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CERTIFIED IN LOGISTICS,
TRANSPORTATION AND DISTRIBUTION

MODULE 4:
CAPACITY PLANNING AND DEMAND MANAGEMENT

APICS

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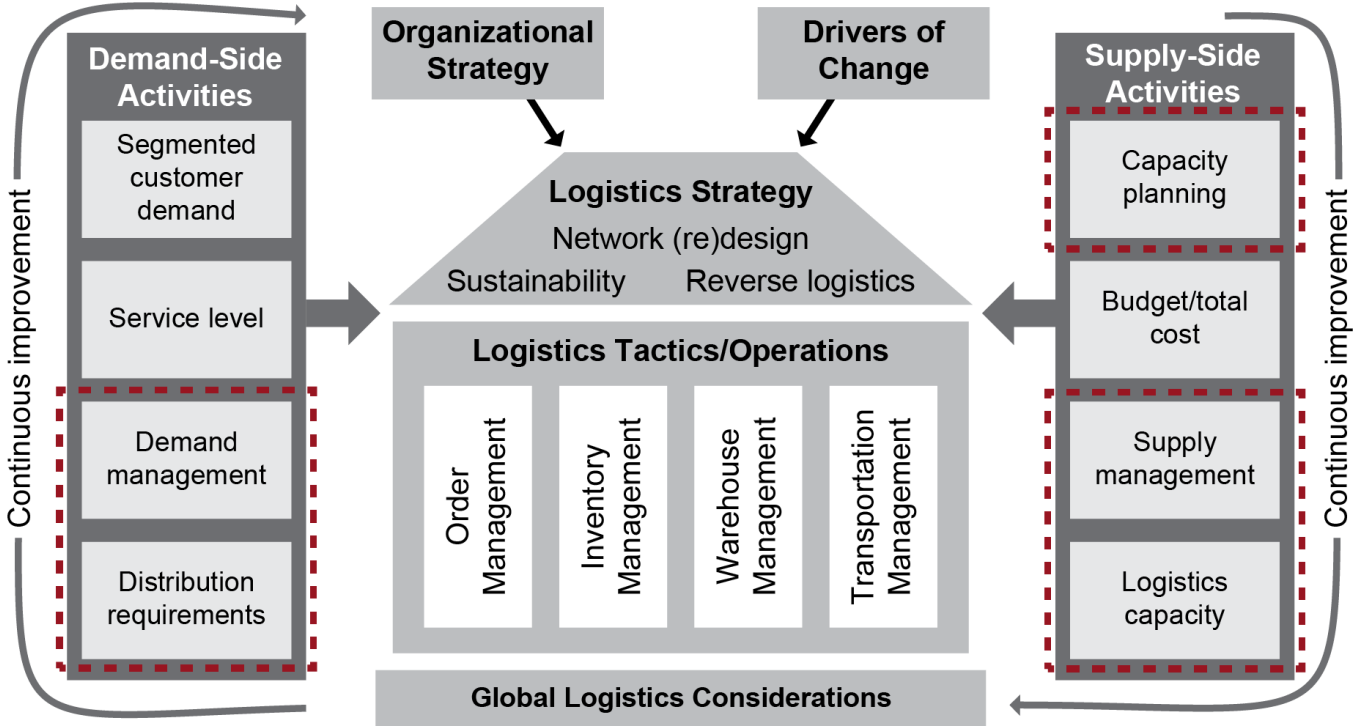
Module 4 Overview



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MODULE 4, SECTION A: FORECASTING

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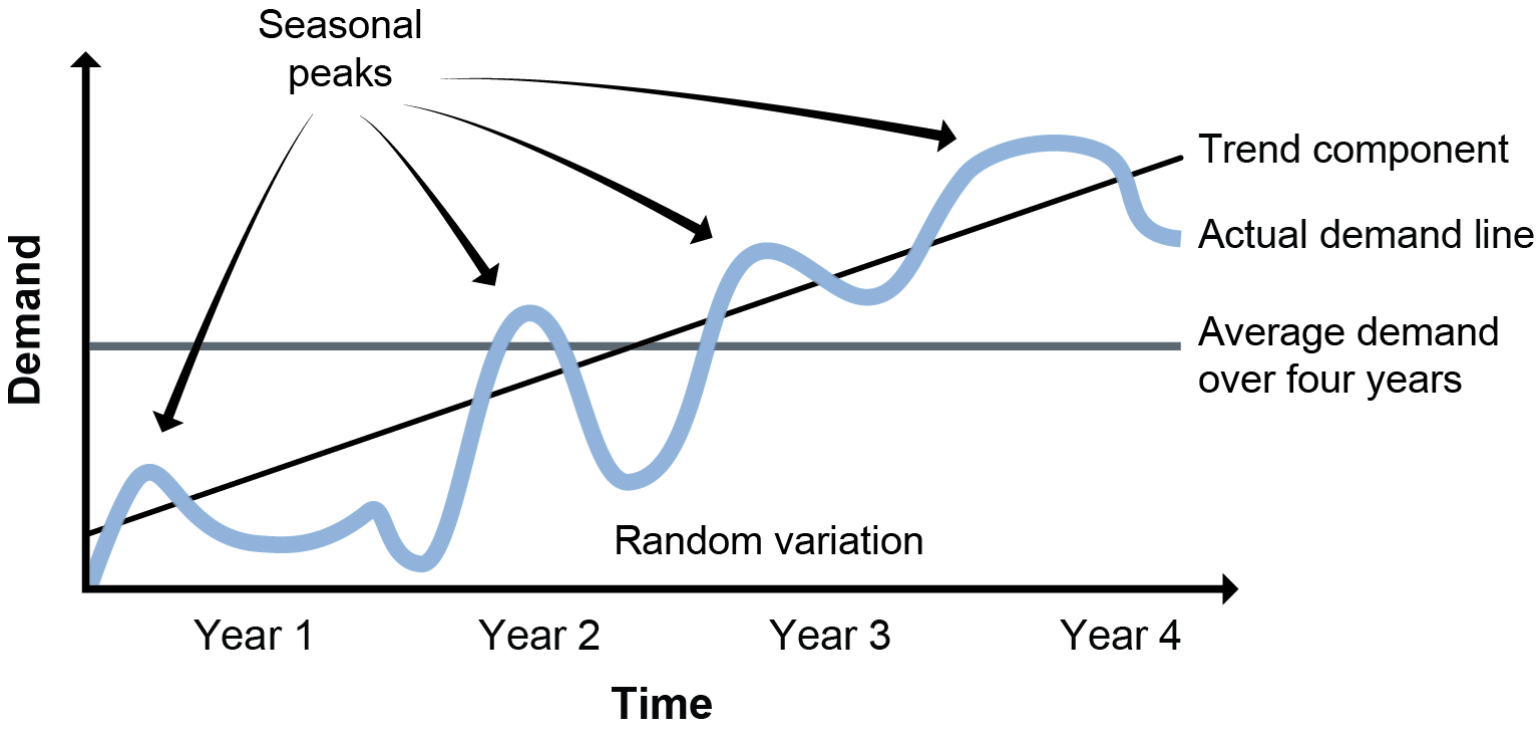
Forecasting

- Forecasts
  - When lead time is insufficient
  - On push side of push-pull frontier
- Logistics provides input on constraints.
- Term (Shorter terms are more reliable.)
  - Long-term (3+ years)
  - Medium-term (1 year or up to 2 years)
  - Short-term (less than 1 year)

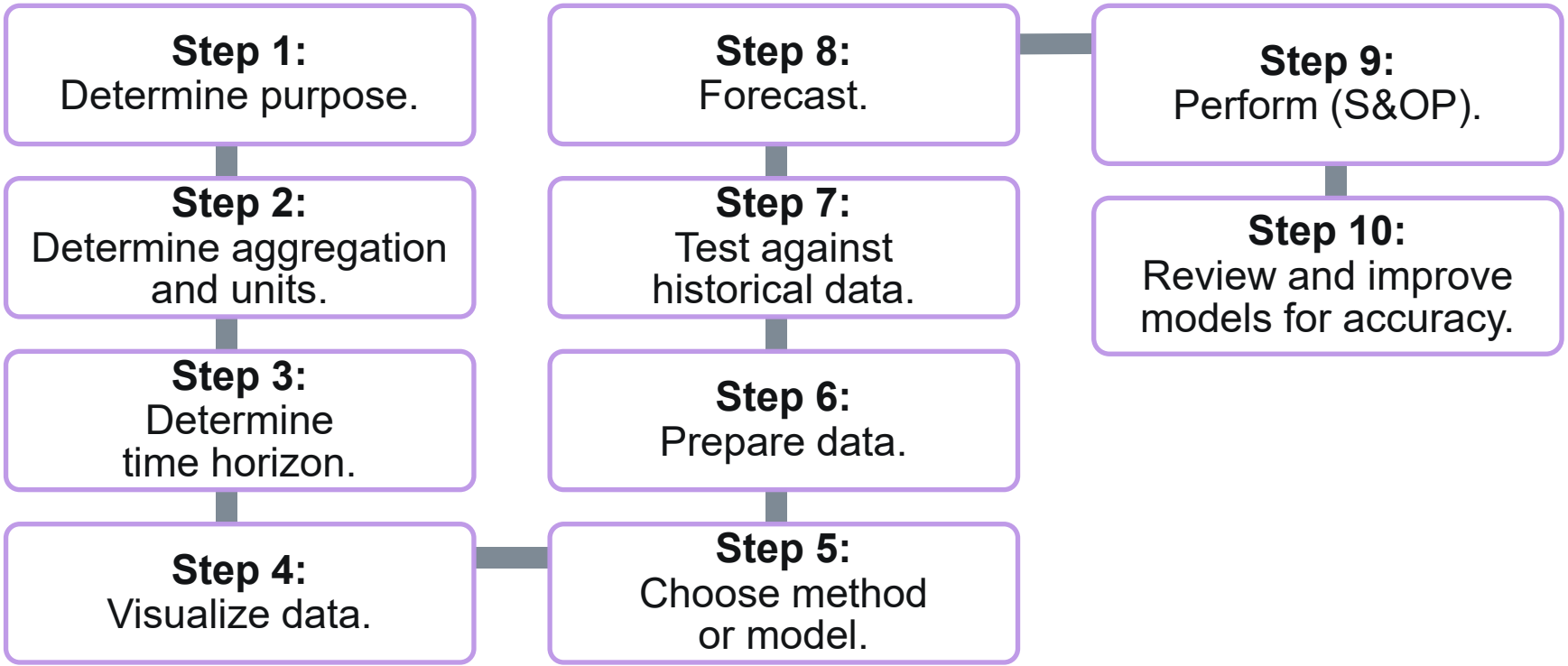
The Nature of Forecasting

- Future is uncertain.
- “Forecasts are always wrong.”
- Bias.
- Cost-benefit.
- Aggregate more reliable.
- Check data sources and simplify models .
- Use demand history.
- Consumer demand.

Factors Affecting Demand



Forecasting Process



Forecasting Methods

Qualitative

- Beware of bias
- Judgmental/expert judgment
- Delphi method
  - Anonymous experts
  - Consensus of opinion
  - Avoids groupthink

Quantitative

Time series:

- Naive
- Simple moving average
- Weighted moving average
- Exponential smoothing

Deseasonalizing

	A	B	C	D	E	I	J	K	L
1		Raw Data					Deseasonalized Data		
2	**Month**	**Year 1**	**Year 2**	**Year 3**	**Month Average**	**Seasonal Index**	**Year 1**	**Year 2**	**Year 3**
3	Jan	34	27	32	31.00	2.214	15.35	12.19	14.45
4	Feb	33	31	26	30.00	2.143	15.40	14.47	12.13
5	Mar	10	11	12	11.00	0.786	12.73	14.00	15.27
6	Apr	3	4	5	4.00	0.286	10.50	14.00	17.50
7	May	0	2	4	2.00	0.143	0.00	14.00	28.00
8	Jun	2	1	3	2.00	0.143	14.00	7.00	21.00
9	Jul	0	1	2	1.00	0.071	0.00	14.00	28.00
10	Aug	4	3	5	4.00	0.286	14.00	10.50	17.50
11	Sep	9	11	10	10.00	0.714	12.60	15.40	14.00
12	Oct	14	13	15	14.00	1.000	14.00	13.00	15.00
13	Nov	27	29	25	27.00	1.929	14.00	15.04	12.96
14	Dec	34	30	32	32.00	2.286	14.88	13.13	14.00
15	**SUM**	170	163	171	168				
16	**Year Average**	14.17	13.58	14.25	14.00				

Deseasonalized values closer to year average

Simple and Weighted Moving Average

Smooths out random spikes or dips:

- 3−Month Moving Average = $\frac{(M1 + M2 + M3)}{3}$
- January Year 4 Forecast = $\frac{(15 + 12.96 + 14)}{3} = 13.99$ Units

If recent periods are better predictors:

- 3−Month Weighted Moving Average = $\frac{(1 \times M1) + (2 \times M2) + (3 \times M3)}{6}$
- January Year 4 Forecast = $\frac{(1 \times 15) + (2 \times 12.96) + (3 \times 14)}{6}$ $= 13.82$ Units

Sum of weights

Exponential Smoothing and Reseasonalizing

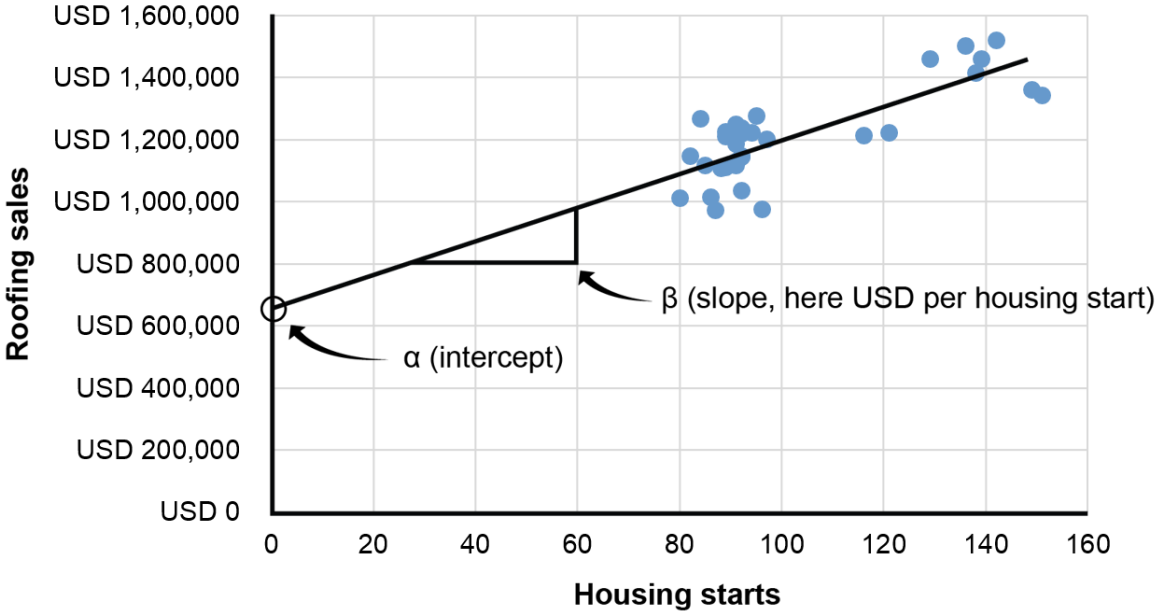
- Smoothing constant (alpha, α): 0–1 (percentage)
- New Forecast = (α × Last Period's Demand)
  + [(1 − α) × Last Period's Forecast]
- January Year 4 Forecast = (0.3 × 14) + [(1 − 0.3) × 16.2]
  = 15.54 Units

  30% weight 70% weight
- Reseasonalize
  - 15.54 units × 2.214 (January year 3 seasonal index)

    = 34.4 units, the forecast for January year 4

Quantitative: Associative (Causal)

- Simple regression
  - Independent variable (predictor, *x*)
  - Dependent variable (predicted, *y*)
- $y = \alpha + \beta x$
  - Roofing Sales = α + (β × Prior Month's Housing Starts)



Coefficient of Correlation (*r*) and *r*-Squared

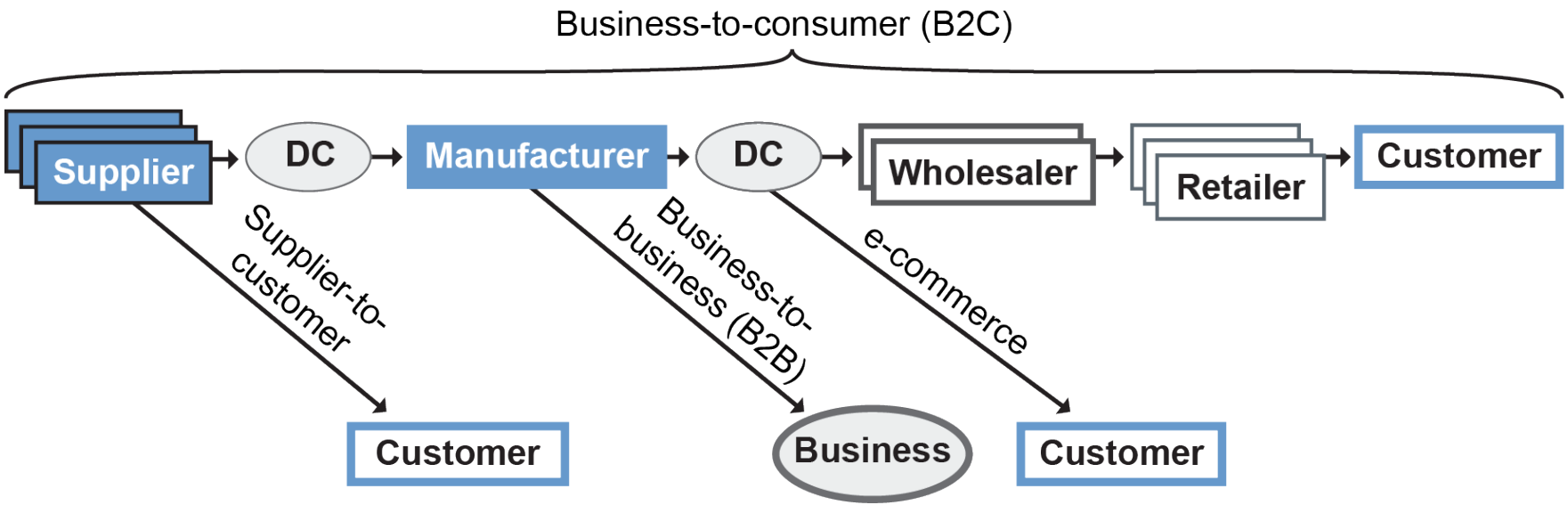
- Statistical measure of degree to which changes to the value of one variable predict change to value of another *(r)*
  - R-squared *(r^2)* shows fit: e.g., *r* of 0.79 squared = 0.6241, so housing starts explain 62.41% of change in roofing sales.
- *R* is range of values between –1.0 and +1.0

***r* = 1.0** is *perfect* positive correlation.

***r* = 0.0** is not correlated at all.

***r* = –1.0** is *perfect* negative correlation.

Distribution Channels



Accuracy (Error Rates)

- **Forecast error:** Forecast Error = $|\text{Actual} - \text{Forecast}|$
- **APE:** Forecast Error as a Percentage = $|\text{Actual} - \text{Forecast}| \div \text{Actual}$
- **MAD:** Average of absolute deviations
- **MSE:** Average of errors squared and then summed
- **MAPE:** Average of summed forecast error percentages

Accuracy (Error Rates)

- Tracking signal: Used to indicate the existence of any positive or negative bias in a forecast.
- Tracking Signal = $\frac{\text{Algebraic Sum of Forecast Errors}}{\text{MAD}}$
- Exceptions: Outliers could be errors or not.

How Logistics Uses Sales Forecasts

3- to 5-Year forecast

- Size and number of warehouses
- Average shipments per shipping line

Annual forecast

- Staffing levels and equipment
- Capacity to book with carriers in RFP/ITT

Monthly forecast

- Worker, warehouse capacity constraints
- Number of payloads: minimum orders, weight restrictions

Logistics Demand using Forecasting Tools

- Long-term TL freight volume trends
- Product trends
- Weather, road/rail conditions
- Product return rates
- Cost escalation rates

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MODULE 4, SECTION B: DEMAND MANAGEMENT AND LOGISTICS CAPACITY

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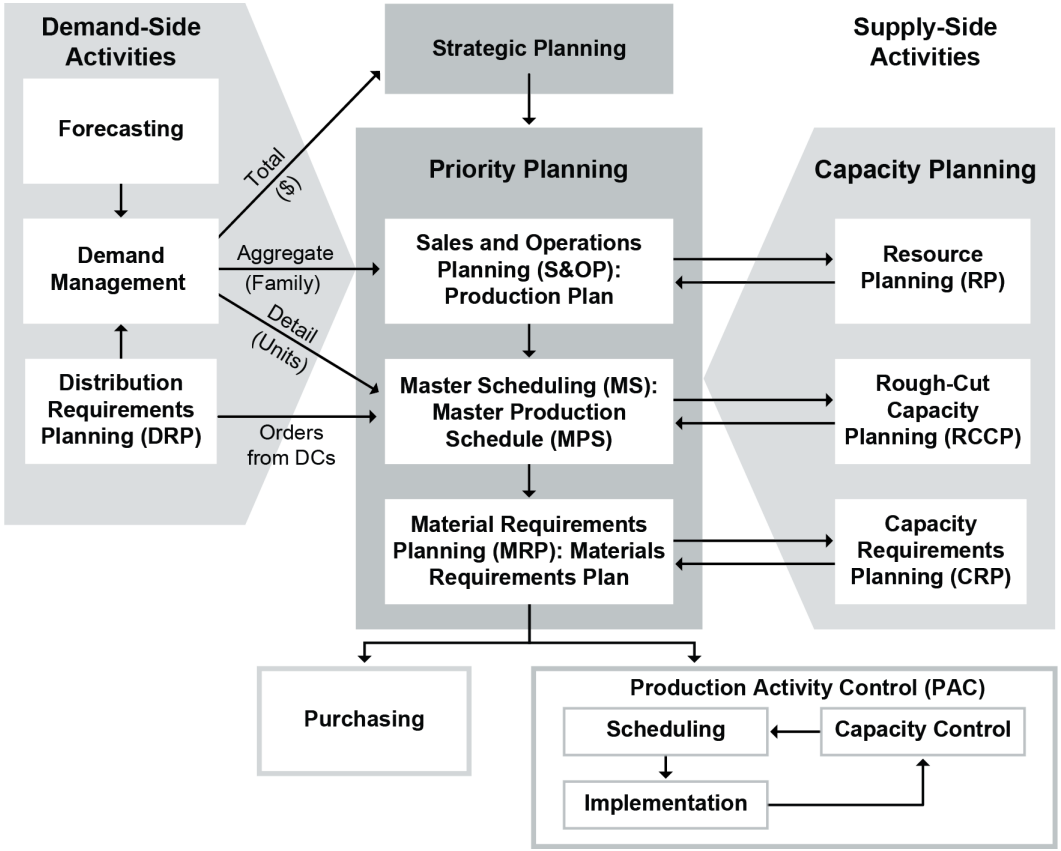
Topic 1: Introduction to and Components of Demand Management



Components of Demand Management

Supply Planning

- Production planning
  - Production Rate = $\frac{(\text{Ending Inventory} - \text{Beginning Inventory}) + \text{Forecast}}{\text{Number of Periods}}$
  - = $\frac{(12{,}000 - 10{,}000) + 100{,}000}{12}$ = 8,500 Units per Month
- Resource planning
- Inventory planning
- Distribution requirements planning (DRP)
- Performance metrics and targets

Resource Planning

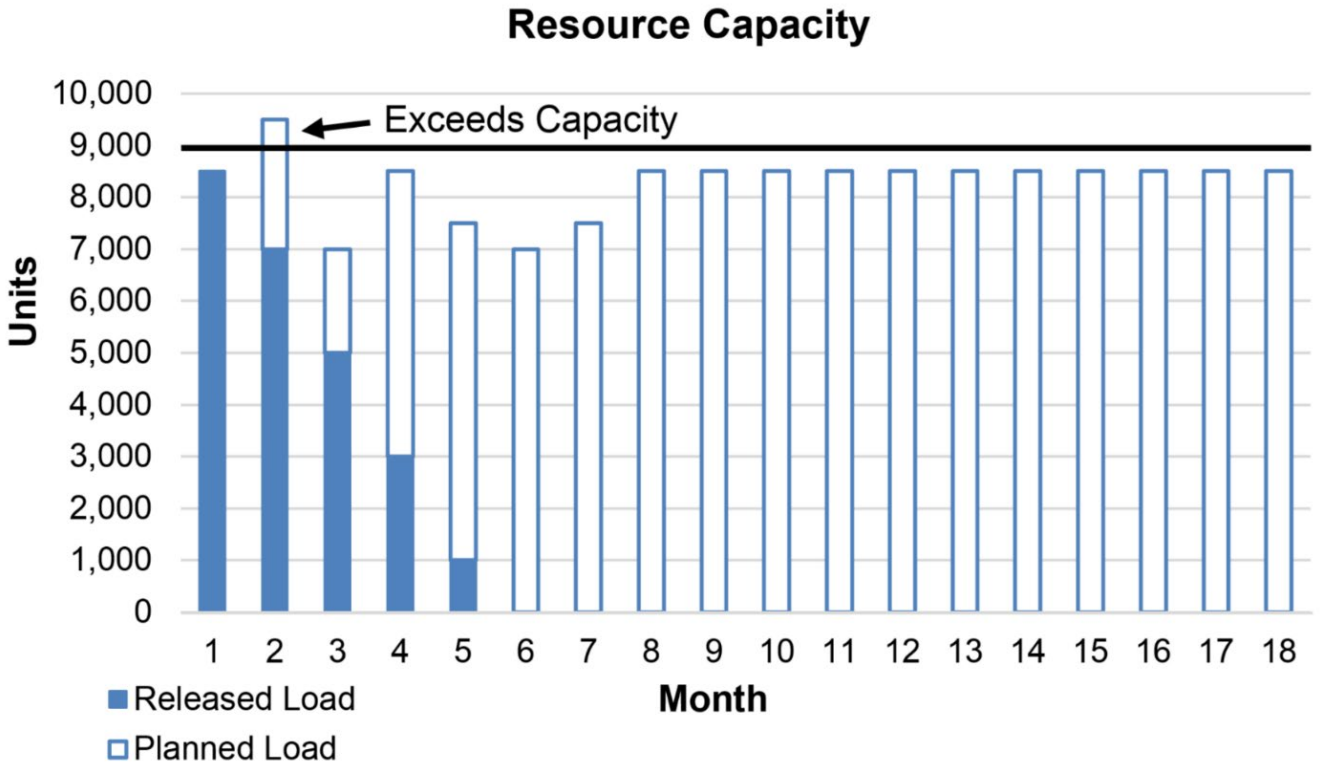
Resource Profile	Units	Capacity (Monthly)
Condenser shop	Hours	35,000
Final assembly	Cubic meters	8,000

Bill of Resources	Units	Family A	Family B	Family C
Condenser shop	Hours	3	5	5
Final assembly	Cubic meters	0.6	1.2	1.4

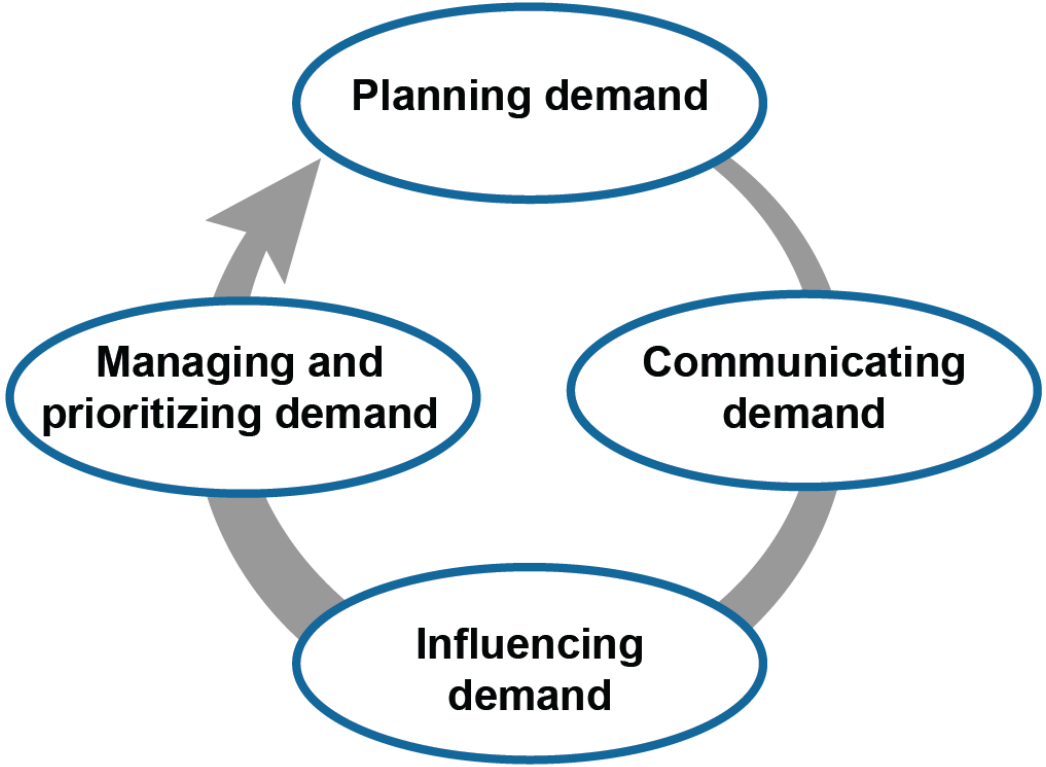
Resource Plan	Units	Family A	Family B	Family C	Total Load	Capacity	Load vs. Capacity
Jan. plan	Units	5,000	2,000	1,500	8,500		
Condenser shop	Hours	15,000	10,000	7,500	32,500	35,000	92.9%
Final assembly	Cubic meters	3,000	2,400	2,100	7,500	8,000	93.8%

Source: Adapted from David F. Ross, *Distribution Planning and Control—Managing in the Era of Supply Chain Management,* third edition.

Fulfillment Center Capacity Bar Chart



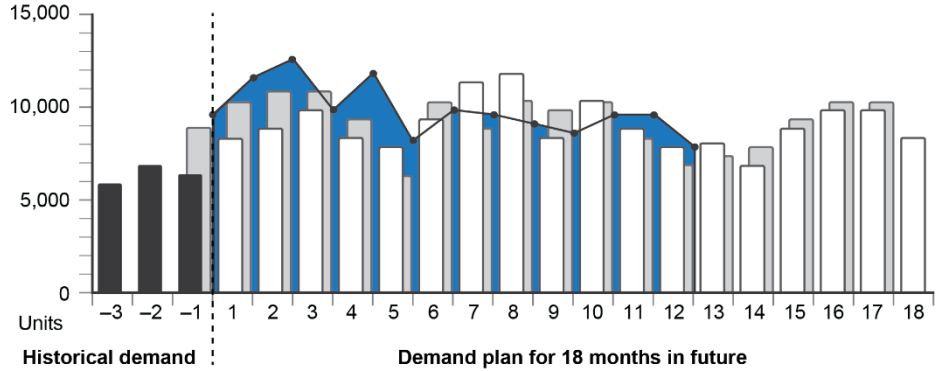
Demand Management Process



Topic 2: Demand Management Process

Demand Plan Dashboard: Units

- Rolling 18-month demand plan
- Output of S&OP



Key:
Actual demand
Annual business plan
Prior demand plan
Current demand plan

Product family XYZ:
Lead time = 2 weeks
Inventory turnover = 2 weeks

Metrics (excerpt)		Historical Month		
Goal	Metric	–3	–2	–1
Delivery promises	On time in full	88%	86%	80%
Improve cash flow	Cash-to-cash	16d	13d	14d
Plan accuracy	Plan vs. actual	75%	80%	68%

Key assumptions
- **Internal:** Period 6 TV ad buy, results seen in Periods 6–8
- **External:** Competitor X will mimic Product XYZ feature ABC by Period 14 at lower price

Key events
- **Internal:** Period 1 deliveries delayed due to Machine 123 breakdown, will continue to delay in Period 1.
- **External:** Economic growth will continue to be flat for next 12 periods.

Risks/Opportunities
- **Risk:** Customer Z is vulnerable.
- **Opportunity:** Breakthrough in product development can reduce product replacement time by 3 months.

Decisions
- Rapid development of Product Family XYZ replacement for release in Period 14.

Demand Shaping: Influencing Demand

- Develop products that customers are demanding.
- Determine profitable product mix.
- Set strategic pricing.
- Place products at distribution points to establish presence and customer convenience.
- Promote products.
- Support customer expectations and needs.
- Support organization’s business objectives.

Manufacturing/Distribution Balancing

External balancing

- Price
- Lead time
- Product substitution
- Lost sale

Internal balancing

- Production flexibility
- Safety stock
  - May prevent stockouts
  - May worsen oversupply
- Marketing methods
  - Sales incentives
  - Trade discounts
  - Consumer promotions

Demand Shaping: Managing and Prioritizing Demand

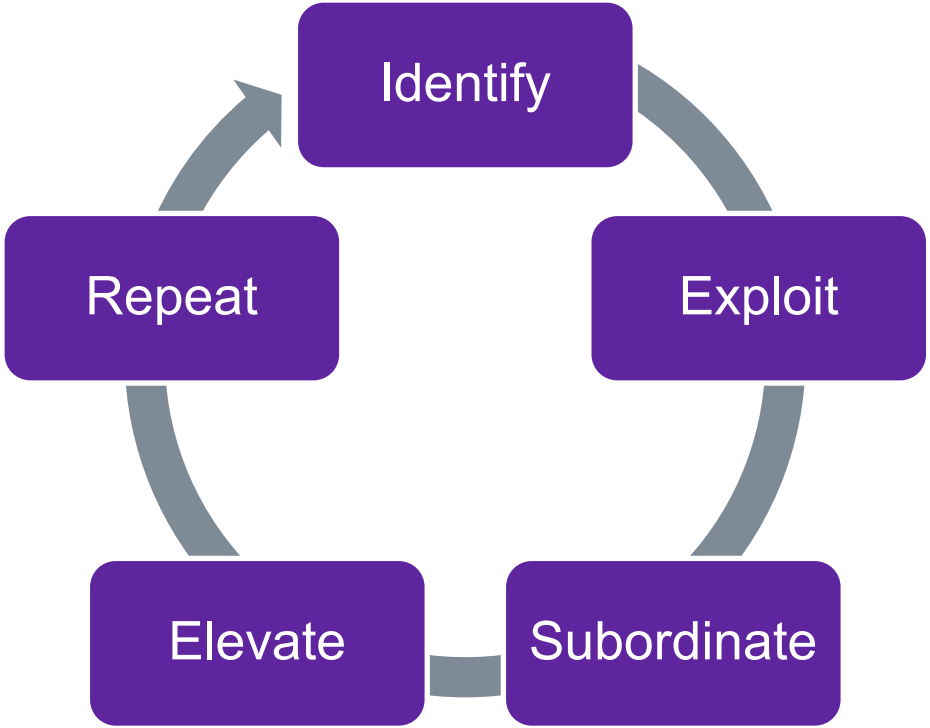
- Prioritize by customer value.
- Rationing, queues, substitute incentives.
- Time fences reduce oversupply.
- Retain scarce inventory at central supply longer.
- Policies promote optimum profit and service.
- Supply and demand evaluate custom orders.
- Management prioritizes, not salespersons.
- Fulfill all demand if feasible and adds marginal profit.

Logistics Demand Shaping

B2B	B2C
▪ Purchase, shipment, and payment timing history ▪ Incentive or not? – Find customers who want to delay order – Discount for order in AM – Nonpeak discount – Forward shipping	▪ Free shipping may be expectation (competitors) ▪ Store credit for slow ship ▪ Free shipping subscription – Marketing tool – Incentive to wait for “full basket”

Topic 4: Transportation and Capacity Planning

Using Constraints Management to Optimize Capacity



Transportation Decisions

- Minimizing partial loads reduces strain on capacity.
- If few carriers (reliability), give capacity estimates.
- Ship earlier or book capacity as soon as possible.
- Inbound capacity:
  - Backscheduling
  - Can you transport cheaper than suppliers?
- Outbound capacity:
  - Annual requirement versus capacity, need for fleet planning

System Capacity, Throughput, and Load Planning

Capacity/throughput

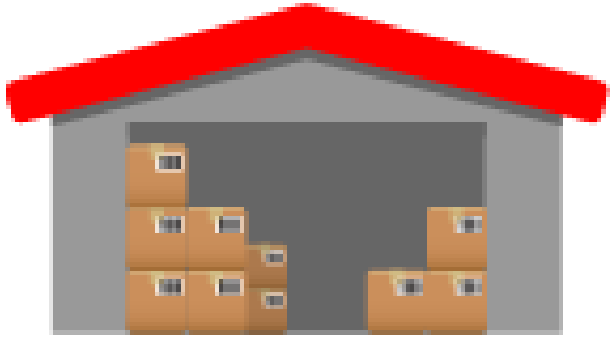
- Plan inbound and outbound jointly.
- Collaborative transportation management with partners and LSPs.

Load planning

- Calculate loads based on payload volume and weight limits.
- Best loads optimize both.
- Break aggregate plan into weekly shipping schedule.

Determining Warehousing Needs

- A strategic decision—has strong impact on profitability
- Considerations:
  - Strategic forecast (long-term)
  - Warehouse usage mode
  - Storage capacity forecasting
  - Shipping and receiving dock needs
  - Equipment, labor, throughput constraints



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MODULE 4, SECTION C:
SALES AND OPERATIONS PLANNING (S&OP)

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Monthly Sales and Operations Planning Process

Step 1: Data gathering	Statistical forecast updated.
Step 2: Demand planning	Statistical forecast reviewed by product/brand, marketing, sales.
Step 3: Supply planning	Supply management team may alter operations plan if necessary.
Step 4: Pre-executive meeting	Key players review data, set executive meeting agenda.
Step 5: Executive meeting	VPs meet monthly to review decisions and strategy.

Supply Planning Phase Meeting

Supply/demand match

- Production plan matches demand plan.

Supply/demand mismatch

- Supply develops alternative plans:
  - Produce above demand to meet later spikes.
  - Increase capacity by hiring, adding shifts, planning overtime, leasing new equipment, or outsourcing (or opposite).
  - Reduce demand plan (last resort).

Topic 2: Related Planning Tools

CPFR®

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

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MODULE 4, SECTION D: DISTRIBUTION REQUIREMENTS PLANNING (DRP)

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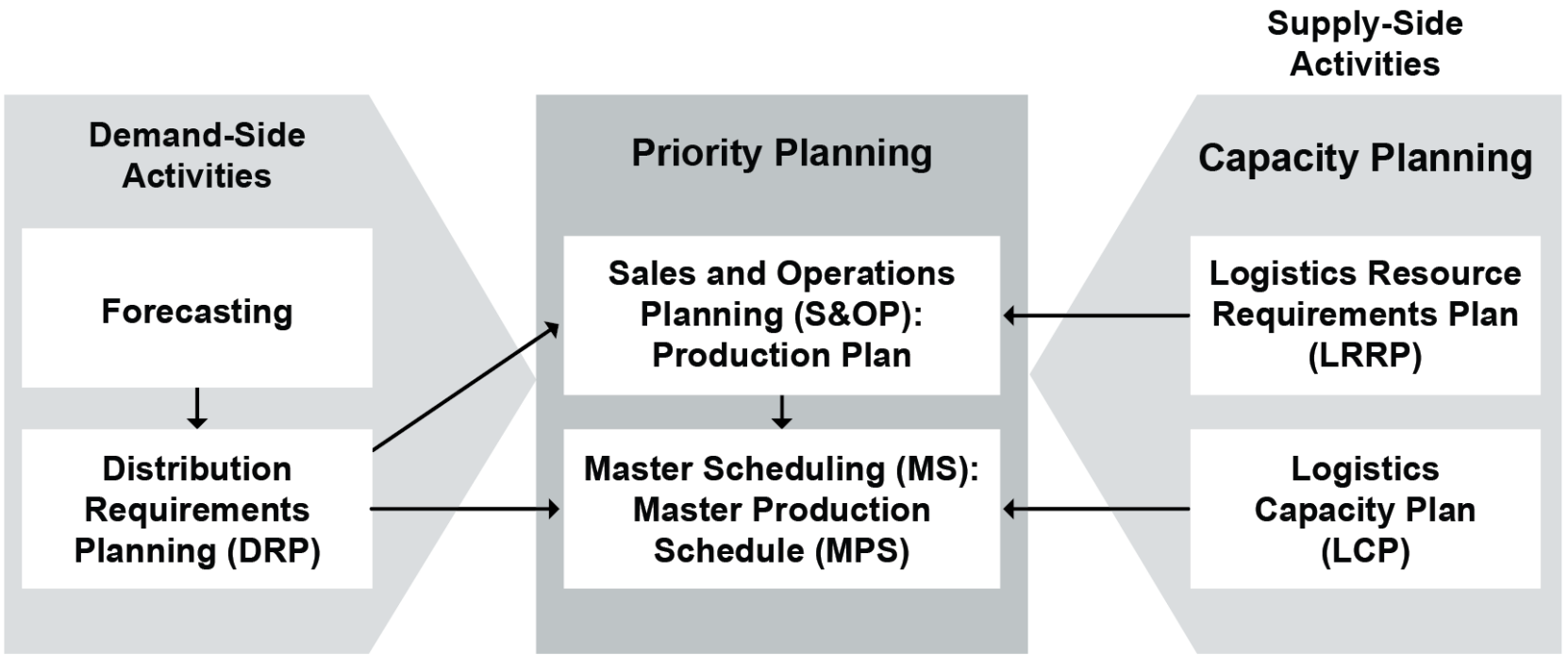
Logistics Planning and Control



Inventory Planning

$$\text{Production Rate} = \frac{(\text{Ending Inventory} - \text{Beginning Inventory}) + \text{Forecast}}{\text{Number of Periods}}$$

$$= \frac{(1{,}000 - 1{,}500) + (5{,}200 + 5{,}400 + 4{,}900)}{3} = 5{,}000 \text{ Units per Month in Q1}$$

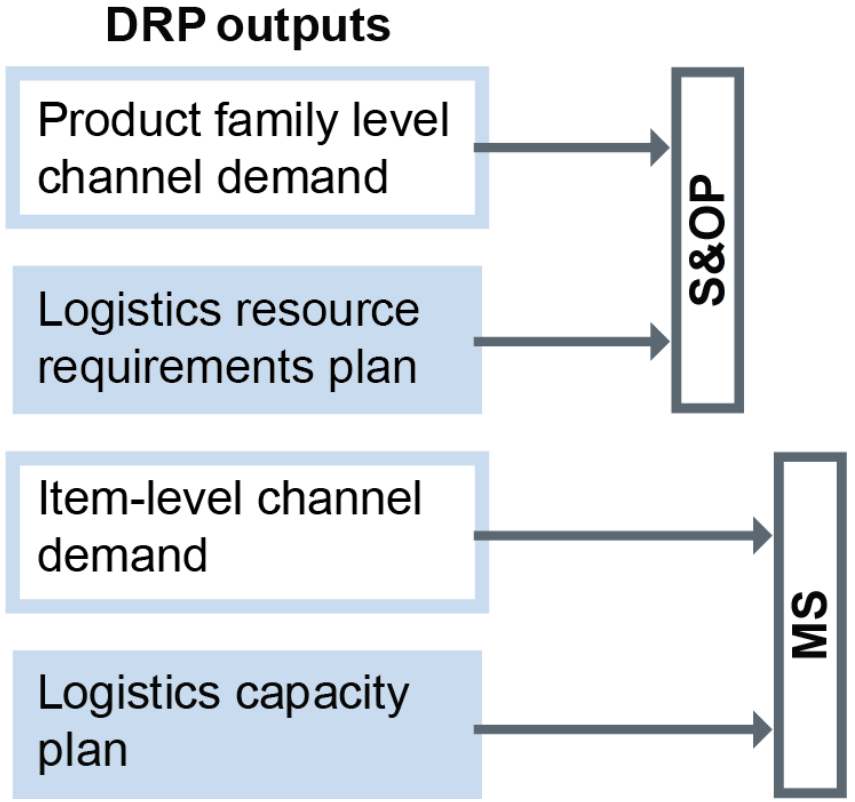
Family (in units), Family A, Mini-Refrigerator								
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Forecast		5,200	5,400	4,900	4,700	4,800	5,100	5,000
Production plan		5,000	5,000	5,000	5,033	5,033	5,033	6,667
Ending inventory plan	1,500	1,300	900	1,000	1,333	1,567	1,500	3,167
Qtr. inventory target				1,000			1,500	
Max inventory (OK?)	2,000	OK	OK	OK	OK	OK	OK	FIX
Min inventory (OK?)	1,000	OK	FIX	OK	OK	OK	OK	OK

Source: Adapted from David F. Ross, *Distribution Planning and Control – Managing in the Era of Supply Chain Management,* third edition.

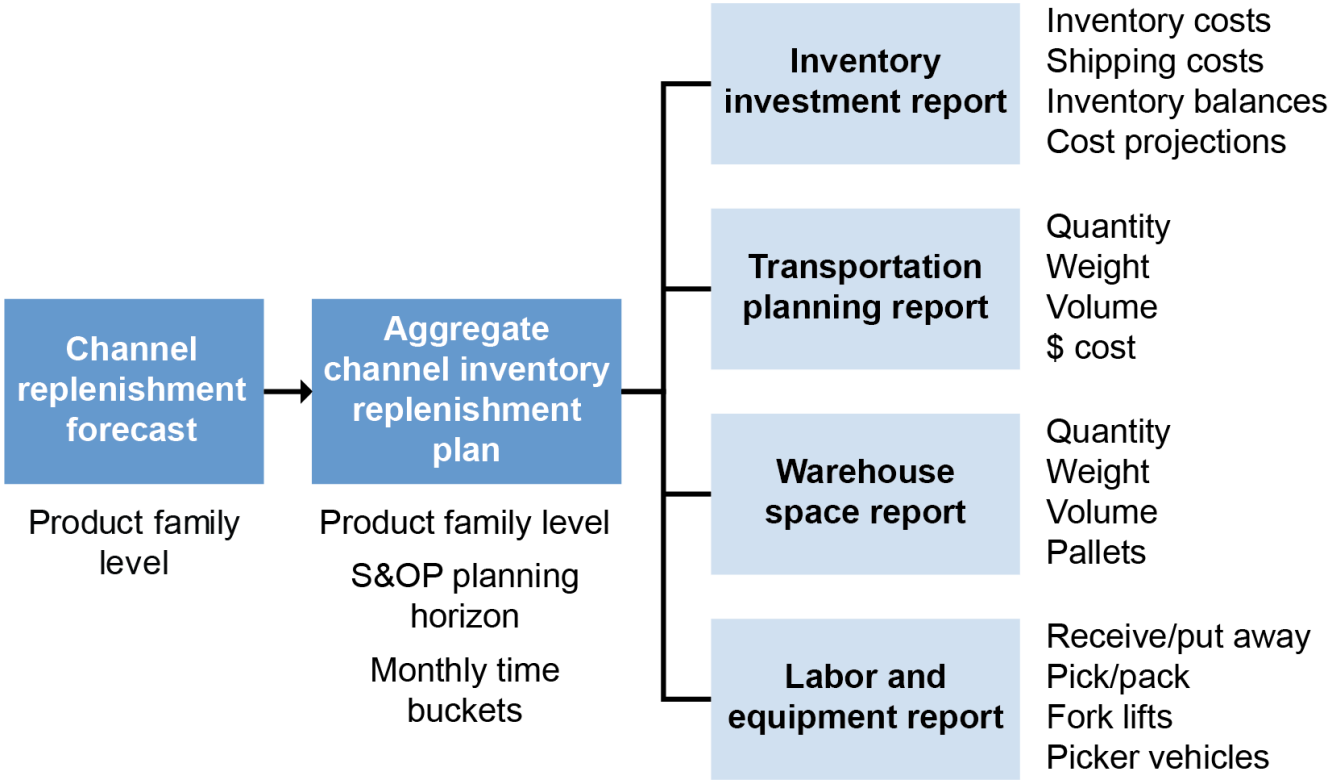
Links to S&OP and MS

Forecasts needed at two levels in DRP

- Product family by distribution channel during S&OP
- Item level during master scheduling



LRRP Information Flow



Logistics Resource Requirements Planning

- Tactical-level check
- Warehouse capacity—aggregate by storage type
- Labor capacity, equipment capacity, load
  - Set standard hours by product family
  - Two categories: receiving and put-away, picking and shipping
- Transportation volume—from DRP

LRRP Elements

Report	Description
Inventory investment	• Financial resource adequacy • Aggregate costs over horizon • Product family replenishment and shipping costs
Transportation planning	• DC transportation requirements • Transportation unit factors and product family shipping profiles
Warehouse space	• Space required based on above reports and shipping profiles
Labor and equipment	• Aggregate labor/equipment at DCs • Aggregate standards for unloading, put-away, etc.

Logistics Capacity Planning

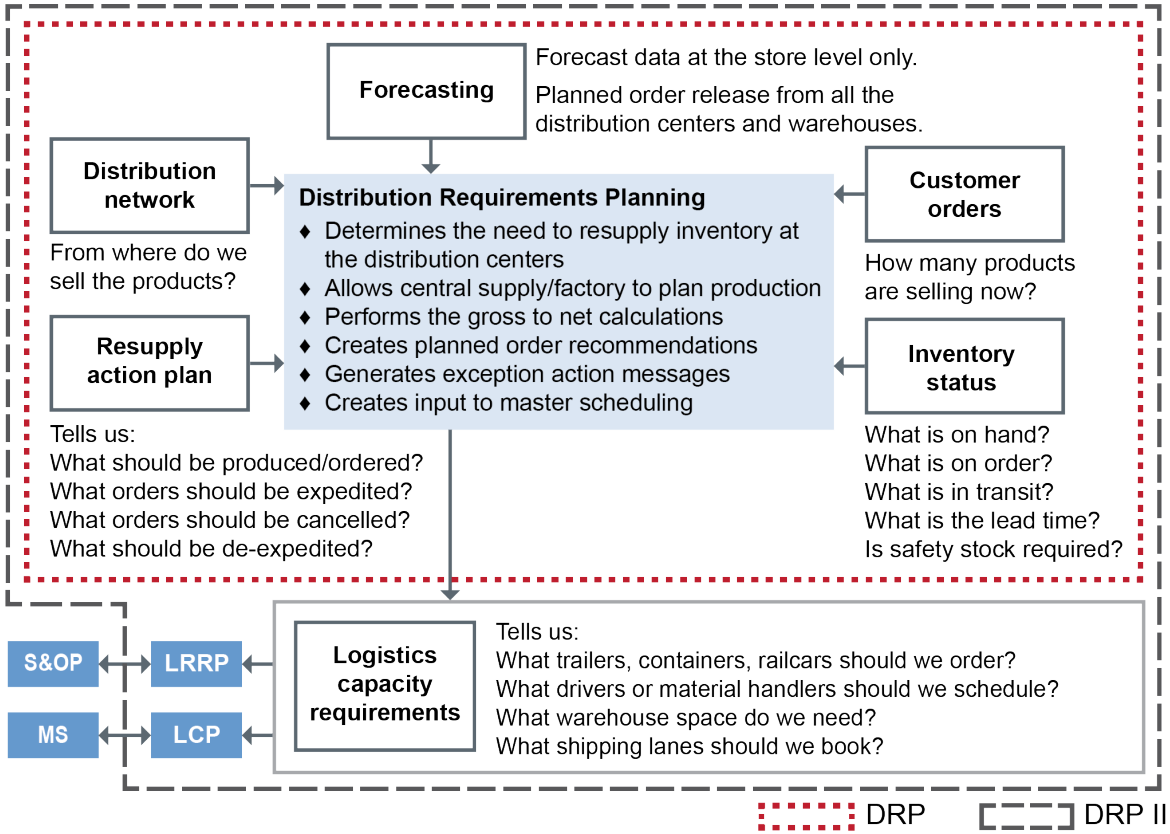
Operation-level capacity check

- Unit-level shipping and storage plan
- In same units of measure/time periods as MPS
- Current customer order backlogs
- Pending customer backorders
- Unit-level short-term forecasts
- Financial impacts of changes in logistics plans or MPS

Topic 3: DRP Process, Logic, and Ordering Policies

DRP and DRP II

- Replenish inventory at distribution centers
- DRP output used in DRP II for logistics capacity



Distribution Requirements Planning

Push systems	Hybrid systems (DRP)	Pull systems
▪ Forecasts and schedules centrally coordinated. ▪ Customers don't determine own orders. ▪ Doesn't account for local conditions.	▪ Push to given echelon, pull from there, use retail demand data. ▪ Coordination and control. ▪ Responsive to local demand.	▪ Partners determine own orders. ▪ Bullwhip effect if partners don't collaborate. ▪ Doesn't account for needs of other SC partners. ▪ Ignores supplier's ability.

DRP Grid, Prior to Planned Orders

Safety stock: 0 units
Min. order quantity: 50 units
Lead time: 2 weeks
Lot size: 50 units

PAB = Beginning Inventory or Prior Period PAB + Scheduled Receipts + Planned Order Receipts – Gross Requirements

DRP Grid							
Week		**1**	**2**	**3**	**4**	**5**	**6**
Gross Requirements		110	110	110	110		
Scheduled Receipts			100				
PAB	170	60	50	–60	–170		
Net Requirements		0	0	60	170		
Planned Order Receipts		0	0				
Planned Order Releases		0	0				

DRP Grid, with a Planned Order

Safety stock: 0 units
Min. order quantity: 50 units
Lead time: 2 weeks
Lot size: 50 units

Net Requirements = Gross Requirements – Scheduled Receipts – Beginning Inventory or Prior Period PAB + Safety Stock

DRP Grid							
Week		**1**	**2**	**3**	**4**	**5**	**6**
Gross Requirements		110	110	110	110		
Scheduled Receipts			100				
PAB	170	60	50	40	–70		
Net Requirements		0	0	60	70		
Planned Order Receipts		0	0	100			
Planned Order Releases		100	0				

DRP Grid, Completed

Safety stock: 0 units
Min. order quantity: 50 units
Lead time: 2 weeks
Lot size: 50 units

Given safety stock, planned order receipts and corresponding releases would be scheduled whenever PAB will go below minimum safety stock level (not when it will go negative).

DRP Grid							
Week		**1**	**2**	**3**	**4**	**5**	**6**
Gross Requirements		110	110	110	110	110	110
Scheduled Receipts			100				
PAB	170	60	50	40	30	20	10
Net Requirements		0	0	60	70	80	90
Planned Order Receipts		0	0	100	100	100	100
Planned Order Releases		100	100	100	100	100	150

DRP Logic

(Lead time = 1 week)

DC A: Week	~	6	7
Gross Reqs.			300
PAB	170	170	270
Net Requirements			200
Planned Order Receipts			400
Planned Order Releases		400	

(Lead time = 2 weeks)

DC B: Week	~	6	7	8
Gross Reqs.				500
PAB	200	200	200	200
Net Requirements				400
Planned Order Receipts				500
Planned Order Releases		500		

Central Supply: Week	~	3	~	5	6	7
Gross Reqs.					900	
PAB	500	500		500	200	200
Net Requirements					600	
Planned Order Receipts					600	
Planned Order Releases		600				

(Lead time = 3 weeks)

MS Grid: Week	~	2	3	4
Gross Reqs.			600	
PAB		0	200	200
MPS			800	

Lot sizes: **DC A: 400**
DC B: 500 **Central: 600**
Safety stock: **DC A: 70** **DC B: 100**
Central: 200

Source: *APICS CPIM Basics of Supply Chain Management*

Exceptions and Action Messages

- Releases
- Lead-time violations
- Cancel notices
- Expedite scheduled receipts
- De-expedite scheduled receipts

Ordering Policies

- Lot-for-lot
  - Lot-for-lot above minimum quantity
  - Lot size quantities
- Fixed period requirements
- Min-max
- Economic order quantity

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MODULE 4, SECTION E:
MASTER SCHEDULING AND MATERIAL REQUIREMENTS PLANNING

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Shared Central Database Files for Logistics

- Customer files
- Product-price files
- Supplier files
- Open order files
- Purchase order (PO) files
- Bill of material files
- Inventory files
- Order and PO history files
- Warehouse and DC files
- Carrier files

Controlling Priorities: Master Scheduling

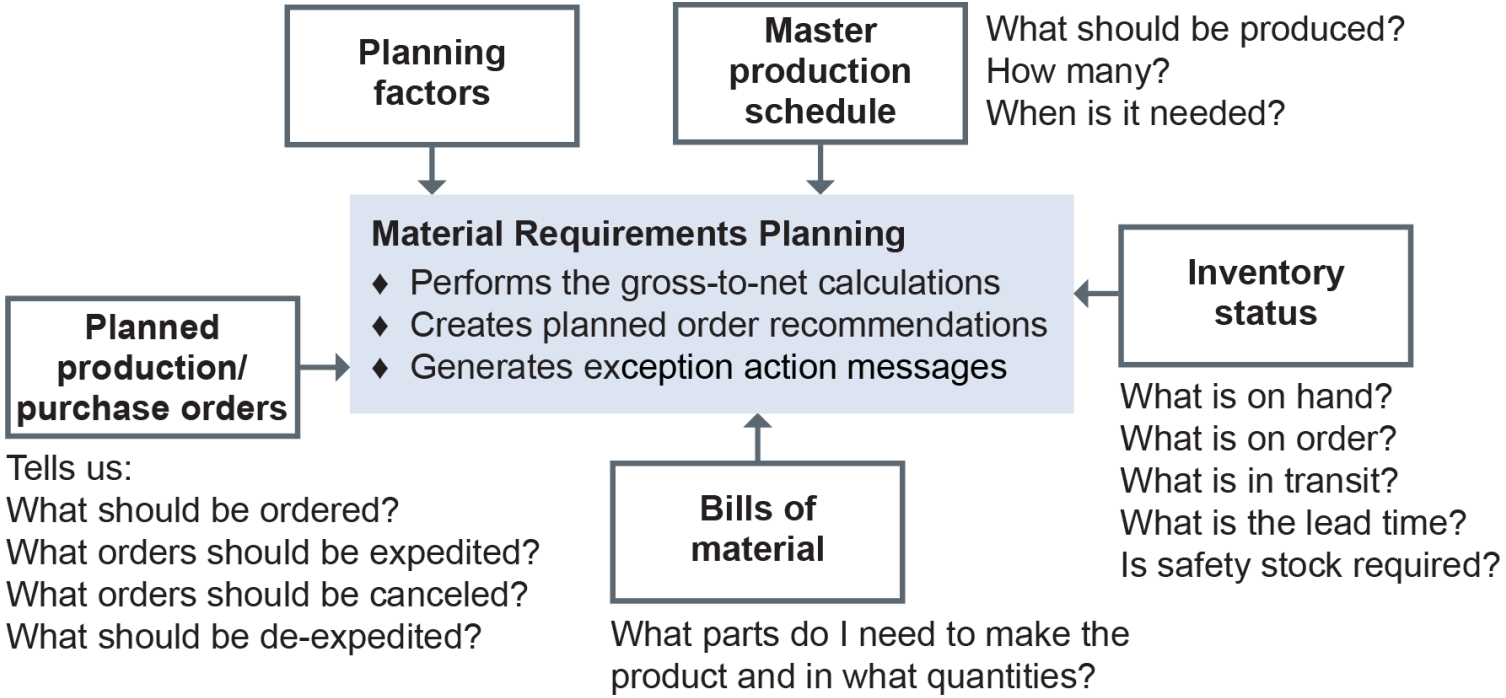
		Frozen zone			Slushy zone					Liquid zone	
Period		1	2	3	4	5	6	7	8	9	10
Forecast		20	22	21	25	24	23	21	21	25	25
Customer orders		19	17	15	11	9	5	2	1	0	0
Projected available balance (PAB)	50	31	14	49	24	0	27	6	35	10	35
Available-to-promise (ATP)		14		15			43		49		
Master production schedule (MPS)				50			50		50		50

Demand Time Fence

Planning Time Fence

Source: *APICS Master Planning of Resources*, Version 3.1

Materials Requirements Planning



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MODULE 4, SECTION F:
SOURCING AND PROCUREMENT

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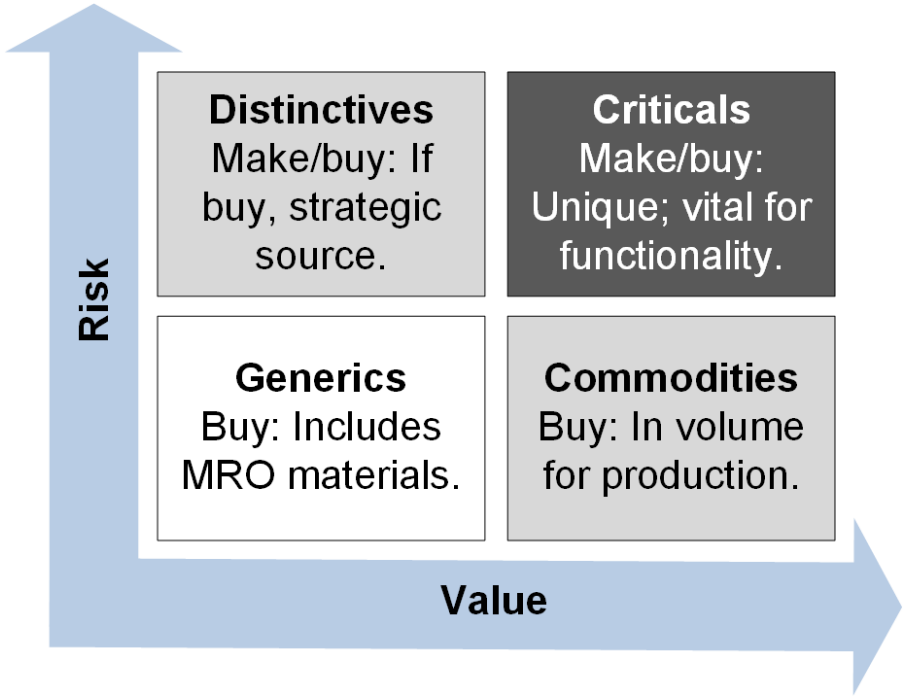
Purchasing Strategy

- Procurement at executive, director, or operations level
- Spend analysis
- Strategic sourcing
  - High reliability
  - Very low variability
  - Lowest total cost of ownership (TCO)
  - Multisource over single-source or sole source if possible



Selecting and Managing Suppliers

Selecting suppliers

- Identify direct/indirect material purchasing requirements.
- Set price, quantity, functionality, and esthetics.
- Identify potential suppliers.
- Specify evaluation criteria and weights.
- Issue RFP/ITT.
- Rank and select candidates.
- Negotiate price and service levels.
- Review terms/conditions and sign contracts.

Managing suppliers

- Issue purchase orders.
- Monitor and control deliveries.
- Receive and accept goods and pay invoices.
- Continually improve supplier performance.

Weighted Selection Criteria

- Ranking 1 = worst to 5 = best
- Cost for 10,000 units delivered to Factory ABC warehouse
- Weights sum to 100%

	Rating	Supplier A		Supplier B		Supplier C	
Landed Cost							
Price		$2,200		$3,200		$2,000	
Transportation cost		$800		$500		$1,400	
Inventory carrying cost*		$400		$200		$600	
Total landed cost		$3,400		$3,900		$4,000	
Rank/weighted rank	15%	5	**0.75**	2	**0.30**	1	**0.15**
Value Factors							
Technical capability	10%	2	**0.20**	4	**0.40**	5	**0.50**
Capacity	10%	5	**0.50**	3	**0.30**	3	**0.30**
Reliability	10%	2	**0.20**	2	**0.20**	3	**0.30**
Flexibility	5%	2	**0.10**	4	**0.20**	5	**0.25**
Agility	5%	4	**0.20**	5	**0.25**	2	**0.10**
Collaboration	10%	3	**0.30**	3	**0.30**	4	**0.40**
Quality	5%	1	**0.05**	2	**0.10**	5	**0.25**
Rank/weighted rank			**1.55**		**1.75**		**2.10**
Risks							
Availability	10%	2	**0.20**	3	**0.30**	4	**0.40**
Lead time	15%	3	**0.45**	4	**0.60**	4	**0.60**
Price change	5%	5	**0.25**	2	**0.10**	1	**0.05**
Rank/weighted rank	100%		**0.90**		**1.00**		**1.05**
Cumulative weighted rank			**3.20**		**3.05**		**3.30**

Traditional Position-Based Negotiation Tactics

Hard negotiations	Soft negotiations
▪ Win/lose ▪ View other parties as adversaries ▪ Threaten, mislead, pressure ▪ Endangers long-term success	▪ Lose/win ▪ Value agreement ▪ Disclose bottom line, alter position, accept one-sided agreements that involve only concessions ▪ Feel exploited, financially at risk

Principled Negotiation Tactics: Win/Win

Negotiations should:

- Efficiently solve underlying issues.
- Preserve or increase positive relationships.

Agreements should:

- Endure.
- Meet both parties' actual needs.
- Resolve conflicts of interest fairly.
- Be in the community's interests.

Contracts

- Contracts for the international sale of goods (CISG)
- Cost-based
  - Cost-plus-fixed-fee
- Fixed price
  - Firm fixed-price
- Incentives
  - Cost-plus-incentive-fee
  - Fixed-price-incentive-fee

Contract Terms and Conditions

- Good faith
- Term, scope, territory, corporate account
- Pricing, delivery
- Trade/payment/order terms
- Performance, quality
- Incentives and penalties
- Status reporting
- Problem resolution, termination
- Security, intellectual property, nondisclosure
- Language, legal authority
- Indemnification
- “Entire agreement supersedes”
- “Executed in counterparts”

Terms of Sale and Trade

	Freight Charges Paid By	Ownership in Transit	Files Freight Claims
FOB Origin, Freight Collect	Buyer	Buyer	Buyer
FOB Origin, Freight Prepaid	Seller	Buyer	Buyer
FOB Origin, Freight Prepaid and Charged Back	Seller (but invoices buyer)	Buyer	Buyer
FOB Destination, Freight Collect	Buyer	Seller	Seller
FOB Destination, Freight Prepaid	Seller	Seller	Seller
FOB Destination Freight Prepaid and Charged Back	Seller (but invoices buyer)	Seller	Seller

Key Procurement Metrics

- Suppliers should participate.
- Act on failures.
- Formal and informal communications.
- Supplier scorecard—dashboard with weightings:
  - Magnitude of cost savings
  - Variances from price, quantity, type, timing, quality
  - Benchmark prices
  - Magnitude and frequency of early and late deliveries
  - Sustainability, ethics
  - Supplier certification