Connecting the Dots

MIT Center for
Transportation & Logistics

Forecasting Approaches

		Product Technology: Current (Have History)	Product Technology: New (No History)
Market	Current (Have History)	**Market Penetration** **Forecasting Approach**: Quantitative analysis of similar situations with item using history Time Series, Exponential Smoothing, Regression	**Product Development** **Forecasting Approach**: Analysis of similar items: "looks-like" analysis or analogous forecasting Regression of "looks like" items
Market	New (No History)	**Market Development** **Forecasting Approach**: Customer and market analysis to understand market dynamics and drivers Customer Panels, Experimental	**Diversification** **Forecasting Approach**: Scenario planning & analysis to understand key uncertainties & factors Delphi, Expert Panel, Scenario Planning, Bass Diffusion

Adapted from Kahn, Kenneth (2006) New Product Forecasting.

Regardless of Method:

- 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 as late as possible

$$e_t = A_t - F_t$$

Mean Deviation (MD)

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

Mean Absolute Percent Error (MAPE)

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

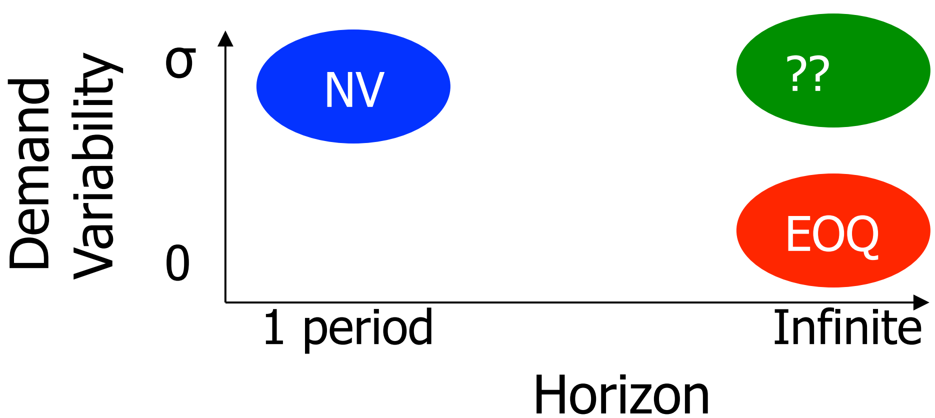
Root Mean Squared Error (RMSE)

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

Inventory Replenishment Policies

Policy: How much to order and when

- EOQ – deterministic demand with infinite horizon
  - Trading off fixed and variable costs
  - Order Q* every T* time periods /Order Q* when IP=μ_{DL}
- Newsvendor – variable demand over single period
  - Trading off shortage and excess costs
  - Order Q* at start of period where P[x≤Q]=CR



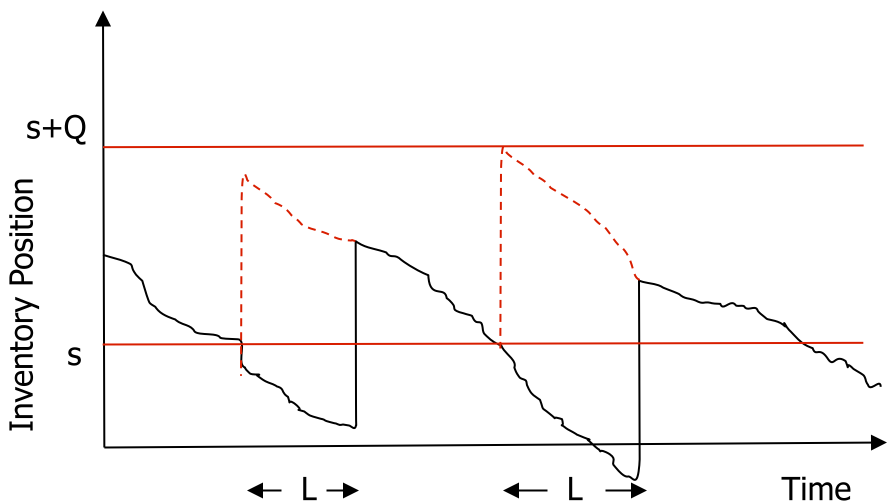
Periodic vs. Continuous Review Policies

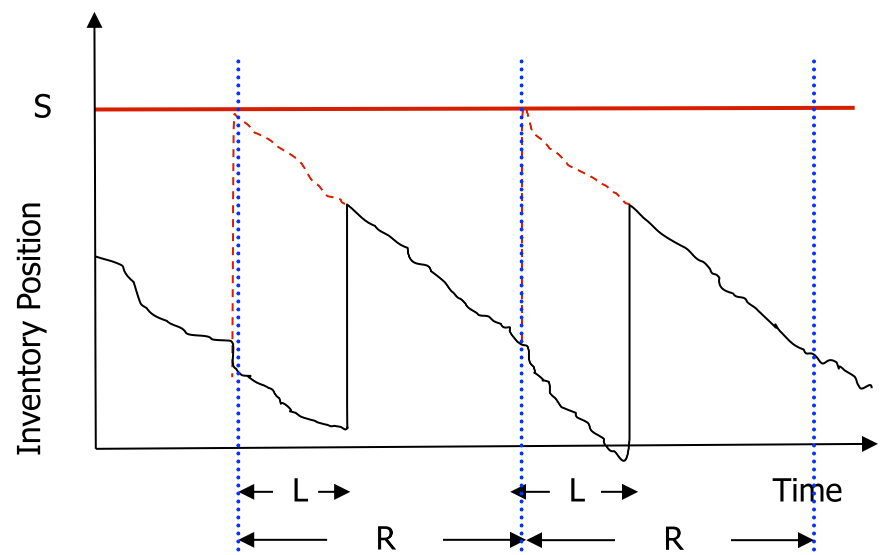
Continuous Review (s,Q)

- Order Q if IP ≤ s

Periodic Review (R, S)

- Order S-IP every R periods



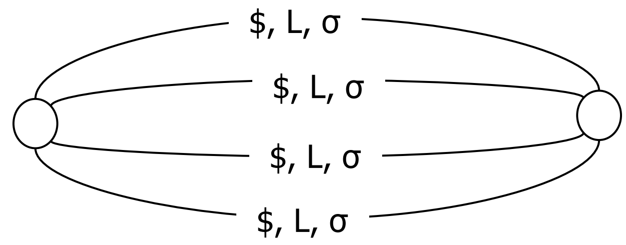


$$s = \mu_{DL} + k\sigma_{DL} \qquad Q^* = \sqrt{\frac{2c_t D}{c_e}}$$

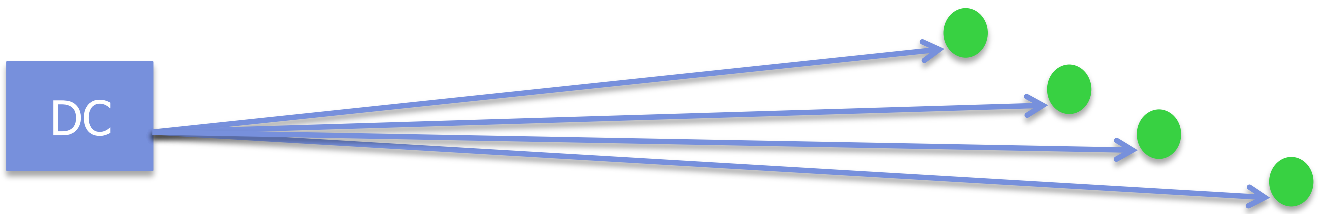
$$S = \mu_{DL+R} + k\sigma_{DL+R}$$

Q ➔ D*R, s➔S, L➔L+R

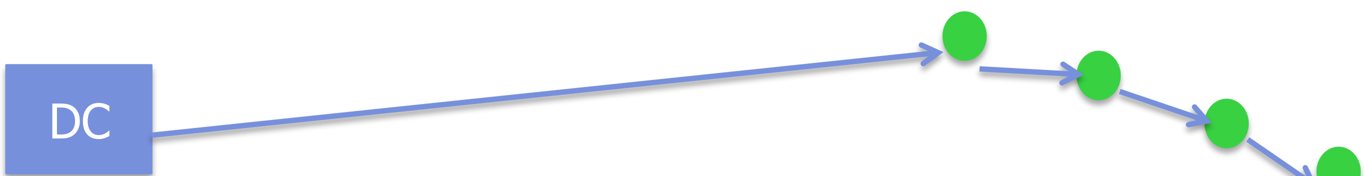
Transportation Options



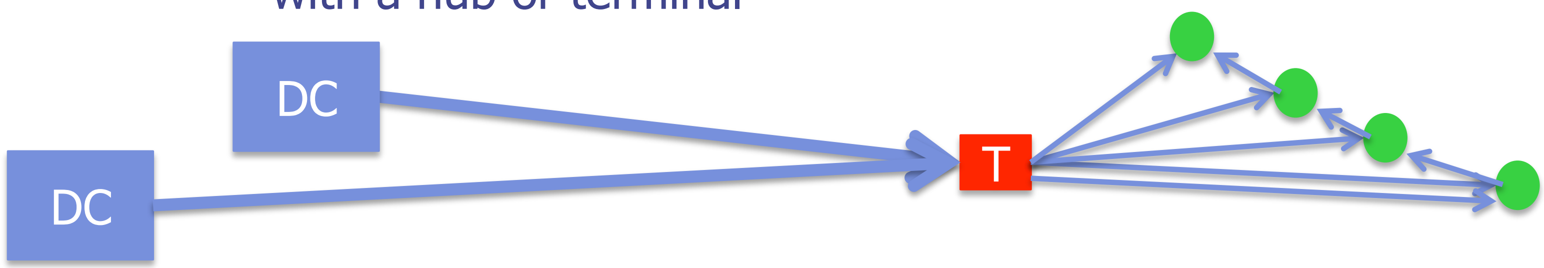
One-to-One – direct or point to point movements from origin to destination



One-to-Many – multi-stop moves from a single origin to many destinations



Many-to-Many – moving from multiple origins to multiple destinations usually with a hub or terminal



Total Cost Equation

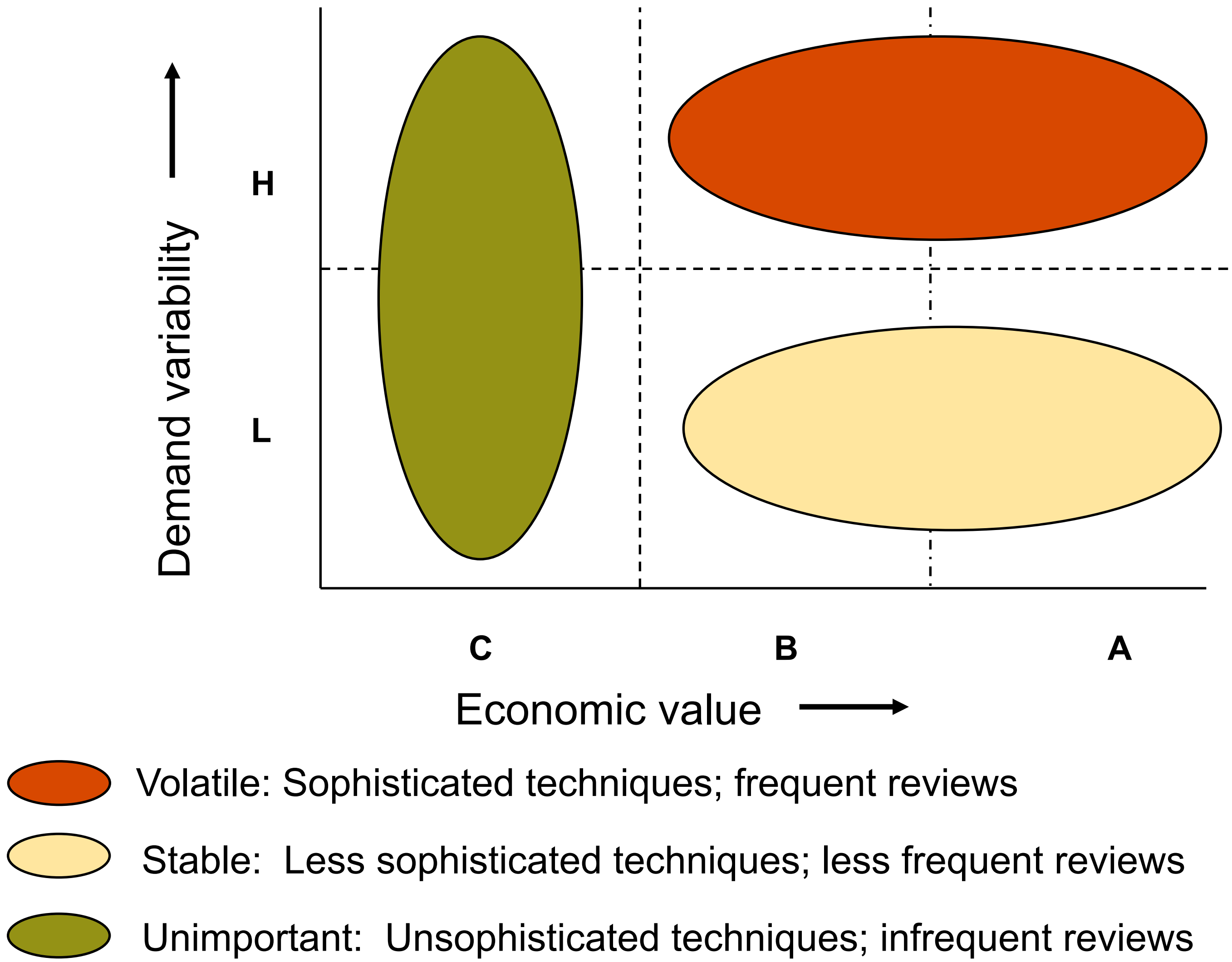
$$TC = cD + c_t\left(\frac{D}{Q}\right) + c_e\left(\frac{Q}{2} + k\sigma_{DL} + DL\right) + c_s P[StockOutType]$$

- Connection to Forecasting & Transportation
  - Forecasting Impact – expected demand and error
  - Transportation Impact – costs and lead time
- Setting Safety Stock
  - Service Based Metrics – set k to meet expected LOS
  - Cost Based Metrics – find k that minimizes total costs

$$\mu_{DL} = \mu_L \mu_D \qquad \sigma_{DL} = \sqrt{\mu_L \sigma_D^2 + (\mu_D)^2 \sigma_L^2}$$

Putting It All Together

Segmentation



Adapted from Prashant Yadav (2005) Course Notes, Zaragoza Logistics Center.

Management by Segment

	A Items	B Items	C Items
Type of records	Extensive, Transactional	Moderate	None – use a rule
Level of Management Reporting	Frequent (Monthly or more)	Infrequently - Aggregated	Only as Aggregate
Interaction w/ Demand	Direct Input High Data Integrity Manipulate (pricing etc.)	Modified Forecast (promotions etc.)	Simple Forecast at best
Interaction w/ Supply	Actively Manage	Manage by Exception	None
Initial Deployment	Minimize exposure (high v)	Steady State	Steady State
Frequency of Policy Review	Very Frequent (monthly or more)	Moderate (Annually/Event Based)	Very Infrequent
Importance of Parameter Precision	Very High – accuracy worthwhile	Moderate – rounding & approximation is ok	Very Low
Shortage Strategy	Actively manage (confront)	Set service levels & manage by exception	Set & forget service levels
Demand Distribution	Consider alternatives to Normal as situation fits	Normal	N/A

ACTIVE **AUTOMATIC** **PASSIVE**

Demand: steady w/some seasonality
Value: high value
Forecasting: Time series
Inventory: Periodic Review (high k)
Transportation: Low cost & high reliability

Demand: volatile, short periods
Value: high value
Forecasting: subjective w/ "looks like" analysis
Inventory: Single (or two) Period w/high k
Transportation:
- Lower cost initial deployment
- Fast replenishment

Final Thoughts

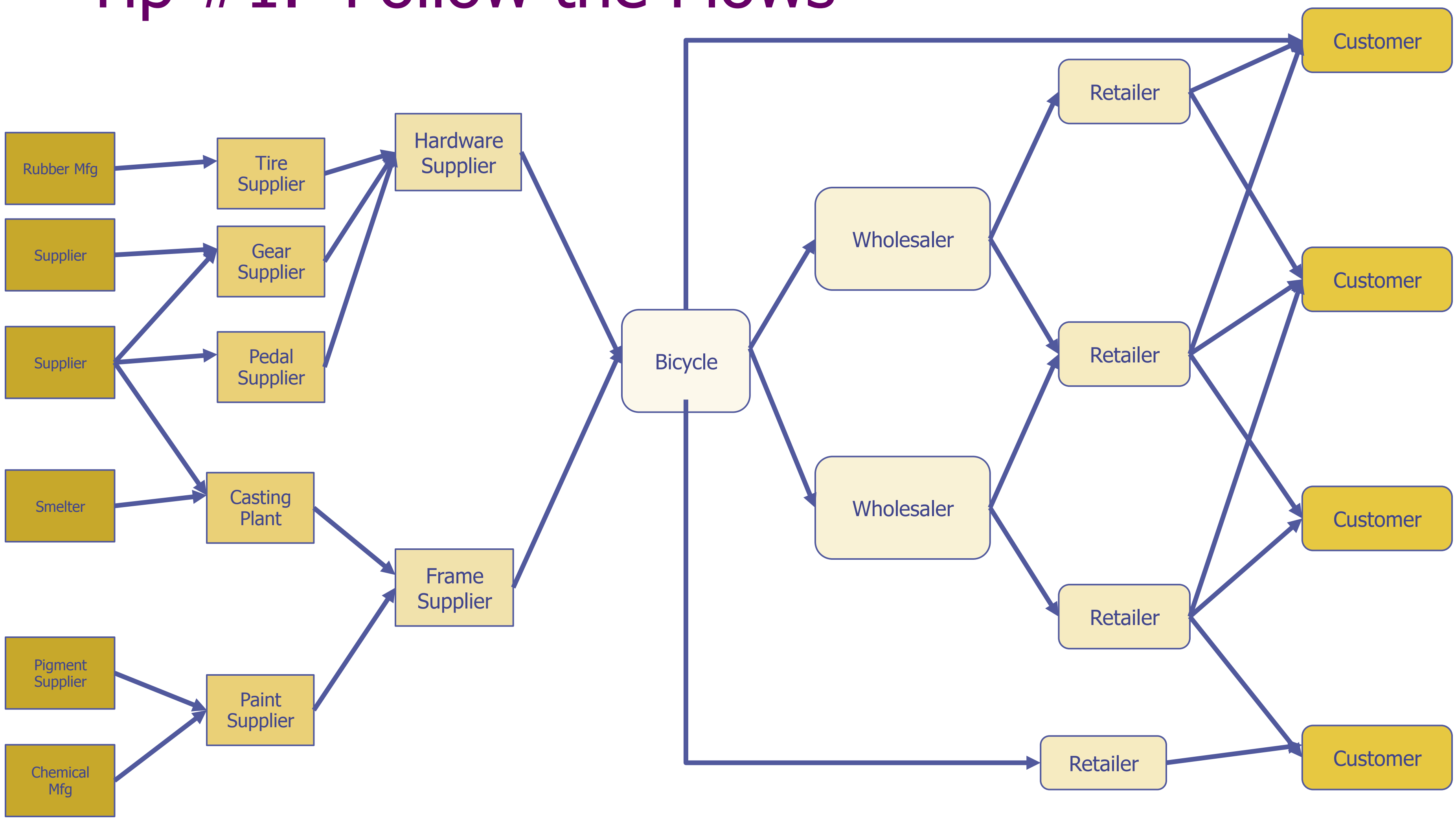
Final Thoughts

- Information is often gating factor for analysis
  - Data is not always available, accessible, or relevant
  - People are good resources, but often need help

- Three real-world tips for gathering information
  1. Follow the supply chain flows (product, info, financial)
  2. Use the Piñata Principle
  3. Coax with estimates and approximations

3 Real-World Tips on Gathering Info

Tip #1. Follow the Flows



3 Real-World Tips on Gathering Info

Tip #2. Use the Piñata Principle

- People are better at critiquing than creating
- You will get more input by having people comment on something rather than starting from scratch
- Examples:
  - Forecasting – Pick a model and make estimates
  - Inventory – Pick a LOS or cost value and model
  - Transportation – Select a route and show impact

3 Real-World Tips on Gathering Info

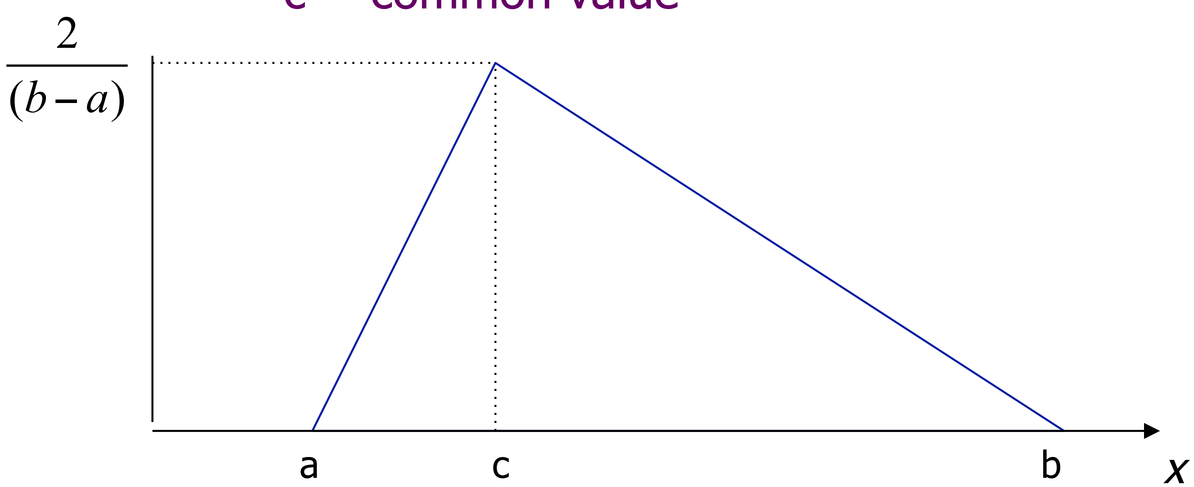
Tip #3. Coax with Estimates & Approximations

- Example: Triangle Distribution
  - Good way to get a sense of a distribution
  - Handles asymmetric distributions
  - People tend to recall extreme and common values

- Let's try it! Think of your daily commute.
  - What is the fastest time (minimum)?
  - What is the slowest time (maximum)?
  - What is the most common (mode)?

Triangle Distribution

a = minimum value
b = maximum value
c = common value



$$f(x)=\begin{cases} 0 & x<a \\ \frac{2(x-a)}{(b-a)(c-a)} & a\le x\le c \\ \frac{2(b-x)}{(b-a)(b-c)} & c\le x\le b \\ 0 & x>b \end{cases}$$

$$E[x]=\frac{a+b+c}{3}$$

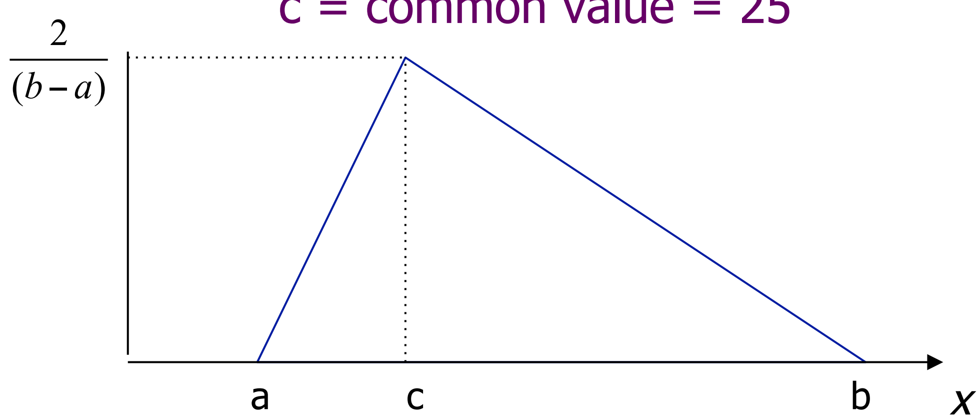
$$Var[x]=\left(\frac{1}{18}\right)\left(a^2+b^2+c^2-ab-ac-bc\right)$$

Example:
a=15 minutes
b=60 minutes
c=25 minutes

E[x] = 33.3 minutes
Var[x] = 93.1 minutes^2
σ[x] = 9.65 minutes

Triangle Distribution

a = minimum value = 15
b = maximum value = 60
c = common value = 25



$$f(x) = \begin{cases} 0 & x < a \\ \dfrac{2(x-a)}{(b-a)(c-a)} & a \le x \le c \\ \dfrac{2(b-x)}{(b-a)(b-c)} & c \le x \le b \\ 0 & x > b \end{cases}$$

$$P[x > d] = \left(\frac{1}{2}\right)(b-d)\left(\frac{2(b-d)}{(b-a)(b-c)}\right) \qquad \text{for } c \le d \le b$$

$$d = b - \sqrt{P[x > d](b-a)(b-c)} \qquad \text{for } c \le d \le b$$

What is the probability that time >45 min?
P[x>45]=(1/2)(15)(0.019)=.142
= 14%

What is the 95% time?
d=60-√[(0.05)(45)(35)] = 51.12
= 51 minutes

Final Thoughts

- Supply chains are all about trade-offs
  - Fixed vs. Variable costs
  - Shortage vs. Excess costs
  - Lead Time vs. Inventory
- CTL.SC1x gave you a toolbox of methods for:
  - Demand Forecasting
  - Inventory Management
  - Transportation Planning
- Problems rarely announce themselves, so knowing which tool to use is as critical as how to use it!

CTL.SC1x -Supply Chain & Logistics Fundamentals

Questions, Comments, Suggestions?
Use the Discussion!

Patches

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