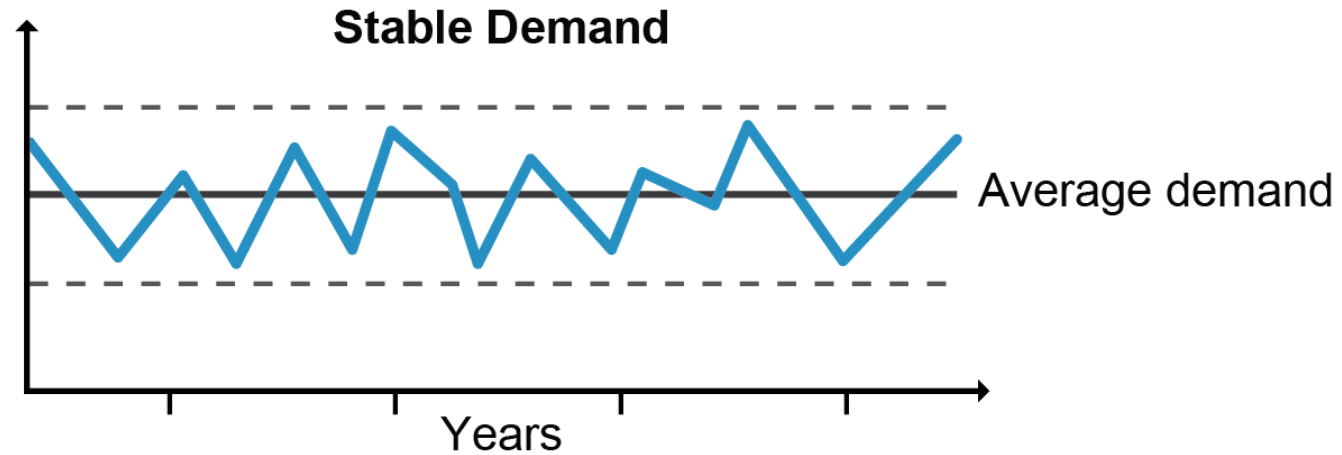
- Moving averages
- Exponential smoothing

## Demand Patterns



# Forecasting Overview and Selection

## Stable versus Dynamic Demand



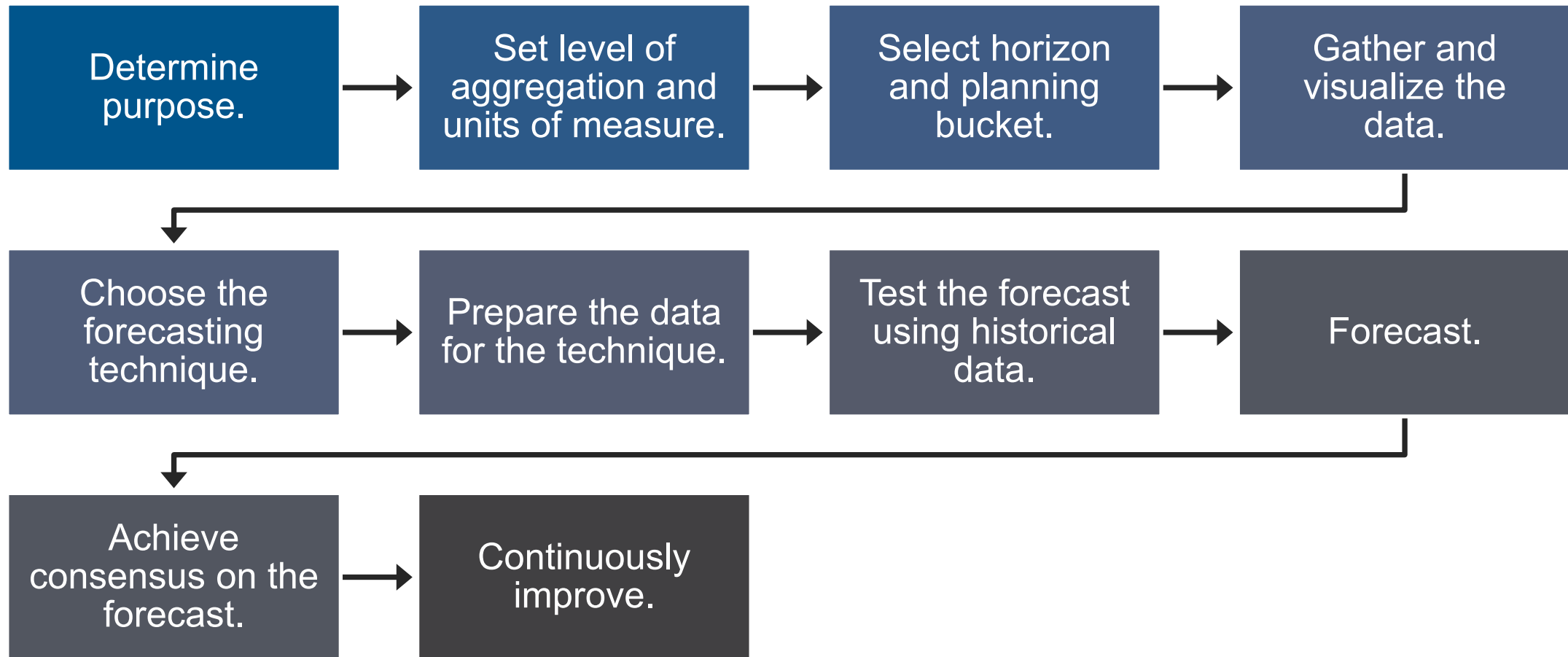
# Forecasting Overview and Selection

## Demand Variation by Environment

Environment	Types of Uncertainty Requiring Forecasting
<b>MTS</b>	Variations in demand stated in forecasts for each inventory location
<b>ATO</b>	Variations in quantity, customer order timing, and product mix
<b>MTO</b>	Size of the backlog and the level of company resources needed to finish the engineering and make products per specifications
<b>ETO</b>	Hiring difficult-to-find design engineers and ordering materials with long lead times

# Forecasting Overview and Selection

## Forecasting Process



# Forecasting Overview and Selection

## Data Collection and Preparation Principles

- Forecast based on demand, not orders. Estimate demand from net sales, backorders, and requests that had to be turned away and/or filled from other plants.
- Collect data in needed format.
- Record related circumstances.
- Separate demand by customer segment.



Month	1	2	3	4	5	6	7	8	9	10	11	12	SUM
Segment A			6,000						6,000				12,000
Segment B	478	470	440	360	330	290	260	200	160	190	280	420	3,878
B avg.	323	323	323	323	323	323	323	323	323	323	323	323	
A+B avg.	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	1,323	

## Information Needs by Environment

All manufacturing environments require sharing the forecast and other data among various functions, including sales and operations planning (S&OP), master scheduling (MS), and their customers.

- MTS uses forecasts for S&OP and actual demand for the master production schedule (MPS).
- ATO will use product family mix for S&OP and mix forecasts and actual demand for the MPS.
- MTO will need engineering detail for S&OP but final configuration for the MPS.
- ETO may use similar products with focus on engineering hours for S&OP and the MPS.

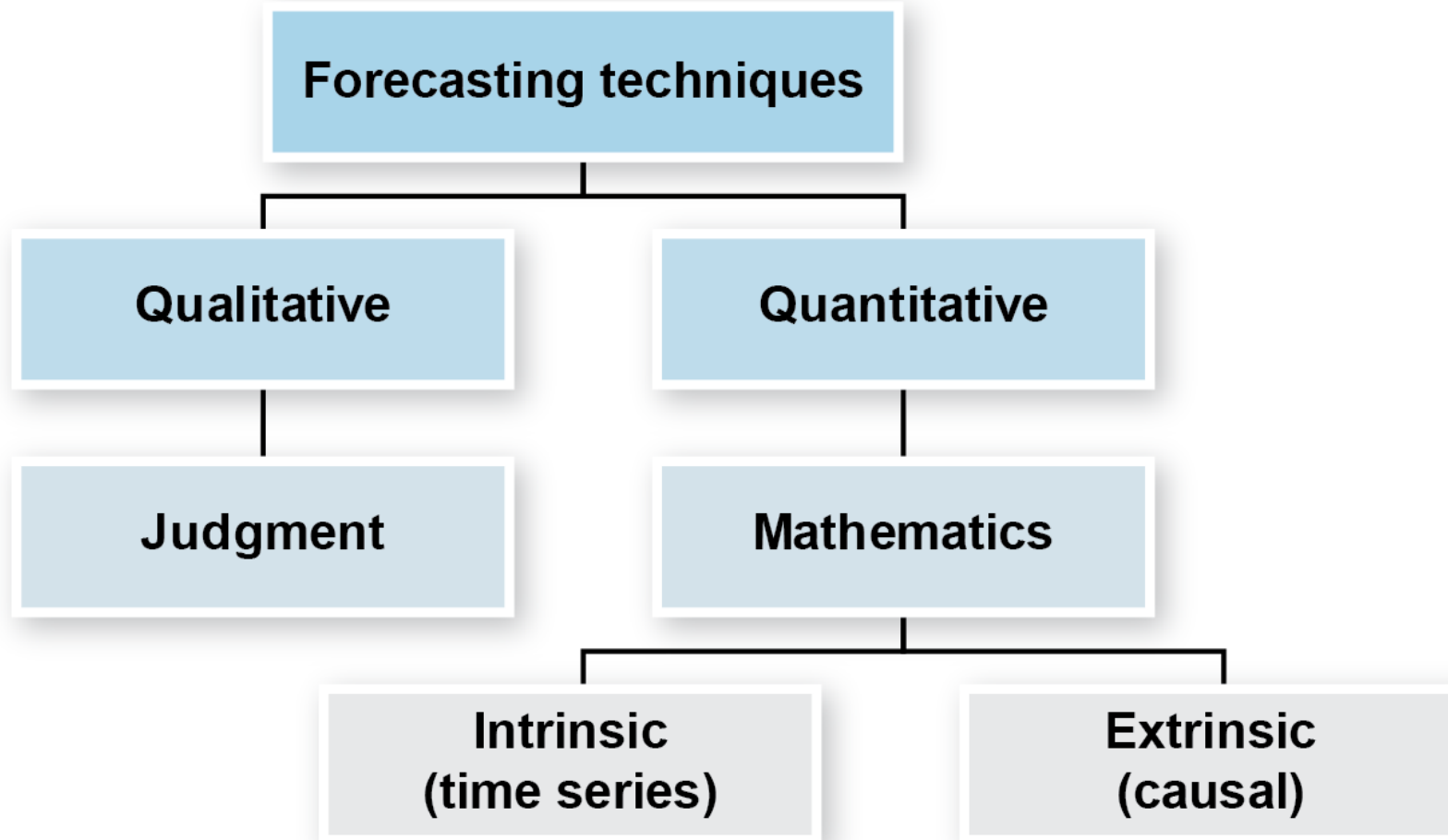
# Forecasting Overview and Selection

## Forecast Audiences by Planning Level

Audience	Use
Business planning	<ul style="list-style-type: none"><li>▪ Set a direction.</li><li>▪ Plan product expansions and introductions.</li><li>▪ Evaluate strategic growth options.</li></ul>
S&OP	<ul style="list-style-type: none"><li>▪ Reconcile functional plans with planned output.</li></ul>
Master planning and scheduling	<ul style="list-style-type: none"><li>▪ Determine the number and timing of finished products.</li><li>▪ Provide input into rough-cut capacity plan.</li></ul>
Distribution requirements planning	<ul style="list-style-type: none"><li>▪ Plan inventory levels at DCs and inventory replenishment schedules.</li></ul>

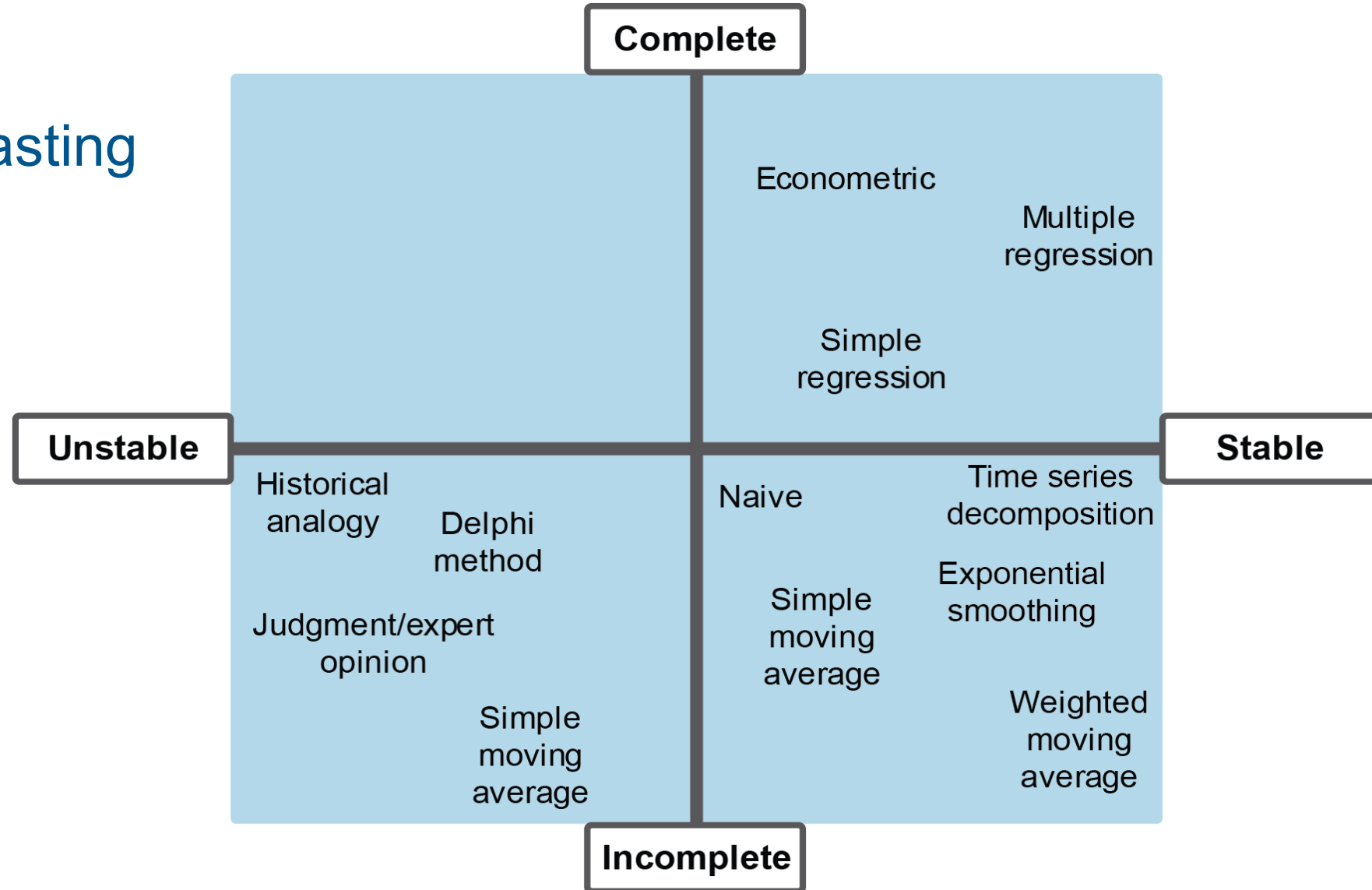
# Forecasting Overview and Selection

## Forecast Selection



# Forecasting Overview and Selection

## Variables Affecting Selection of Forecasting Method



## Qualitative Forecasting Methods

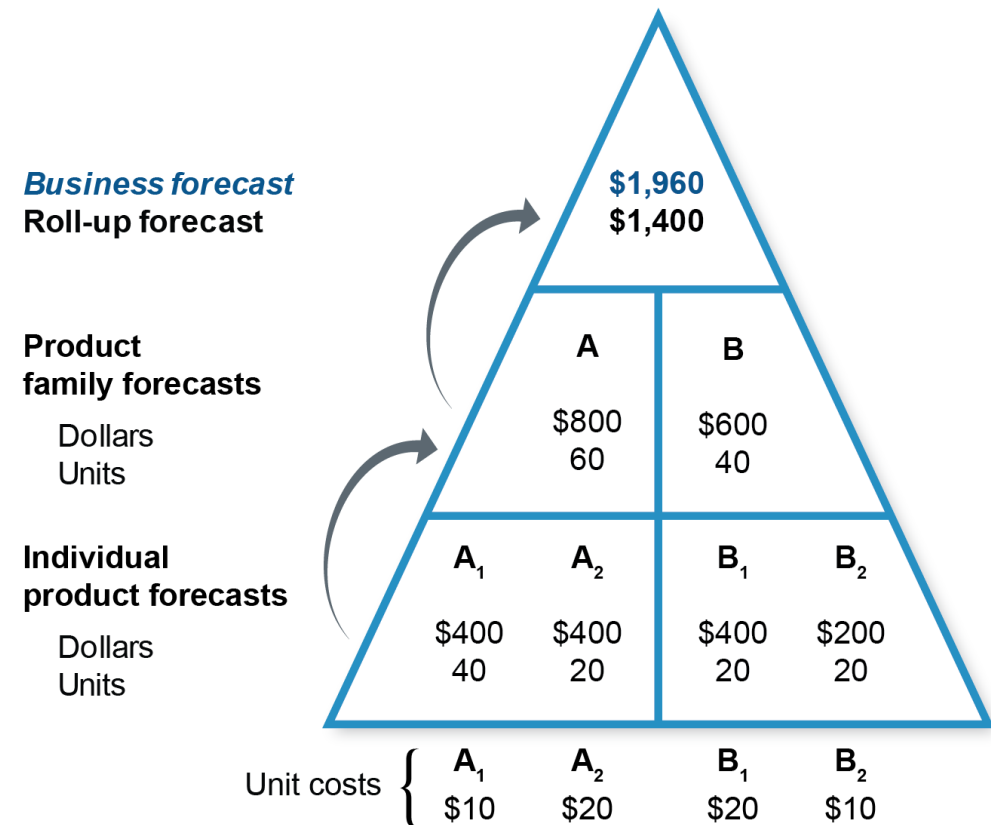
- Subjective approach based on intuitive or judgmental evaluation.
- Used when data is scarce, not available, or no longer relevant.
- May modify a quantitative forecast.
- Qualitative techniques:
  - Historical analogy (e.g., similar product)
  - Judgmental/expert opinion: experts forecast or modify quantitative forecast
  - Delphi method
  - Pyramid forecasting: hybrid of qualitative and quantitative

## Qualitative Forecasting Methods

### Delphi method

- Combines the opinions of experts in a series of iterations, each iteration being used to develop the next.
- Anonymity is maintained to avoid groupthink or “stake in the ground” mentality.

### Pyramid forecasting



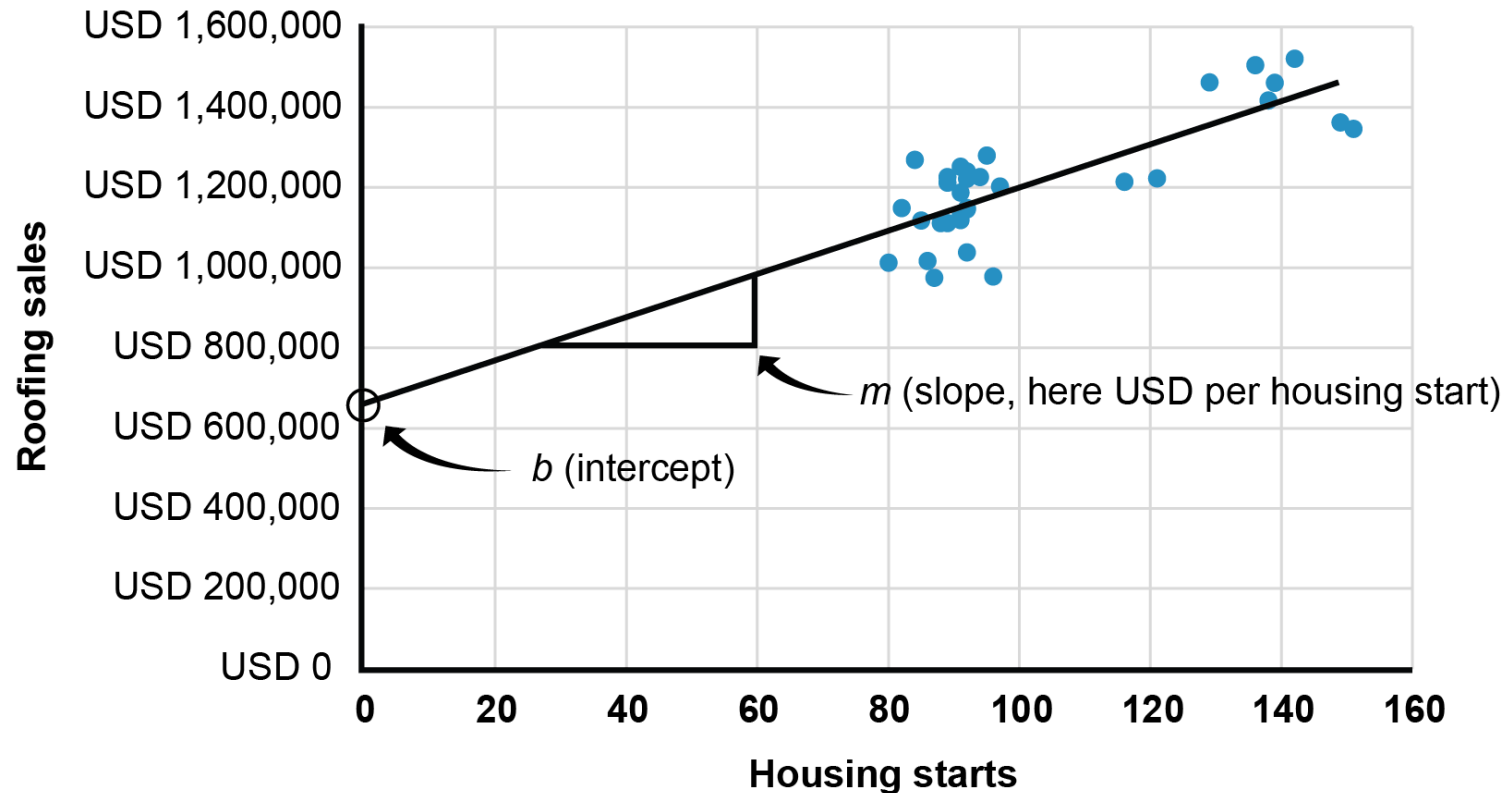
## Quantitative Forecasting Techniques

Approach where historical demand data is used to project future demand.

Quantitative techniques:

- Extrinsic (causal)
- Intrinsic (time series)

## Extrinsic (Causal) Techniques: Simple Regression



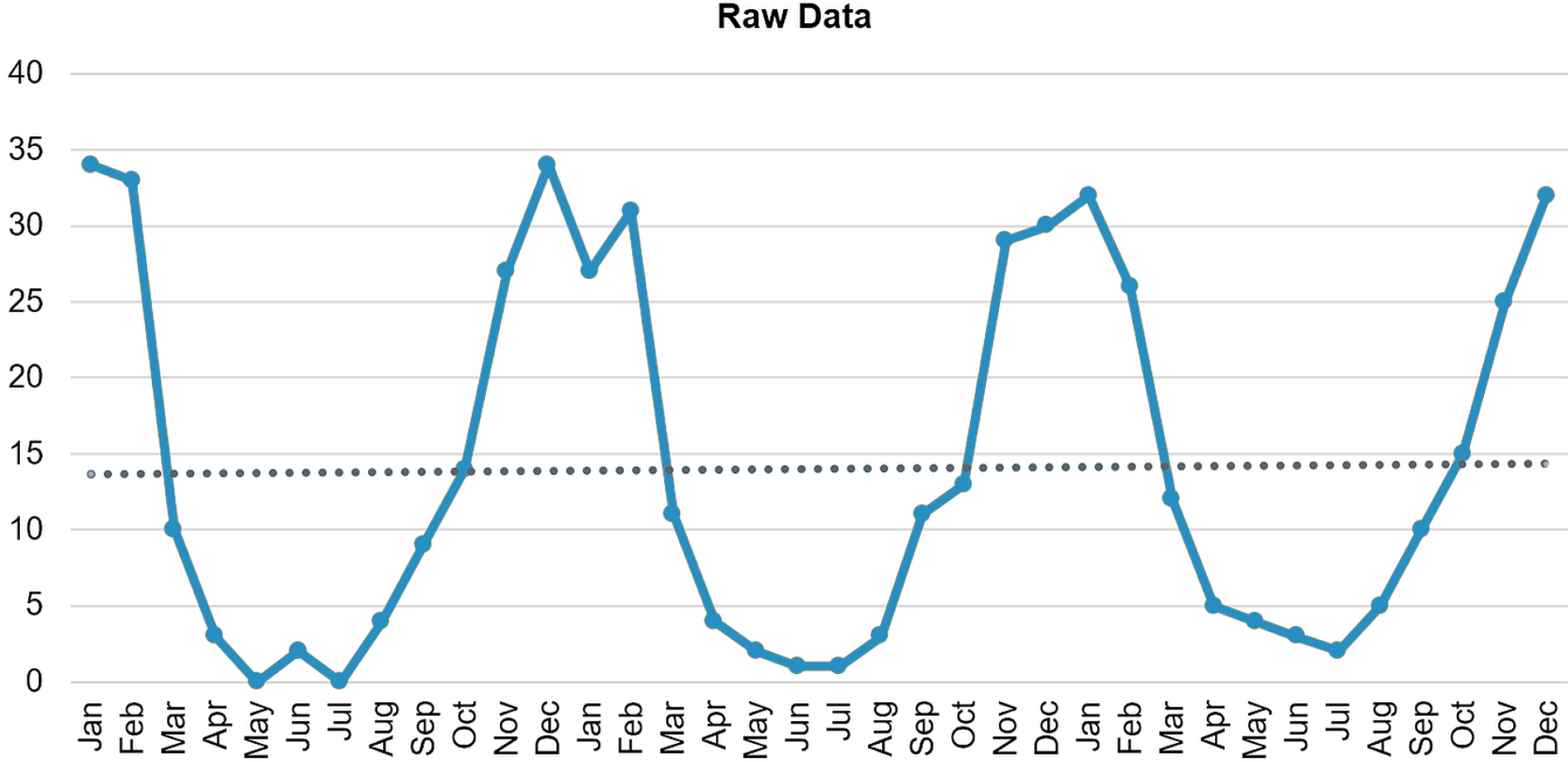
$$y = mx + b$$

Roofing Sales = (m × Prior Month's Housing Starts) + b

## Quantitative Methods: Intrinsic (Time Series) Forecasting

- Near-term past is good guide to near-term future.
  - True in current business environment?
- To deseasonalize, divide by period's seasonal index.
- After forecasting, multiply by seasonal index.
- Short- or medium-term: Get period's actuals; use for next period's forecast.
- All lag changes in trend and smooth out random variation.
  - Methods that make one factor better make the other factor worse.

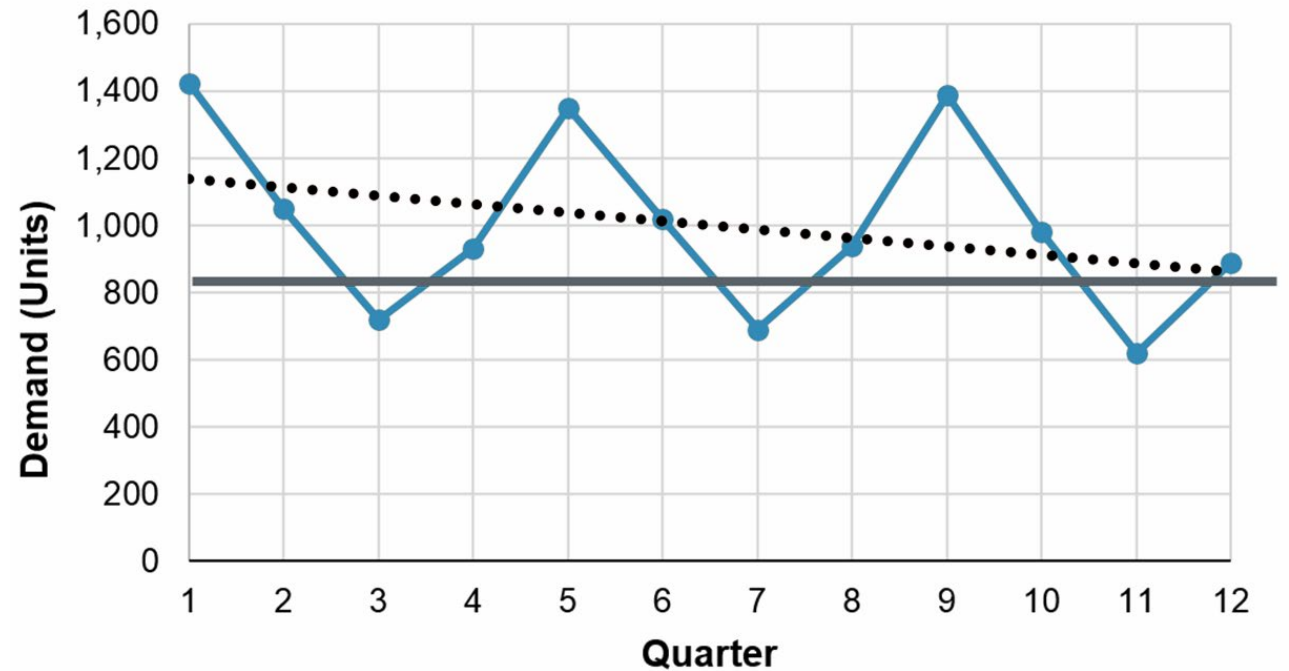
## Time Series Techniques: Visualizing



## Seasonality: Deseasonalization and Seasonal Index

- Find period average demand, e.g., sum all Q1s and divide by number of Q1s.
- Find average demand for all periods, e.g., sum of quarterly averages divided by 4.

Family A, Segment B, Actual Demand (3-Year Period)



$$\text{Seasonal Index} = \frac{\text{Period Average Demand}}{\text{Average Demand for All Periods}}$$

## Deseasonalized Demand

- Average is deseasonalized by definition.
- Apply seasonality: Multiply by period's seasonal index.
- Y4 forecast of 3,756 units/4 quarters = 939 units per quarter average.
- Q1 seasonal forecast =  $1.387 \times 939 = 1,302$  units.

Actual Demand History					
	Year 1	Year 2	Year 3	Quarterly Average	Seasonal Index
Quarter 1	1,422	1,351	1,388	1,387	1.387
Quarter 2	1,050	1,018	980	1,016	1.016
Quarter 3	720	691	620	677	0.677
Quarter 4	930	940	890	920	0.920
Sum	4,122	4,000	3,878	4,000	4.000
Average Demand (Qtr. Avg. Sum/4) =				1,000	

# Quantitative Forecasting

## Seasonal Index Exercise

<b>Sales Information</b>							
<b>Quarter</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>Total</b>	<b>Avg.</b>	
<b>Year 1</b>	<b>30</b>	<b>600</b>	<b>1,650</b>	<b>120</b>	<b>2,400</b>	<b>600</b>	
<b>Year 2</b>	<b>36</b>	<b>635</b>	<b>1,713</b>	<b>134</b>	<b>2,518</b>	<b>630</b>	
<b>Year 3</b>	<b>42</b>	<b>670</b>	<b>1,788</b>	<b>150</b>	<b>2,650</b>	<b>663</b>	
<b>3-Year Average</b>	<b>36</b>	<b>635</b>	<b>1,717</b>	<b>135</b>	<b>2,523</b>	<b>631</b>	
<b>Seasonal Index</b> (3 decimal places for rounding purposes)	<b>0.057</b>	<b>1.007</b>	<b>2.723</b>	<b>0.214</b>			
<b>Year 4</b> (Quarterly avg. x 3-yr. index)	<b>54</b>	<b>954</b>	<b>2,580</b>	<b>202</b>	<b>3,790</b>	<b>948</b>	

$$\text{Seasonal Index} = \frac{\text{Period Average Demand}}{\text{Average Demand for All Periods}}$$

## Moving Averages

Moving Average =

$$\frac{\text{Sum of Demand for Most Recent Set of Periods}}{\text{Number of Periods}}$$

Weighted Moving Average =

$$\frac{(1 \times \text{Period 1}) + (2 \times \text{Period 2}) + (3 \times \text{Period 3})}{\text{Sum of Weights } (1 + 2 + 3 = 6)}$$

## Exponential Smoothing

- Weighted average of latest period demand, forecast.
- Alpha ( $\alpha$ ) is smoothing constant between 0.0 and 1.0 (usually set from 0.0 to 0.3).
- Lower alphas lag more and smooth more.

**New Forecast = ( $\alpha \times$  Latest Demand) + ((1 -  $\alpha$ )  $\times$  Previous Forecast)**

**New Forecast (Deseasonalized) = (0.3  $\times$  967) + (0.7  $\times$  973) = 971**

Qtr.	Deseasonalized Demand	Deseasonalized Forecast	0.3 Exp. Forecast
Y3-Q4	967	973	
Y4-Q1		971	$\times 1.387 = 1,347$

Q1 seasonal index

## Exponential Smoothing Forecast Exercise 1

- Prepare an exponential smoothing forecast for June.
  - May data: actual demand = 220; forecast = 200.
  - Calculate the forecast for June using a smoothing constant ( $\alpha$ ) of 0.20.
- New forecast = ( $\alpha$ ) (latest demand) + (1 –  $\alpha$ ) (previous forecast)

$$(0.2) 220 + (0.8) 200 = 44 + 160 = 204$$

## Exponential Smoothing Forecast Exercise 2

- Prepare an exponential smoothing forecast for July.
  - June data: actual demand = 240
  - Calculate the forecast for July also using a smoothing constant ( $\alpha$ ) of 0.20.
- New forecast = ( $\alpha$ ) (latest demand) + (1 –  $\alpha$ ) (previous forecast)

$$(0.2) 240 + (0.8) 204 = 48 + 163 = 211$$

## Time Series Techniques: Exponential Smoothing Exercise

- Demand for a new product is rising faster than forecasts based on 0.2 alpha value exponential smoothing. Would you recommend use of a higher or lower alpha value, and what would your forecast be for September?

Demand	May	June	July	August	September
Forecast	200,000	204,000	211,200	221,160	
Actual	220,000	240,000	261,000	275,000	

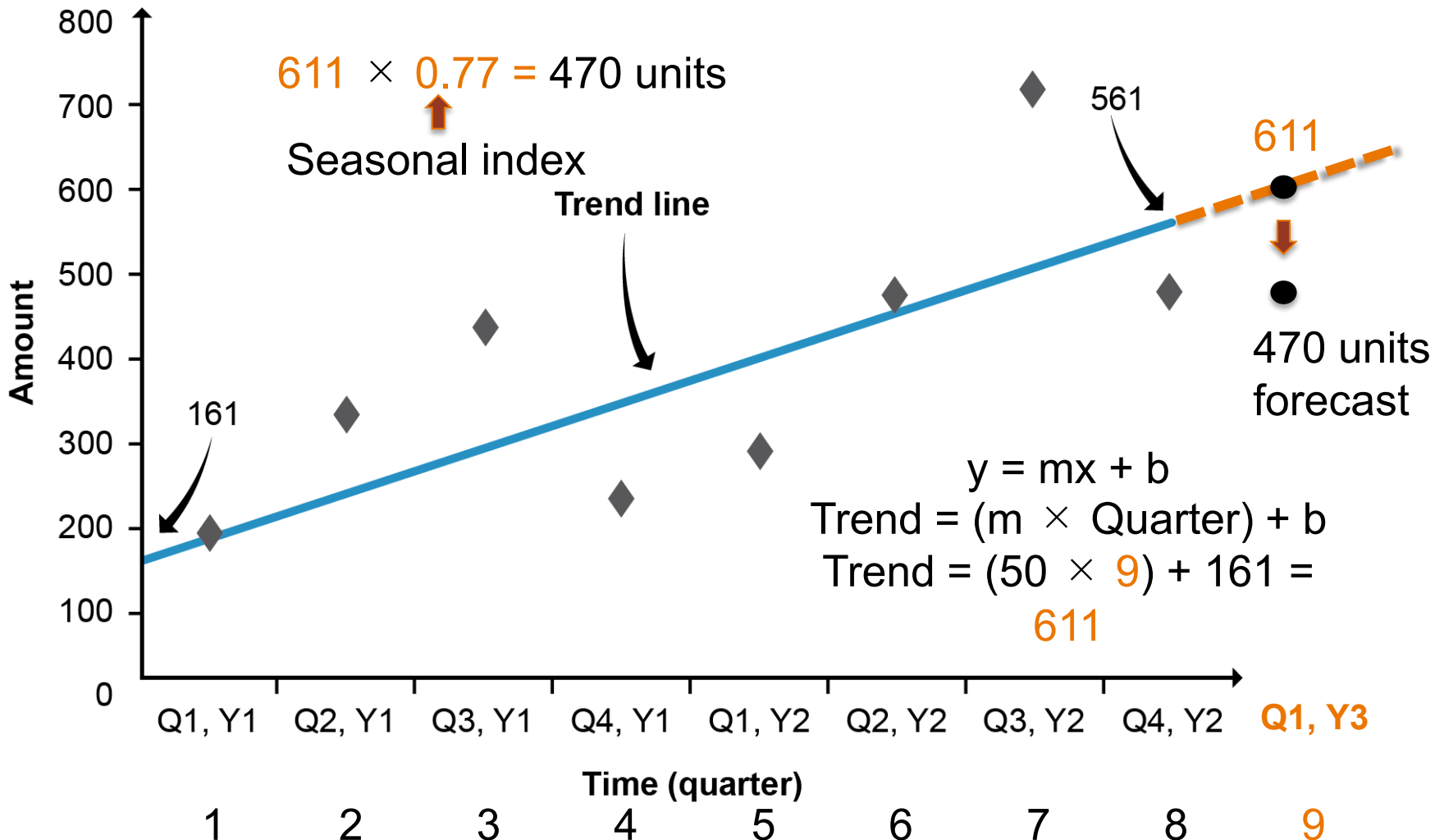
- Demand for a consumer product appears to be random with low variability. Do you recommend a high, medium, or low alpha value?

Period	1	2	3	4	5	6	7	8
Demand	95	91	104	95	106	89	94	110

- If demand shows a definite declining trend, would you recommend a high, medium, or low alpha value?

# Quantitative Forecasting

## Decomposition: Trend and Seasonality



# **CPIM** CERTIFIED IN PLANNING AND INVENTORY MANAGEMENT

## **SECTION C: FORECAST PERFORMANCE**

## Section C Learning Objectives

- Evaluating forecast performance
- Benefits of forecast accuracy
- Bias versus random variation
- Mean absolute deviation (MAD) and other forecast error metrics
- Tracking signal for identifying forecasts to evaluate
- Bullwhip effect on supply chain instability
- Collaborative planning, forecasting, and replenishment (CPFR<sup>®</sup>)

## Forecast Evaluation Road Map

### Why track error rates

- Improve forecasts.
- Know how much reliance to place on forecast, e.g., how much safety stock?
- Detect bias.
- Get quantitative data on actual customer service level.
- See forecaster willingness to stand by results.

### Benefits of accuracy

- Customer satisfaction (timely)
- Customer loyalty
- Less safety stock or safety lead time
- Understand evolving customer product demands

## Evaluation of Forecast Performance

- Extrapolation
- Mean
- Median
- Mode
- Normal distribution
- Outlier
- Probability distribution
- Sample
- Sampling distribution



# Evaluating Forecast Performance

## Bias Versus Random Variation

- Bias: consistent deviation from mean in one direction.
- Biased means actual and forecast diverge over time.
- Unbiased forecast error root cause = random variation.

Month	Bias			Random Variation		
	Actual	Forecast	Deviation	Actual	Forecast	Deviation
1	70	100	-30	105	100	5
2	150	100	50	94	100	-6
3	120	100	20	98	100	-2
4	60	100	-40	104	100	4
5	160	100	60	103	100	3
6	<u>120</u>	<u>100</u>	<u>20</u>	<u>96</u>	<u>100</u>	<u>-4</u>
<b>Cumulative</b>	680	600	80	600	600	0

# Evaluating Forecast Performance

## Deviation Versus Forecast Error

- Deviation = Actual Demand – Forecast.
- Plus or minus sign shows direction.
- Positive and negative deviations cancel each other out.
- Error (absolute deviation, no + or –) shows full impact.

Qtr.	Actuals	3-Qtr. Moving	Deviation	Error
Y2-Q3	691	674	17	17
Y2-Q4	940	919	21	21
Y3-Q1	1,388	1,408	-20	20
Y3-Q2	980	1,031	-51	51
Y3-Q3	620	674	-54	54
Y3-Q4	890	884	6	6
		<b>SUM</b>	<b>-80</b>	<b>169</b>

\*

# Evaluating Forecast Performance

## Mean Absolute Deviation

$$\text{MAD} = \frac{\sum |\text{Actual} - \text{Forecast}|}{\text{Number of Periods}}$$

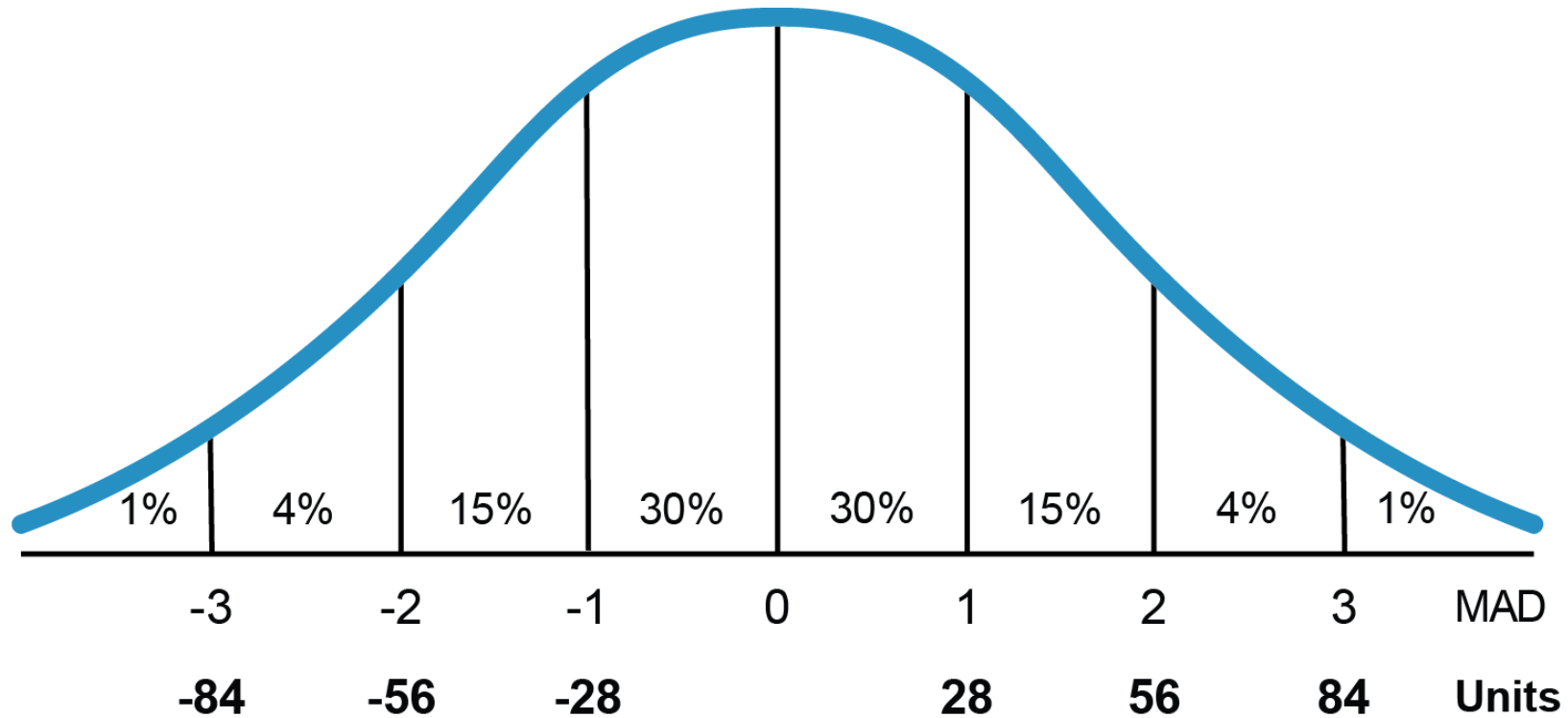
$$\text{MAD} = \frac{(17 + 21 + 20 + 51 + 54 + 6)}{6} = \frac{169}{6} = 28 \text{ Units}$$

Quarter	Actual Demand	3-Qtr. Moving	3-Qtr. Moving Error		
Y2-Q3	691	- 674	= 17		
Y2-Q4	940	- 919	= 21		
Y3-Q1	1,388	- 1,408	= 20		
Y3-Q2	980	- 1,031	= 51		
Y3-Q3	620	- 674	= 54	<b>SUM:</b>	169
Y3-Q4	890	- 884	= 6	<b>MAD:</b>	28

# Evaluating Forecast Performance

## Mean Absolute Deviation

MAD in units for 3-quarter moving average forecast



MAD in units for the 3-quarter moving average forecast

## Mean Squared Error and Mean Absolute Percentage Error

$$\text{MSE} = \frac{\text{Sum of (Errors for Each Period)}^2}{\text{Number of Forecast Periods}}$$

$$\text{MAPE} = \frac{\sum \left( \frac{|| \text{Actual} - \text{Forecast} ||}{\text{Actual}} \right) [\%]}{\text{Number of Periods}}$$

## Tracking Signal

- One-number bias assessment
- Numerator not absolute
  - Cumulative deviation
- Implement contingency plan to manage demand variations (e.g., using safety stock) and maintain customer service level

$$\text{Tracking Signal} = \frac{\text{Algebraic Sum of Forecast Deviations}}{\text{MAD}} = \frac{-80}{28} = -2.83^*$$

## Standard Deviation and WAIT

### Standard deviation

- Widely used to plan for fluctuations
- Dispersion of data around mean
  - Actual versus average (forecast error not used)
  - High variability: more safety stock

Standard Deviation =

$$\sqrt{\frac{\sum(\text{Actual} - \text{Average})^2}{n - 1}}$$

### WAIT for forecast accuracy

- “Within allowable item tolerances”
- How much error is problematic?
  - “Hit” = within tolerance
  - “Miss” = outside tolerance

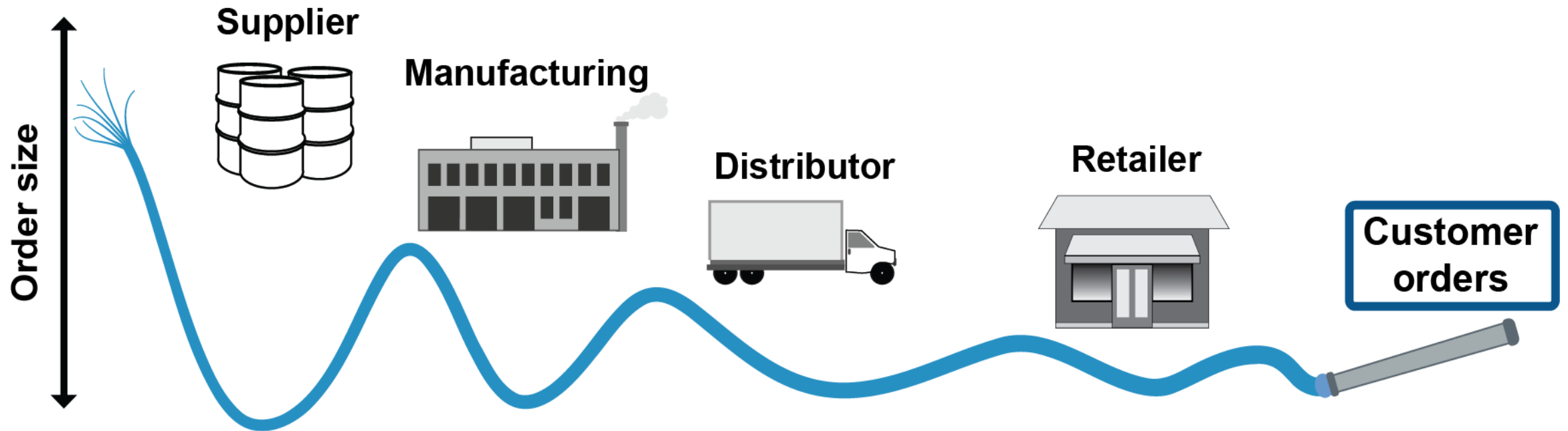
Forecast Accuracy =

$$\frac{\sum(\text{Number of Hits})}{\sum(\text{Number of Hits} + \text{Number of Misses})} \times 100\%$$

## Supply Chain Dynamics

### Bullwhip effect

Extreme change in upstream supply position generated by small change in downstream demand



# Forecast Management

## Bullwhip Effect Example

Period	Supplier 3 (Plastic Liners)		Supplier 2 (Covers)		Supplier 1 (Mattresses)		Manufacturer of Cribs		Retail Demand
	Prod.	B/E	Prod.	B/E	Prod.	B/E	Prod.	B/E	
1	1,000	1,000/ 1,000	1,000	1,000/ 1,000	1,000	1,000/ 1,000	1,000	1,000/ 1,000	1,000
2	200	1,000/ 600	600	1,000/ 800	800	1,000/ 900	900	1,000/ 950	950
3	1,800	600/ 1,200	1,200	800/ 1,000	1,000	900/ 950	950	950/ 950	950
4	600	1,200/ 900	900	1,000/ 950	950	950/ 950	950	950/ 950	950

## Controlling the Bullwhip Effect

### Causes

- Demand forecast updating and orders rather than demand
- Order batching
- Price fluctuation
- Rationing and gaming

### Focus of solutions

- Better accuracy through shared data
- Technology and collaboration to make orders smaller and more frequent
- Agreement on promotions/less of them
- Less forecasting (e.g., DDMRP)
- Historical data to improve decisions
- Less ability to return unsold product
- Vendor-managed inventory

# Forecast Management

## CPFR® Model

Manufacturer Tasks	Collaboration Tasks	Retailer Tasks
<b>Strategy &amp; Planning</b>		
Account Planning	Collaboration Arrangement	Vendor Management
Market Planning	Joint Business Plan	Category Management
<b>Demand &amp; Supply Management</b>		
Market Data Analysis	Sales Forecasting	POS Forecasting
Demand Planning	Order Planning/Forecasting	Replenishment Planning
<b>Execution</b>		
Production & Supply Planning	Order Generation	Buying/Re-buying
Outgoing Logistics/Distribution	Order Fulfillment	Incoming Logistics/Distribution
<b>Analysis</b>		
Execution Monitoring	Exception Management	Store Execution
Customer Scorecard	Performance Assessment	Supplier Scorecard