Introduction to Demand Planning & Forecasting



Demand Process – Three Key Questions

Lesson: Demand Forecasting Basics

What should we do to shape and create demand for our product?

What should we expect demand to

What should we expect demand to be given the demand plan in place?

How do we prepare for and act on demand when it materializes?

Demand Planning

- Product & Packaging
- Promotions
- Pricing
- Place

Demand Forecasting

- Strategic, Tactical, Operational
- Considers internal & external factors
- Baseline, unbiased, & unconstrained

Demand Management

- Balances demand & supply
- Sales & Operations Planning (S&OP)
- Bridges both sides of a firm

Material adapted from Lapide, L. (2006) Course Notes, ESD.260 Logistics Systems.

Forecasting Levels

Level	Horizon	Purposes		
Strategic	Year/Years	Business PlanningCapacity PlanningInvestment Strategies		
Tactical	Quarterly	Brand PlansBudgetingSales PlanningManpower Planning		
	Months/Weeks	Short-term Capacity PlanningMaster PlanningInventory Planning		
Operational	Days/Hours	Transportation PlanningProduction PlanningInventory Deployment		

Lesson: Demand Forecasting Basics

Material adapted from Lapide, L. (2006) Course Notes, ESD.260 Logistics Systems.

Agenda

- Forecasting Truisms
- Subjective vs. Objective Approaches

- Forecast Quality
- Forecasting Metrics

Forecasting Truisms 1: Forecasts are always wrong

Forecasts are always wrong

Why?

Demand is essentially a continuous variable

Lesson: Demand Forecasting Basics

- Every estimate has an "error band"
- Forecasts are highly disaggregated
 - Typically SKU-Location-Time forecasts
- Things happen . . .

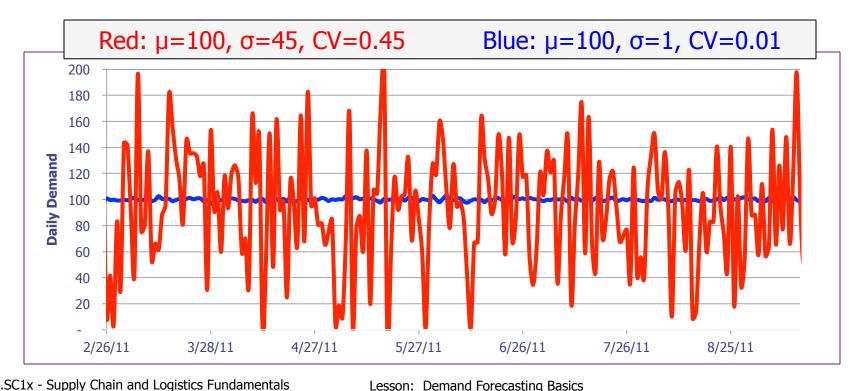
OK, so what can we do?

- Don't fixate on the point value
- Use range forecasts
- Capture error of forecasts
- Use buffer capacity or stock

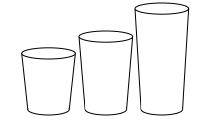
Forecasting Truisms 2: *Aggregated forecasts are more accurate*

2. Aggregated forecasts are more accurate

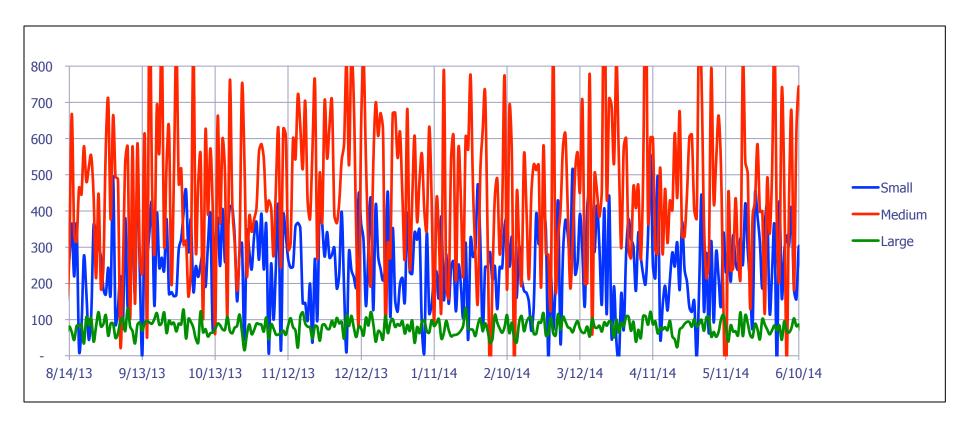
- Aggregation by SKU, Time, Location, etc.
- Coefficient of Variation (CV)
 - Definition: Standard Deviation / Mean = σ/μ
 - Provides a relative measure of volatility or uncertainty
 - CV is non-negative and higher CV indicates higher volatility



Aggregating by SKU

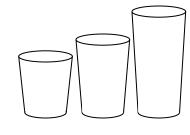


- Coffee Cups and Lids @ the Sandwich Shop
 - Large $\sim N(80, 30)$ CV = 0.38
 - Medium $\sim N(450, 210)$ CV = 0.47
 - Small $\sim N(250, 110)$ CV = 0.44



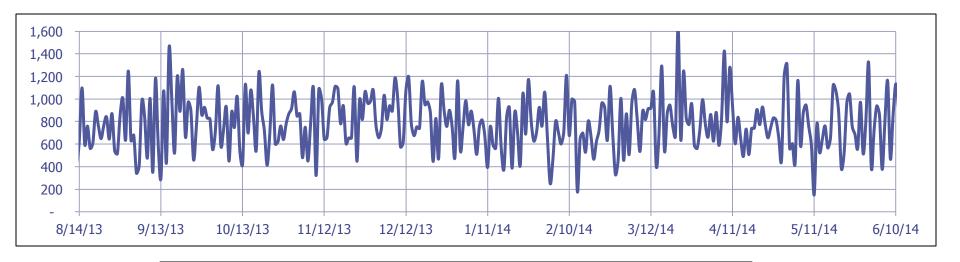
Aggregating by SKU

- What if I design cups with a common lid?
- Common Lid $\sim N(780, 239)$ CV = 0.31
 - $\mu = (80 + 450 + 250) = 780 \text{ units/day}$
 - $\sigma = \text{sqrt}(30^2 + 210^2 + 110^2) = 239 \text{ units/day}$



Large \sim N(80, 30) CV=0.38 Med. \sim N(450, 210) CV=0.47 Small \sim N(250, 110) CV=0.44

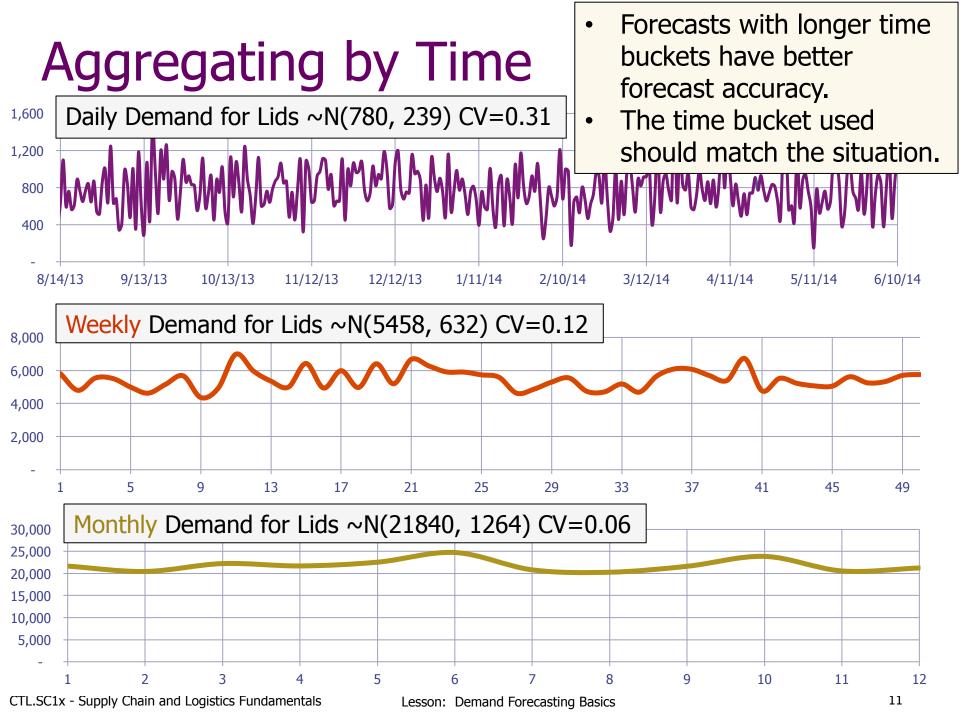
Lids ~N(780, 239) CV=0.31



Lesson: Demand Forecasting Basics

Example of Modularity or Parts Commonality

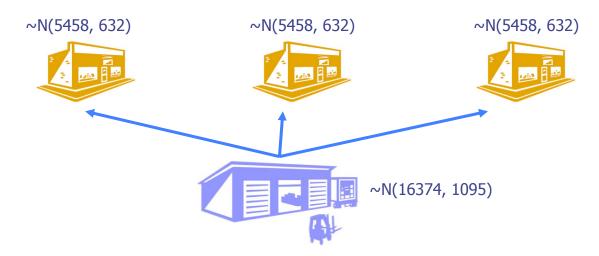
- Reduces the relative variability
- Increases forecasting accuracy
- Lowers safety stock requirements



Aggregating by Locations

CV reduces as we aggregate over SKUs, time, or locations.

- Suppose we have three sandwich shops
 - Weekly lid demand at each \sim N(5458, 632) CV=0.12



- What if demand is pooled at a common Distribution Center?
 - Weekly lid demand at DC ~N(16374, 1095) CV=0.07

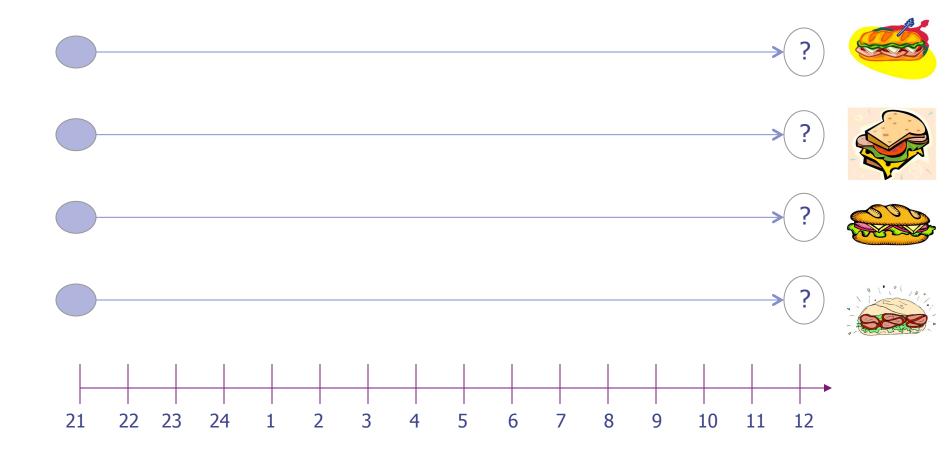
$$CV_{ind} = \frac{\sigma}{\mu}$$

$$CV_{agg} = \frac{\sigma\sqrt{n}}{\mu n} = \frac{\sigma}{\mu\sqrt{n}} = \frac{CV_{ind}}{\sqrt{n}}$$

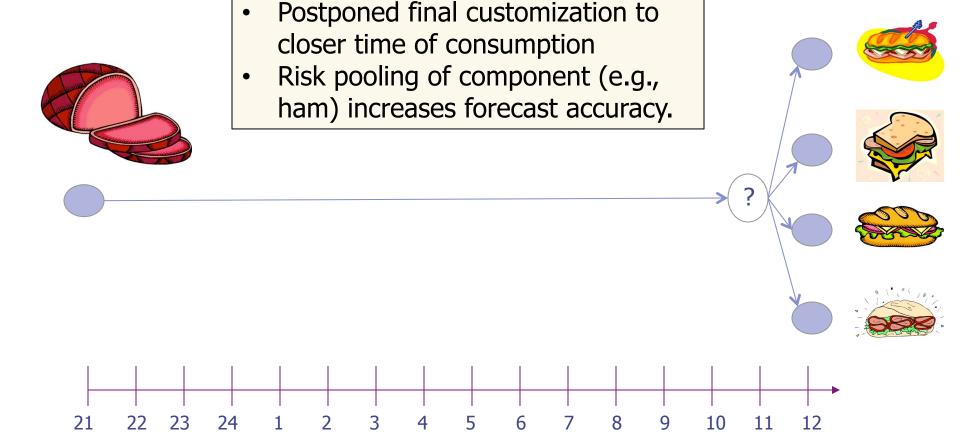
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Forecasting Truisms 3: Shorter horizon forecasts are more accurate

3. Shorter horizon forecasts are more accurate



3. Shorter horizon forecasts are more accurate



Forecasting Truisms

- Forecasts are always wrong
 - → Use ranges & track forecast error
- Aggregated forecasts are more accurate
 - → Risk pooling reduces CV
- Shorter time horizon forecasts are more accurate
 - → Postpone customization until as late as possible

Subjective & Objective Approaches

Fundamental Forecasting Approaches

Subjective

Objective

Judgmental

- Sales force surveys
- Jury of experts
- Delphi techniques

Experimental

- Customer surveys
- Focus group sessions
- Test marketing

Causal / Relational

- Econometric Models
- Leading Indicators
- Input-Output Models

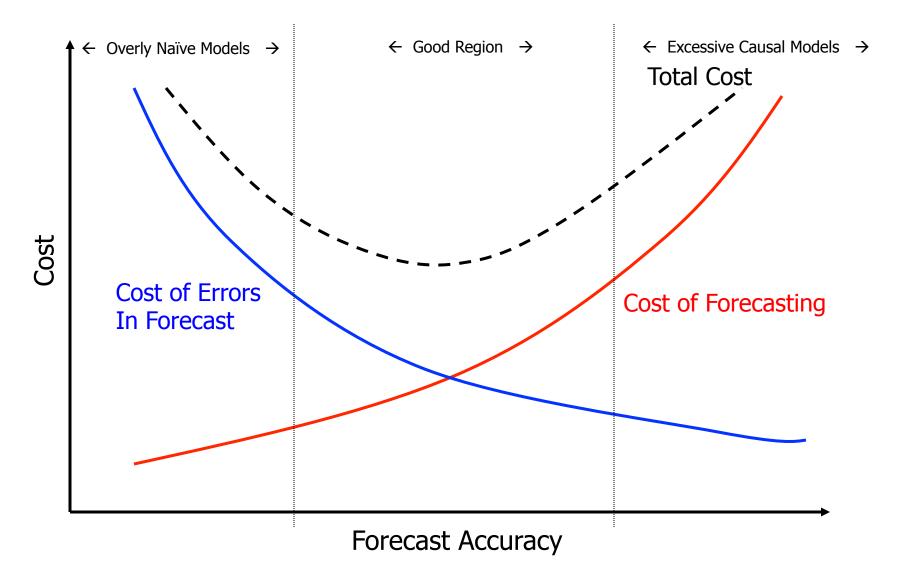
Time Series

- "Black Box" Approach
- Past predicts the future
- Identify patterns

Often times, you will need to use a combination of approaches

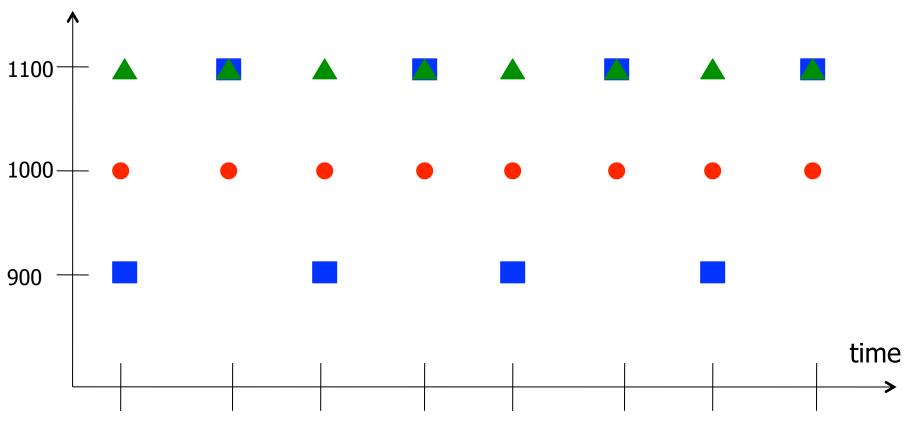
Forecasting Quality

Cost of Forecasting vs Inaccuracy



How do we determine if a forecast is good?

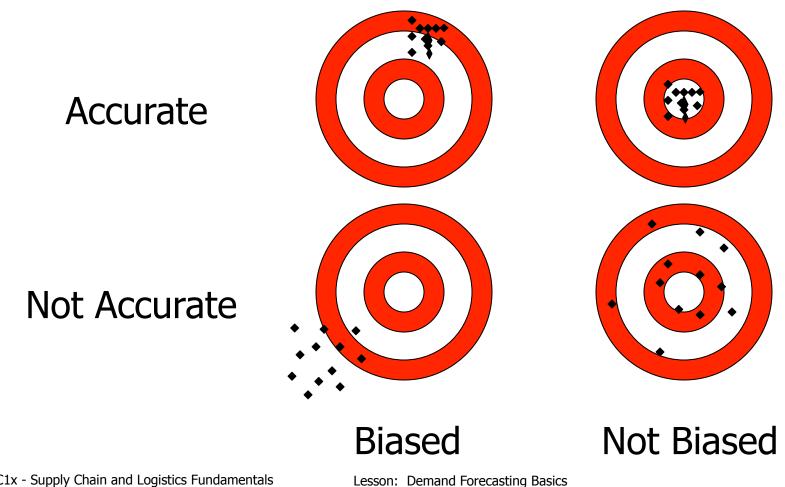
- What metrics should we use?
- Example Which is a better forecast?
 - Squares & triangles are different forecasts
 - Circles are actual values



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Accuracy versus Bias

- **Accuracy Closeness to actual observations**
- Bias Persistent tendency to over or under predict



Forecasting Metrics

Forecasting Metrics

$$e_t = A_t - F_t$$

Mean Deviation (MD)

$$MD = \frac{\sum_{t=1}^{n} e_t}{n}$$

Mean Absolute Deviation (MAD)

$$MAD = \frac{\sum_{t=1}^{n} |e_t|}{n}$$

Mean Squared Error (MSE)

$$MSE = \frac{\sum_{t=1}^{n} e_t^2}{n}$$

Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n} e_t^2}{n}}$$

Mean Percent Error (MPE)

$$MPE = \frac{\sum_{t=1}^{n} \frac{e_t}{A_t}}{n}$$

Mean Absolute
Percent Error (MAPE) $MAPE = \frac{\sum_{t=1}^{n} \frac{|e_t|}{A_t}}{A_t}$

Notation:

 A_t = Actual value for obs. t F_t = Forecasted value for obs. t e_t = Error for observation t n = Number of observations

Example: Forecasting Bagels

- For the bagel forecast and actual values shown below, find the:
 - Mean Absolute Deviation (MAD)
 - Root Mean Square of Error (RMSE)
 - Mean Absolute Percent Error (MAPE)

	Forecast	Actual
Monday	50	43
Tuesday	50	42
Wednesday	50	66
Thursday	50	38
Friday	75	86

$$MAD = \frac{\sum_{t=1}^{n} |e_t|}{n}$$

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n} e_t^2}{n}}$$

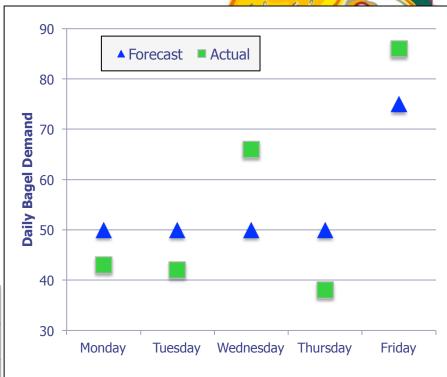
$$MAPE = \frac{\sum_{t=1}^{n} \frac{\left| e_{t} \right|}{A_{t}}}{n}$$

Example: Forecasting Bagels



- 1. Graph it.
- 2. Extend data table:
 - Error: $e_t = A_t F_t$
 - Abs[error] = $|e_t|$
 - Sqr[error] = e^2
 - AbsPct[error] = |e_t/A_t|
- 3. Sum and find means

	F _t	A _t	e _t	e _t	e ²	e _t /A _t
Monday	50	43	-7	7	49	16.3%
Tuesday	50	42	-8	8	64	19.0%
Wednesday	50	66	16	16	256	24.2%
Thursday	50	38	-12	12	144	31.6%
Friday	75	86	11	11	121	12.8%
Sum		0	54	634	104%	
Mean		0	10.8	126.8	21%	



MAD =
$$54/5 = 10.8$$

RMSE = $sqrt(126.8) = 11.3$
MAPE = $104\%/5 = 21\%$

Key Points from Lesson

Key Points

- Forecasting is a means not an end
- Forecasting Truisms
 - Forecasts are always wrong
 - Aggregated forecasts are more accurate
 - Shorter horizon forecasts are more accurate

- Subjective & Objective Approaches
 - Judgmental & experimental
 - Causal & time series
- Forecasting metrics
 - Capture both bias & accuracy
 - MAD, RMSE, MAPE

CTL.SC1x -Supply Chain & Logistics Fundamentals

Questions, Comments, Suggestions? Use the Discussion!



"Janie"
Photo courtesy Yankee Golden
Retriever Rescue (www.ygrr.org)

