SUPPLY CHAIN FUNDAMENTALS

FORECASTING
Introduction

THIS LECTURE IN ENABLED BY COURSE CONTENT FROM DR. CHRIS CAPLICE @ MIT

DEMAND PROCESS – THREE KEY QUESTIONS

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

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

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

FORECASTING LEVELS

LEVEL	HORIZON	PURPOSES
Strategic	Year/Years	– Business Planning – Capacity Planning – Investment Strategies
Tactical	Quarterly	– Brand Plans – Budgeting – Sales Planning – Manpower Planning
	Months/Weeks	– Short-term Capacity Planning – Master Planning – Inventory Planning
Operational	Days/Hours	– Transportation Planning – Production Planning – Inventory Deployment

Source: Material adapted from Lapide, L. (2006) Course Notes, ESD.260 Logistics System.

DIFFERENT FUNCTIONS HAVE DIFFERENT OPERATIONAL NEEDS

Marketing

Drive demand

Sales

Set sales goals

Operations

Plan supply chain activities

Management

Assess sales and profits

Finance

Forecast/budget corporate financials

Operational forecasting drives supply chain planning

WHERE SHOULD FORECASTING BELONG?

Forecasting Requirements of Various Managerial Functions

	Marketing	*Sales*	*Finance/ Accounting*	*Production/ Purchasing: Long Term*	*Production/ Purchasing: Short Term*	*Logistics: Long Term*	*Logistics: Short Term*
Needs	Annual plans (updated monthly or quarterly) for new and existing products or product changes, promotional efforts, channel placement, and pricing	Setting goals for the sales force and motivating salespeople to exceed those goals	Projecting cost and profit levels and capital needs	Planning the development of plant and equipment	Planning specific production runs	Planning the development of storage facilities and transportation equipment	Specific decisions of what products to move to what locations and when
Level	Product or product line	Territory and/or customer	Corporate, division, product line	Product (SKU)	Product (SKU)	Product by location (SKUL)	Product by location (SKUL)
Horizon	Annual	1–2 years	1–5 years	1–3 years	1–6 months	Monthly to several years	Daily, weekly, monthly
Interval	Monthly or quarterly	Monthly or quarterly	Monthly or quarterly	Quarterly	Daily, weekly, monthly	Monthly	Daily, weekly, monthly
Form	Dollars	Dollars	Dollars	Units	Units	Units/ Weight/ Cube	Units/ Weight/ Cube

Source: Chapter 1 - Managing the sales forecasting process

Forecasting Requirements by Functions

FORECASTING TRUISMS

A. Forecasts are always wrong

Forecasts Are Always Wrong

Why?

- Demand is essentially a continuous variable
- 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

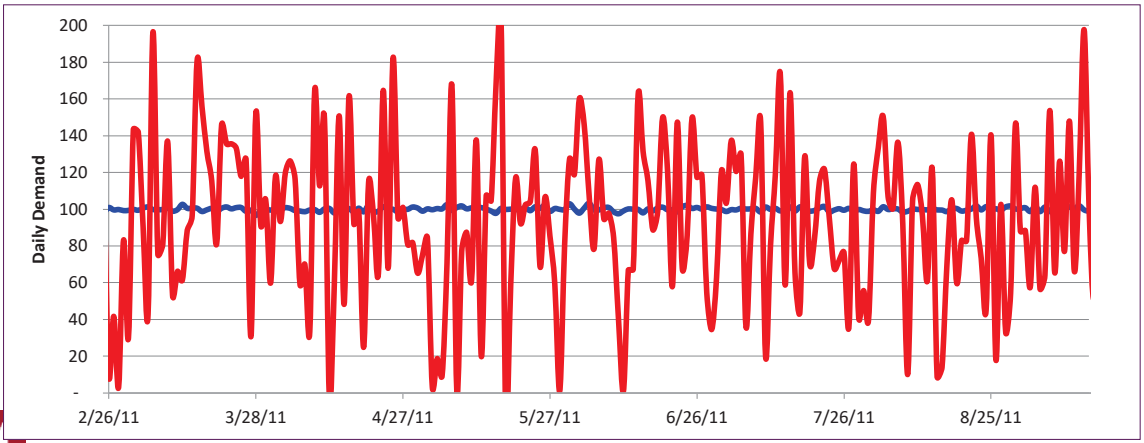
Forecasting Truisms

B. Aggregated forecasts are more accurate

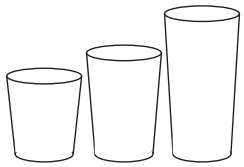
Aggregated Forecasts Are More Accurate

- 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

Red: μ=100, σ=45, CV=0.45 Blue: μ=100, σ=1, CV=0.01



Aggregating by SKU

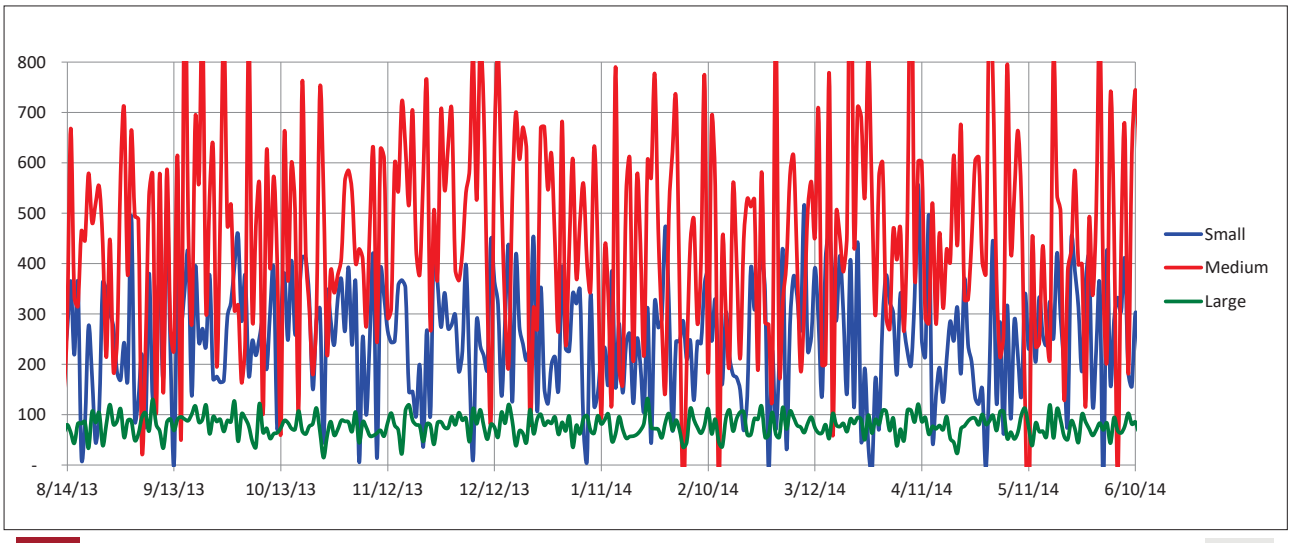


- Coffee Cups and Lids @ the Sandwich Shop
  - Large ~N(80, 30) CV = 0.38
  - Medium ~N(450, 210) CV = 0.47
  - Small ~N(250, 110) CV = 0.44

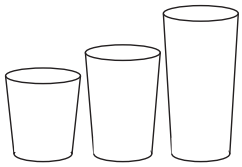
Large: Stable, Do not sell many

Medium has the highest volatility

Smalls: Average sellers, medium volatility



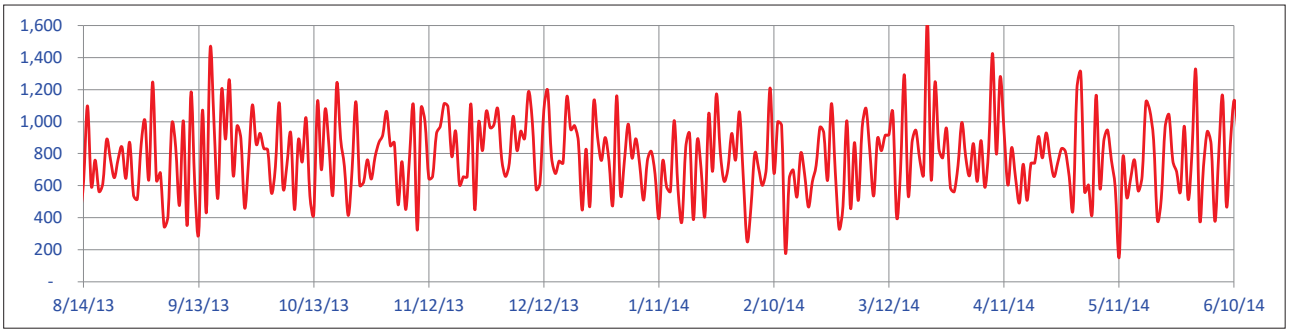
AGGREGATING BY SKU (RISK POOLING)



- What if I design cups with a common lid?
- Common Lid ~N(780, 239) CV = 0.31
  - μ = (80 + 450 + 250) = 780 units/day
  - σ = sqrt (30^2 + 210^2 + 110^2) = 239 units/day

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

Lids ~N(780, 239) CV=0.31

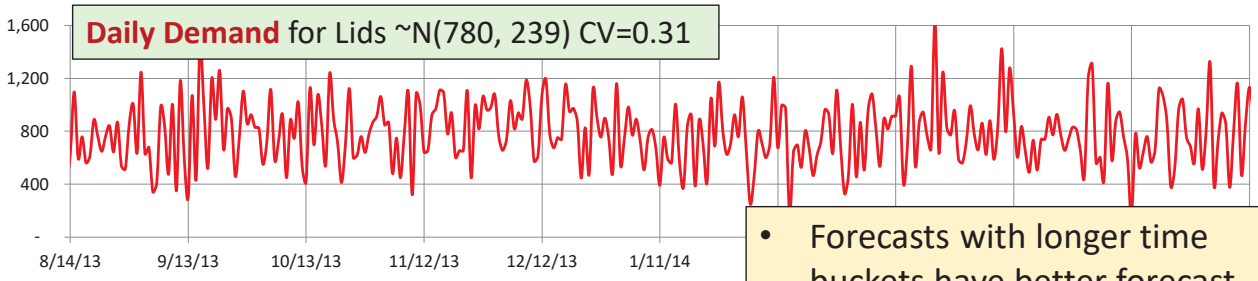


Example of Modularity or Parts Commonality
- Reduces the relative variability
- Increases forecasting accuracy
- Lowers safety stock requirements

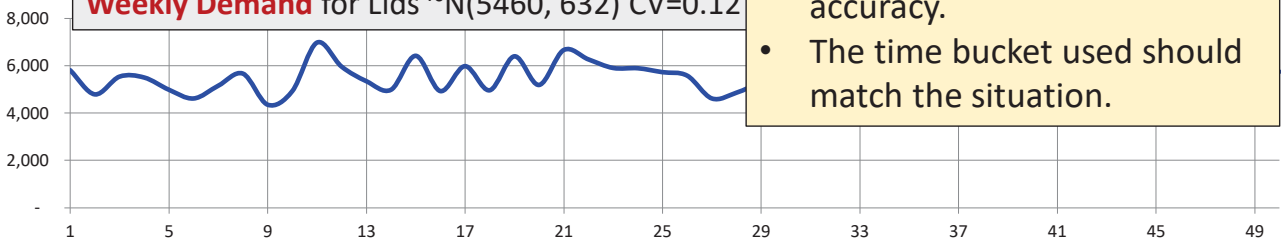
- Engineers can design common parts across, If I aggregate by SKUs or designing Modularity
- Risk Pooling!

AGGREGATING BY TIME

Daily Demand for Lids ~N(780, 239) CV=0.31

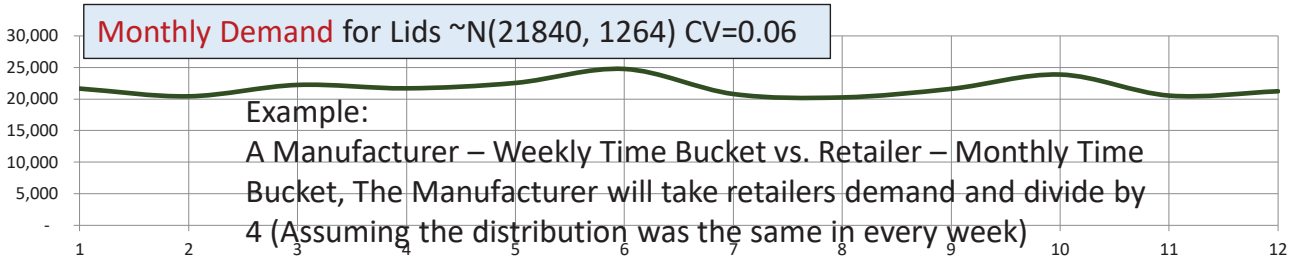


Weekly Demand for Lids ~N(5460, 632) CV=0.12



- Forecasts with longer time buckets have better forecast accuracy.
- The time bucket used should match the situation.

Monthly Demand for Lids ~N(21840, 1264) CV=0.06

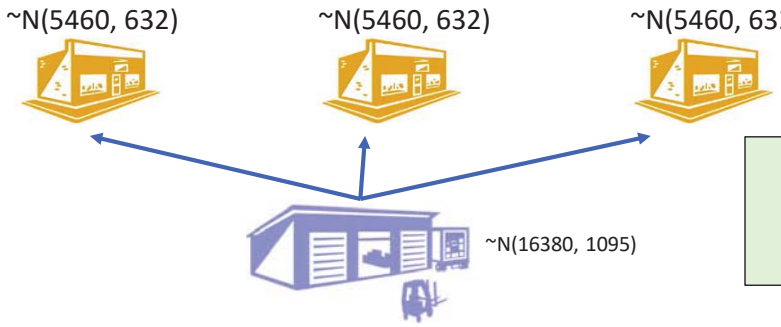


Example:
A Manufacturer – Weekly Time Bucket vs. Retailer – Monthly Time Bucket, The Manufacturer will take retailers demand and divide by 4 (Assuming the distribution was the same in every week)

Aggregating by Locations

- Suppose we have three sandwich shops
  - Weekly lid demand at each ~N(5460, 632), CV=0.12

~ weekly demand example from previous slide



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

- What if demand is pooled at a common Distribution Center?
  - Weekly lid demand at DC ~N(16380, 1095) CV=0.07

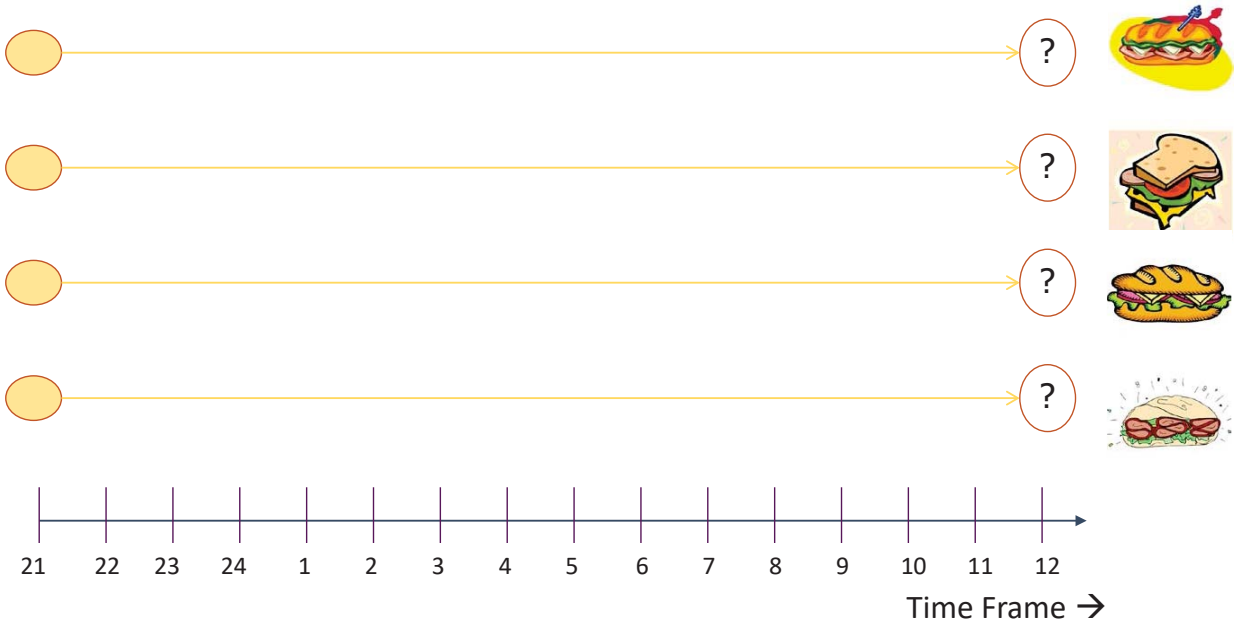
$$CV_{ind} = \frac{\sigma}{\mu}$$

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

Forecasting Truisms

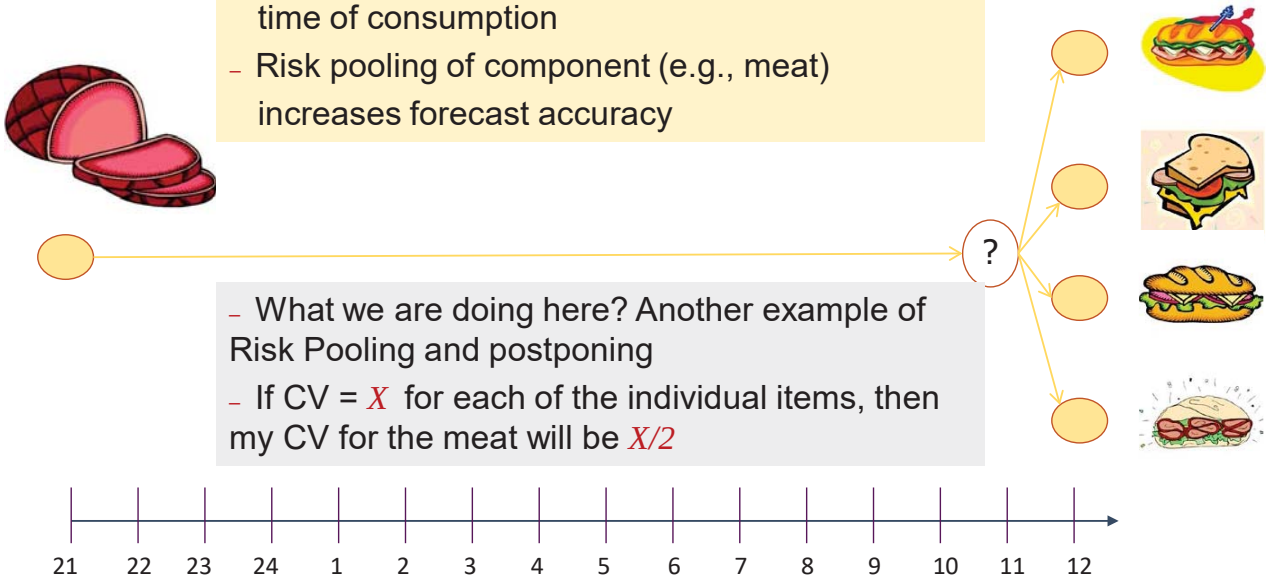
C. Shorter horizon forecasts are more accurate

Forecasting for Shorter Horizons is More Accurate than Longer



Forecasting for Shorter Horizons is More Accurate than Longer

- Postponed final customization to closer time of consumption
- Risk pooling of component (e.g., meat) increases forecast accuracy



- What we are doing here? Another example of Risk Pooling and postponing
- If CV = X for each of the individual items, then my CV for the meat will be $X/2$

FORECASTING TRUISMS

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