



High performance. Delivered.

Role of Forecast Analytics in Inventory Management

ISM Chapter - NAPM Denver Seminar

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Agenda



Forecast Analytics Overview and Benefits

Case Study

- Issues

- Objectives

- Approach and Roadmap

- Algorithm selection based on history patterns

- Simple replenishment strategy for slow moving products

Why Analytics



Changing Customer trends

- Customer base is getting more fragmented, personalized and polarized
- Tailored promotions and offerings needed to capture retail customers
- Want things convenient, simple and ready-for-consumption
- Environmental/Sustainability consciousness
- Mobile, socially interconnected and time compressed



Challenges in Global Supply Chains

- Overseas sourcing and long lead times for products
- Global/Local execution of pricing and promotional strategies
- Profit erosion due to increased markdowns at the end of the season
- Inefficiencies and lack of cohesion between assortment planning, inventory management and vendor management
- Increased competition and lower margins
- Cost equation volatility



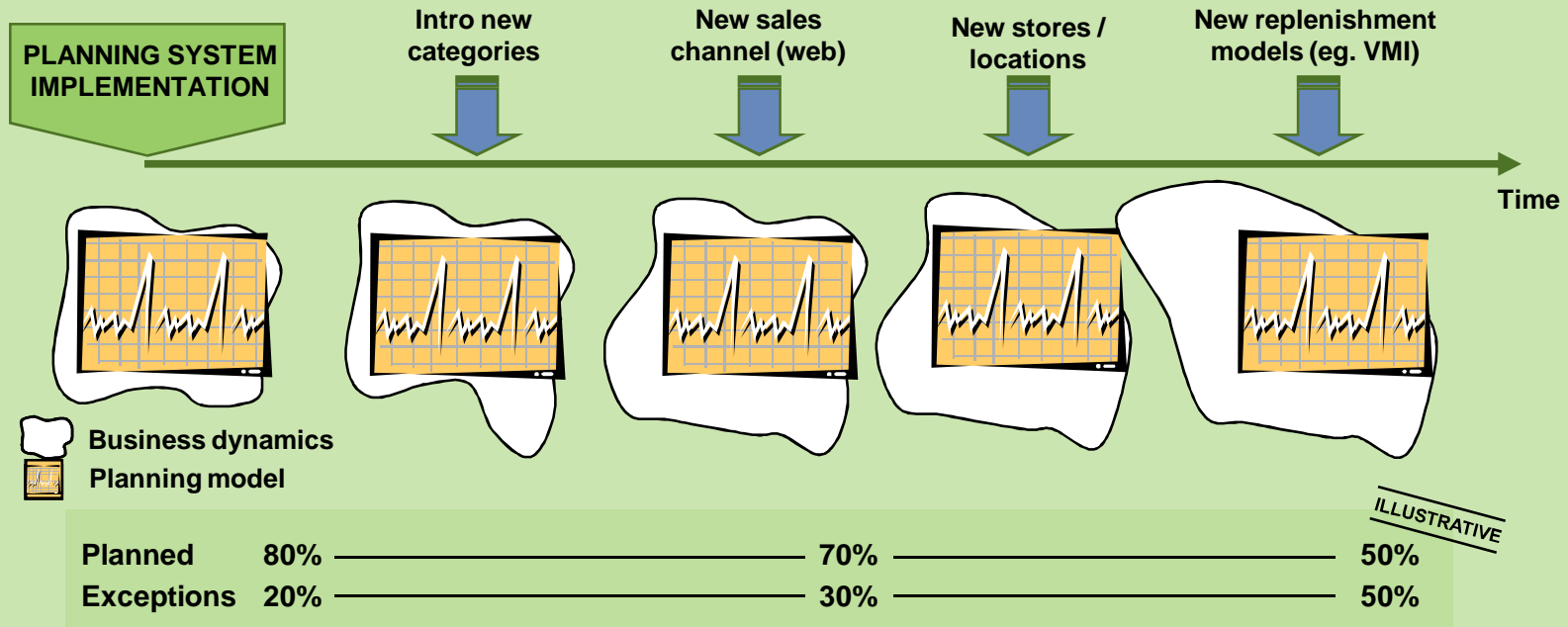
Gradual Misalignment in Planning Models



Misalignment of planning models vs. business dynamics over a period of time

Static planning models

- Basic forecasting and planning models uses mathematical models to project historical data into the future, and allow planners take decisions based on those projections. These models need to evolve as the business does to avoid inaccurate projections driving inefficient decisions.
- Need for an on-going recalibration of the planning models



Implications - Levers



Levers	Some Key Questions
Assortment and Space Planning	<ul style="list-style-type: none">• How can retailers create <i>personalized</i> products “at scale?”• How can retailers best use floor space and allocate the right mix of product types• How do retailers sell <i>sustainable</i> products while keeping costs in control?
Supply Chain	<ul style="list-style-type: none">• How can retailers deliver <i>convenience</i> by delivering product where the customer wants, when he/she wants it ... and at scale?• How can retailers reduce <i>environmental</i> impacts of distributing product?
Advertising and Promotions	<ul style="list-style-type: none">• How can retailers <i>tailor</i> offers to individual consumers?• How can promotions increase the connection between a retailer and their customer, creating a more ubiquitous customer <i>experience</i>?
In-Store Experience	<ul style="list-style-type: none">• How can retailers create a relevant <i>experience</i> that enhances the shopping occasion versus making it more complex?• How can different customer service models increase <i>personalization</i> and enable <i>convenience</i>?

Understanding Product and Customer Characteristics



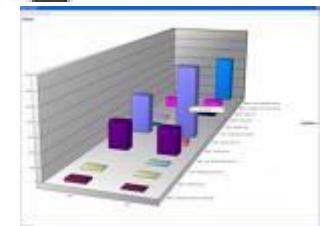
Needs

- Increased need to understand product and customer characteristics based on historical patterns
 - Marketing perspective (Customer segmentation, Campaign management)
 - Sales perspective (Customer profitability, Market basket analysis)
 - Inventory and Merchandise flow (Forecasting, Pricing & Promotions analysis, Inventory Optimization)
 - Customer perspective (Customer loyalty and satisfaction)
- Products, business processes and technologies are gradually losing out as competitive tools. High performance execution, analytics & insights are important differentiation strategies.



Enablers - Supporting Architecture

- Integrated massive data warehouses and data marts
- Mature BI architecture
- Availability of sophisticated statistical and analytical techniques
- Availability of large processing power



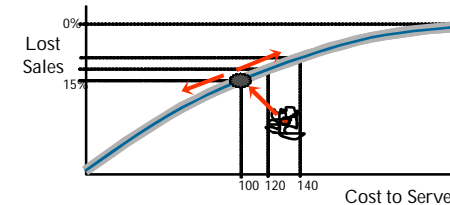
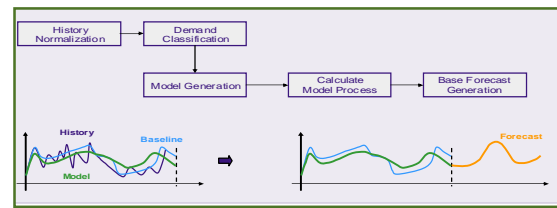
Forecast Analytics Overview



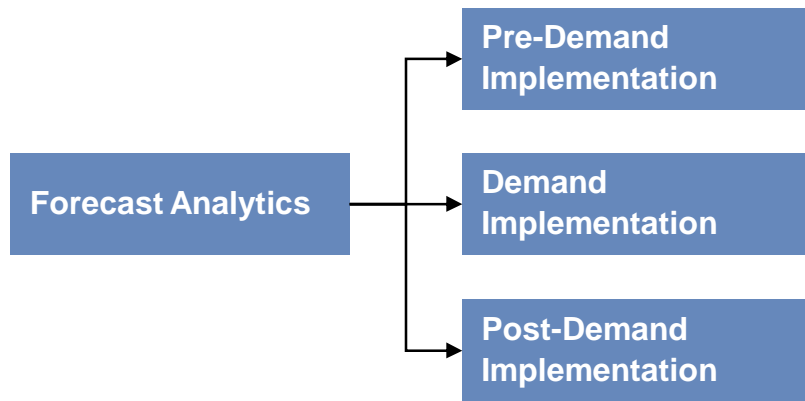
Forecast analytics drives to improve critical forecasting processes, such as, analysis of historical data, forecast algorithm selection & fine tuning, promotional analysis and external factor analysis

- Matching demand patterns with suitable algorithms to generate forecasts
- Classifying product groups based on clustering techniques
- Efficient segmentations to make the forecasting process lean
- Understanding of external casual factors and how it affects the product forecast
- Understanding and predictability of promotional effects on baseline forecast
- Improving control on processing times as segmentation techniques allow the business to focus on processing prioritization

“Aberdeen Research’s Supply Chain Inventory Strategies Benchmark Report states that more than 60% of companies use overly simplistic forecasting and inventory management methods. These companies frequently have 15-30% more inventory than they need and lower service levels”

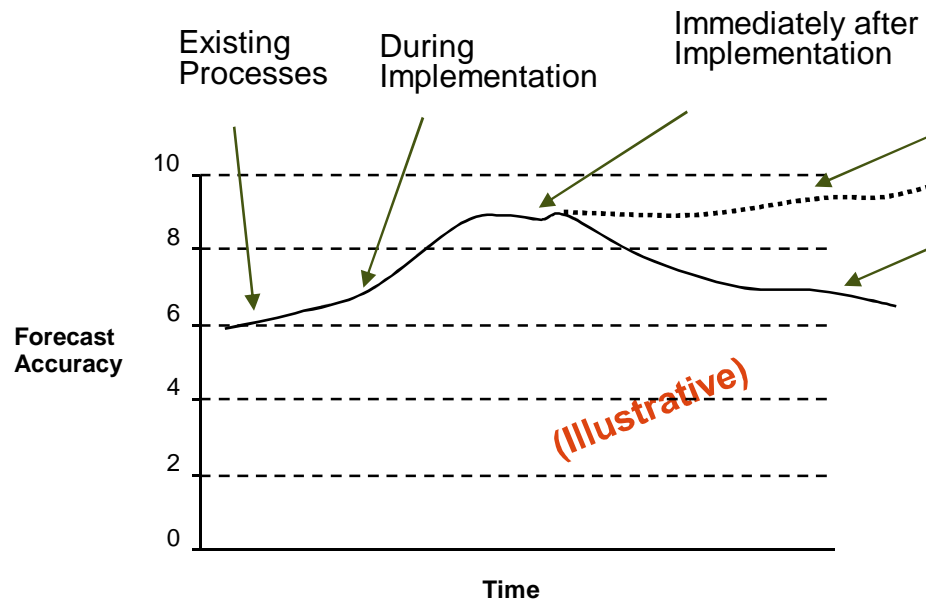


Forecast Analytics - Value at Multiple Stages



- Initial Hierarchy and Clustering of Products
- Determine Forecastability of Products
- Reduced risk and complexity
- Hierarchy Modeling
- Algorithm Selection and Configuration
- KPI's and Accuracy measures modeling
- Algorithm Fine tuning
- KPI's and Accuracy measures modeling
- Cluster and hierarchy fine tuning

Analytics at multiple stages



Tuned Forecast Models with Forecast Analytics

Un-tuned Forecast Models without Forecast Analytics

Additionally, such analytics could lead to additional focus in the supply chain in the following areas:

- Downstream Fulfillment Strategy
- Safety Stock Analysis
- Pricing and Promotional Optimization
- SKU Rationalization

Forecast Analytics Benefits



We typically see companies achieve a range of benefits when focusing on Forecast analytics.

Improvement Opportunities

- Improved forecast accuracy
- Better understanding of market behaviors based on product clusters
- Improving understanding of external causal factors
- Improved control on processing times
- Increased understanding of promotional effects
- Reduced inventory
- Reduced IM risk and improved ROI



Benefits

- Improved forecast accuracy of 5-20% at different levels of the hierarchies
- 10-20% improvement in batch times
- 10-20% reduction in obsolescence with improved life cycle management
- 5-15% reduction in stock-outs
- Improved understanding of product groups behaviors based on historical tendencies
- Improved understanding of the influence of external causal factors



Case Study

Retailer Background



About the Retailer

- Midwest Retailer is a \$12 billion Regional Super Center
- More than 40 departments including Grocery, Fashion, Automotive, Home Decor, Health and Beauty Care, Pharmacy, Electronics, Pets and more)
- Retailer has 181 stores, 164 Gas Stations and 7 Convenience Stores serving the Mid-western United States
- Retailer has over 60,000 people employed across the organization
- Retailer is in the midst of a major Merchandise Transformation program to enable the organization to best meet its mission - Price, Product, Promotion, People, Place, Presentation
- Retailer began implementing systems suite comprised of both custom and JDA packaged systems – Product Master, Financial & Assortment Planning, Space Planning, Promotions Planning, Demand and Replenishment Planning

Common Forecasting Issues at the Retailer



Typical Product Characteristics

- Highly seasonal products
- Sporadic demand
- Irregular demand
- New product introductions
- New store introductions
- Promotional triggers
- Causal factors



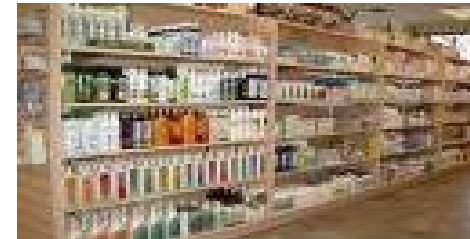
Typical Process Characteristics

- Inadequate understanding of history data
- Limited knowledge on forecasting models
- Non-standard forecasting processes
- Limited knowledge on applying external factors
- Limited statistical skill sets in Demand Planning Organization
- Insufficient time to perform statistical analysis



Typical Business Responses

- Using generic parameters sets for forecasting models
- Treating Seasonal products same as Continuous products
- Executing non-standard forecasting processes
- Application of Causal factors was limited
- Insufficient time and skills to perform statistical analysis



Cost Impacts

- Excess inventory levels
- Inefficient pre-build of products
- Excess clearance and markdowns

Service Impacts

- Out-of-Stock and lost sales
- Inadequate safety stock levels
- Product obsolescence



Forecast Analytics Objectives

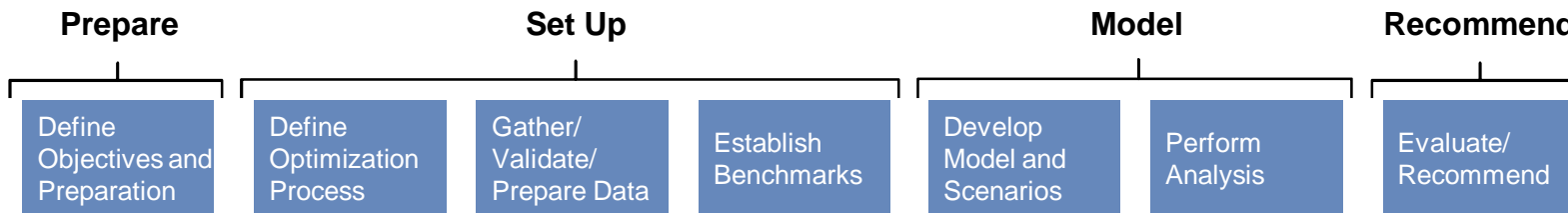


- Improve the understanding of product characteristics based on historical analysis
- Provide sustainable forecasting processes and models
- Provide a process for forecast algorithm selection
- Provide initial set of optimized forecast model parameters
- Provide a process of promotional impact analysis
- Provide replenishment strategies for slow moving products
 - Whether to forecast products or use simple re-ordering?

Algorithm Selection

Replenishment strategy for Slow moving products

Approach for Analytics



Develop/Implement the following: Communication Plan, Status Report, Issue & Risk Management, Recommendation and Findings, Effort schedule with Timeline

Program Management Steps



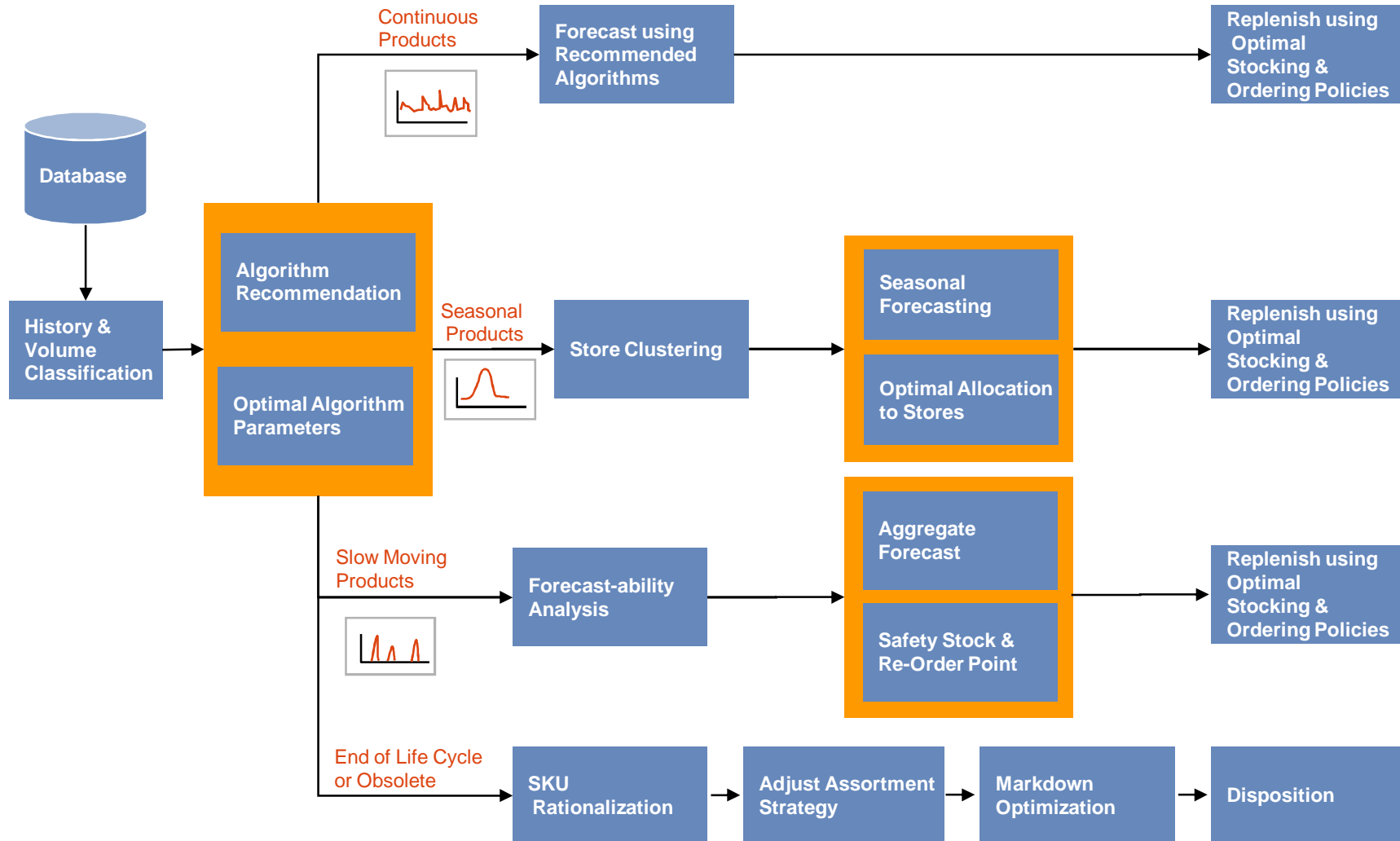
Key Activities

- | Prepare | Set Up | Model | Recommend |
|---|---|--|--|
| <ul style="list-style-type: none"> Conduct kick-off meeting and set forecast optimization objectives Scope confirmation Hold workshop to set objectives and high level tasks and processes | <ul style="list-style-type: none"> Gather, validate, cleanse all data, if applicable Determine potential scenarios Define Optimization procedure and tasks Assess and define segmentation and hierarchy | <ul style="list-style-type: none"> Load/run/validate baseline and document assumptions Potential quick wins Load/run scenarios and perform high level check Summarize data in appropriate comparison chart | <ul style="list-style-type: none"> Assess impact on process, people and technology. Summarize quantitative and qualitative comparisons Assess operational, change readiness and any implementation risk |

Key Outputs/Deliverables

- | Prepare | Set Up | Model | Recommend |
|--|--|--|---|
| <ul style="list-style-type: none"> Stakeholder buy in Communication plan Initial findings/issues Prioritized assessment area | <ul style="list-style-type: none"> Detail flow diagram of optimization processes Summary of generated scenario Sign off on approach with key assumptions Customer / Product segmentation & Hierarchy | <ul style="list-style-type: none"> Summary validation statistics Signed off validation document with key assumptions Scenario run log Scenario analysis statistics | <ul style="list-style-type: none"> Shortlist of solution for in-depth impact assessment Final recommendation on Forecast Optimization Implementation plan for pilot and high level deployment plant Summary of potential quick win opportunities. |

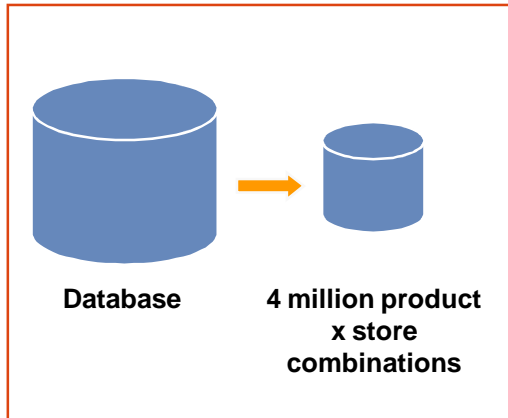
High Level Analytics Roadmap



Algorithm Selection – Classification Approach



Data Selection



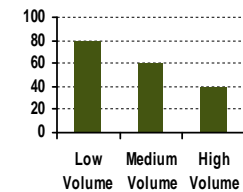
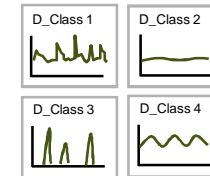
Classification criteria definition

Define History Classes

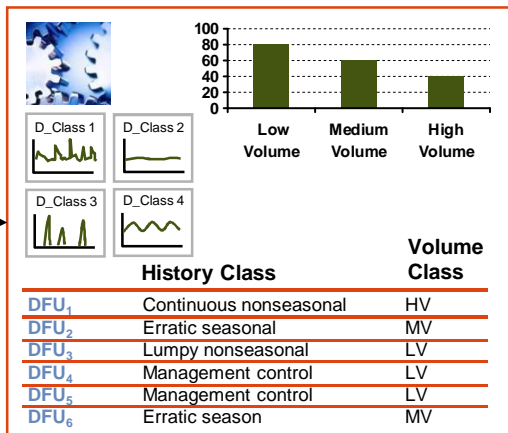
- Continuous, Erratic, Lumpy and Management Control

Define Volume classification

- High Volume – Items that sell > 7 units per week
- Medium Volume – Items that sell between 1 and 7 units per week
- Low Volume – Items that sell < 1 unit per week



Volume classification process



- DFUs Clustering
- Algorithm recommendation

Cluster classification	Algorithm recommendation
D_Class 1	% DFUs Lewandoski % DFUs Crostons % Holt Winters
D_Class 1	% DFUs Lewandoski % DFUs Crostons % Holt Winters
D_Class 2	% DFUs Lewandoski % DFUs Crostons % Holt Winters
D_Class 3	% DFUs Lewandoski % DFUs Crostons % Holt Winters

Analysis

- Analysis by:
- Category
 - Sub Category
 - Product Class
- Analysis of clusters based on algorithms
Create algorithm parameter files for recommended algorithms

n DFUs	% DFU	Recomm. Algorithm
		CN-H_V
		CN-M_V
		CS-H_V
		CS-M_V
		EN-H_V
		EN-L_V
		EN-M_V
		...

Algorithm Selection – History Classes



Continuous

- Good number of history points available. Less than 13-15% of history points are zero or invalid history points

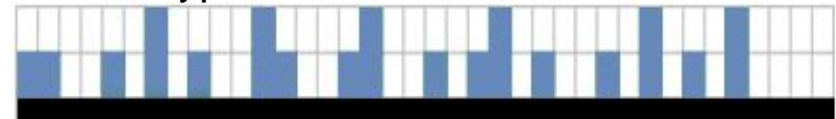
Continuous history pattern



Erratic

- Fair number of history points available. Between 15-40% of history points are zero or invalid history points

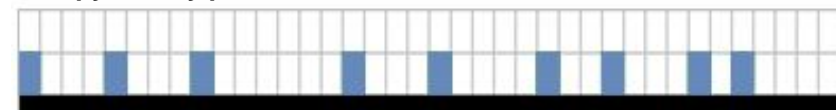
Erratic history pattern



Lumpy

- Poor number of history points available. Between 40-90% of history points are zero or invalid history points

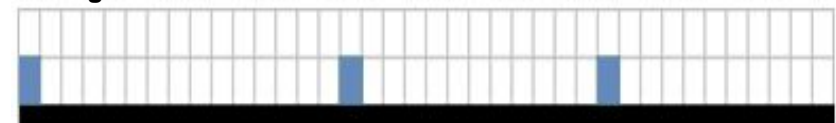
Lumpy history pattern



Management Control

- Almost no history available. Less than 10% of history points are valid history points

Management Control



For each of the above history patterns, the system determines if the items are SEASONAL or NON-SEASONAL

Algorithm Selection – Product Analysis



Typical Volume and History Class distribution for General Merchandise products

Volume

Class	Criteria	% of DFUs	# of DFUs
A	100 units per week	0.009%	959
B	Between 50 and 100 units per week	0.024%	2,426
C	Between 14 and 50 units per week	0.243%	25,000
D	Between 7 and 14 units per week	0.622%	64,000
E	Between 1 and 7 units per week	42.750%	4,400,000
F	Less than 1 unit per week	43.722%	4,500,000
G	Less than 1 unit per month	12.631%	1,300,000

- More than 80% of items sell less than 7 units per week
- The bulk of the items (almost 57%) sell less than 1 unit per week
- Classes F and G are termed as LOW VOLUME
- Classes E is termed as MEDIUM VOLUME
- Classes A,B,C and D are termed as HIGH VOLUME

History Class	# of DFUs	% of DFUs
Management Control	7,624,695	73.2%
Lumpy Non Seasonal	2,099,752	20.2%
Lumpy Seasonal	347,588	3.3%
Obsolete	217,317	2.1%
Erratic Non Seasonal	85,070	0.8%
Erratic Seasonal	25,861	0.2%
Continuous Non Seasonal	12,330	0.1%
Continuous Seasonal	3,789	0.04%
Total	10,416,402	

Algorithm Selection - Results



- Optimal Algorithm selection for each product cluster
- Recommended forecast frequency cadence

CLUSTER	History Class	Volume Class	% of DFU s	Model	Forecast Frequency
LN - M_V	Lumpy Non Seasonal	Medium Velocity	12.596%	Croston	Weekly
LN - L_V	Lumpy Non Seasonal	Low Velocity	6.221%	Croston	Weekly
LN - H_V	Lumpy Non Seasonal	High Velocity	0.862%	Croston	Weekly
EN - M_V	Erratic Non Seasonal	Medium Velocity	0.573%	Croston	Weekly
ES - M_V	Erratic Seasonal	Medium Velocity	0.207%	Lewandowski	Weekly
ES - H_V	Erratic Seasonal	High Velocity	0.141%	Lewandowski	Weekly
CN - M_V	Continuous Non Seasonal	Medium Velocity	0.050%	Lewandowski	Weekly
CN - H_V	Continuous Non Seasonal	High Velocity	0.041%	Lewandowski	Weekly
ES - L_V	Erratic Seasonal	Low Velocity	0.039%	MLR	Weekly
EN - H_V	Erratic Non Seasonal	High Velocity	0.034%	Lewandowski	Weekly
CS - H_V	Continuous Seasonal	High Velocity	0.022%	Lewandowski	Weekly
CS - M_V	Continuous Seasonal	Medium Velocity	0.018%	Lewandowski	Weekly
EN - L_V	Erratic Non Seasonal	Low Velocity	0.009%	Croston	Weekly
CN - L_V	Continuous Non Seasonal	Low Velocity	0.000%	Lewandowski	Weekly
CS - L_V	Continuous Seasonal	Low Velocity	0.000%	Lewandowski	Weekly
MC - L_V	Management Control	Low Velocity	46.725%	Lewandowski	Monthly
MC - M_V	Management Control	Medium Velocity	18.386%	Lewandowski	Monthly
MC - H_V	Management Control	High Velocity	8.597%	Lewandowski	Monthly
LS - M_V	Lumpy Seasonal	Medium Velocity	2.623%	MLR	Monthly
LS - L_V	Lumpy Seasonal	Low Velocity	0.721%	MLR	Monthly
LS - H_V	Lumpy Seasonal	High Velocity	0.112%	Lewandowski	Monthly

Some Early Benefits...



- Forecast Accuracy has improved by 11% this year compared with the same period last year
- Dropped 15-20% of inventory at the DC. This resulted in around \$8-9 Million in annualized savings
- The client starting seeing a drop in inventory at the DC within 4 months of the initial analysis
- Service level remained constant/slightly above an average
- Better management of Daily and Weekly batch processes based on product classes

Overview of Replenishment Problem



Situation

- Business was struggling to determine the best inventory policy for slow moving products. Demand for slow moving products are often difficult to forecast and as a result, the business was not sure if they should even use forecasting as a method to drive replenishment or simply to use reorder replenishment and thereby further reduce forecasting/batch process overhead

Complication

- Inventory replenishment decisions need to consider many operational and financial variables—each of which could impact the final decision

Desired outcome

- A simple and transparent analysis that:
 - Recommends the right policy to follow for each replenishment scenario
 - Estimates the \$ value of the benefit that can be realized by following the recommended policy

Solution Approach

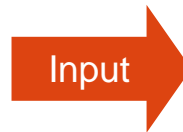
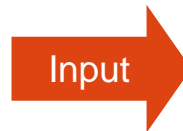


Operations Metrics

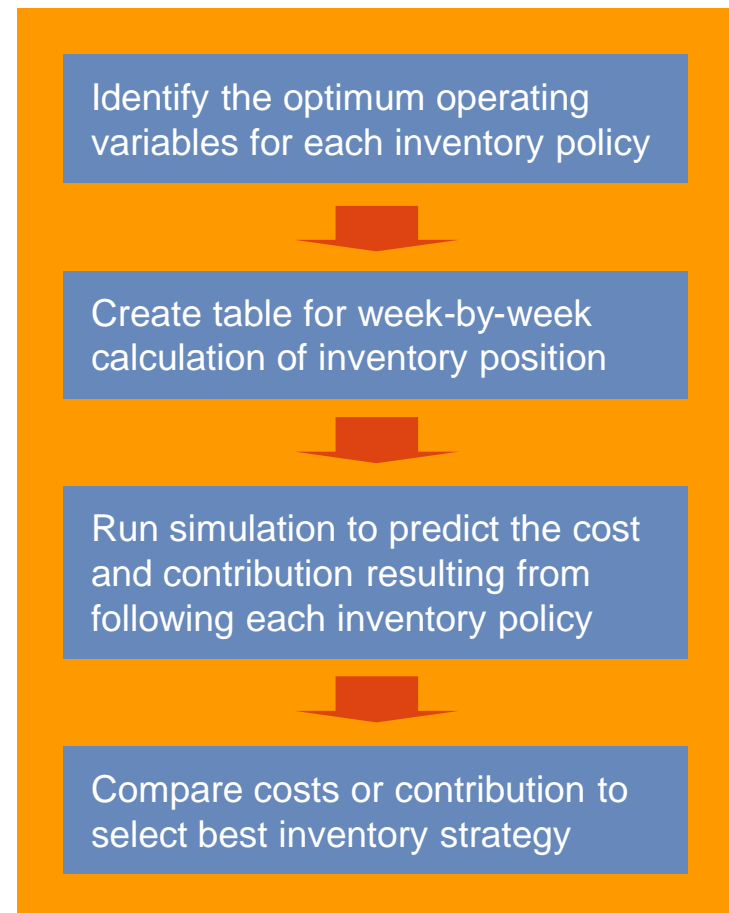
- Demand Pattern
- Initial Inventory and inventory position
- Lead Time
- Order Cost
- Inventory Holding Cost
- Inventory Handling Cost
- Mean Forecast Error

Financial/Business Metrics

- Weighted Average Cost of Capital (WACC)
- Price of SKU
- Contribution Margin per SKU
- Cost of lost sale/SKU



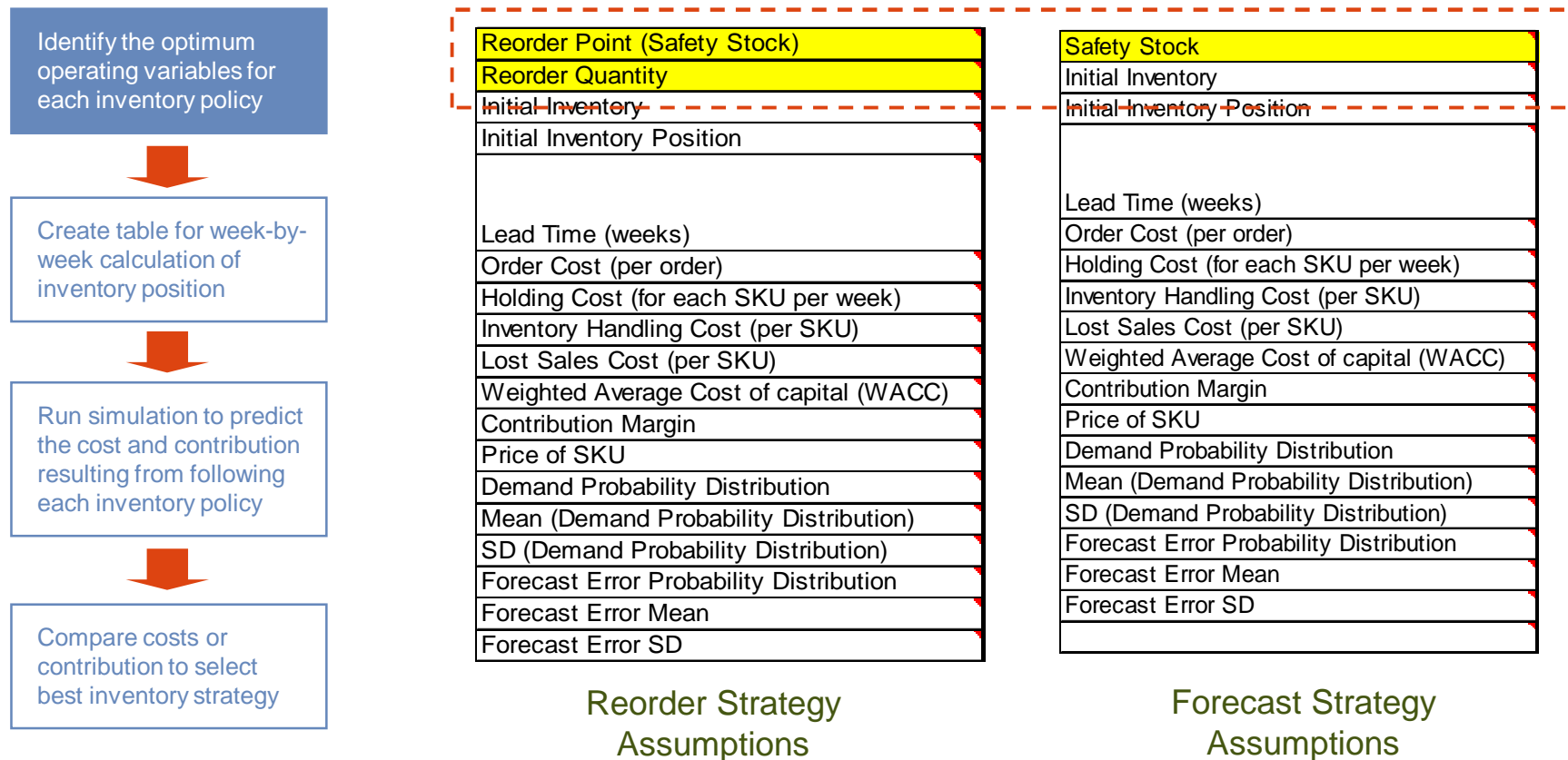
Simulation



Solution Approach – Input Variables



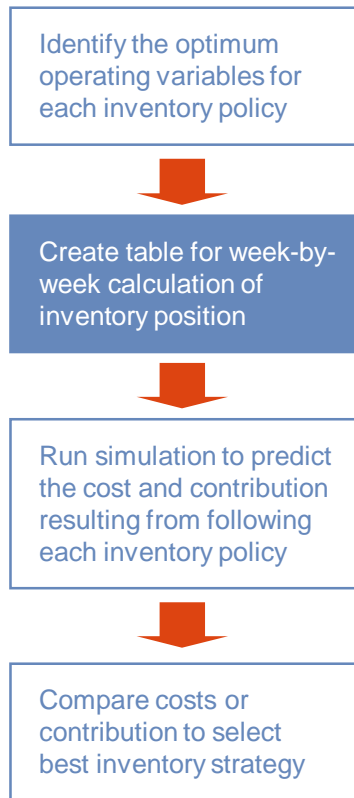
As a first step towards the solution, we identify the operating variables for each inventory strategy.



Solution Approach – Projections



The next step is to create and populate a week-by-week inventory table.



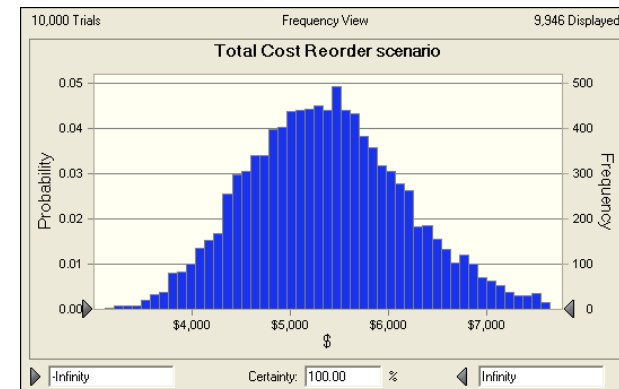
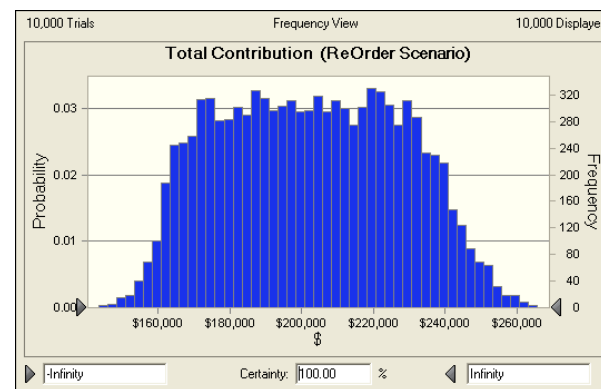
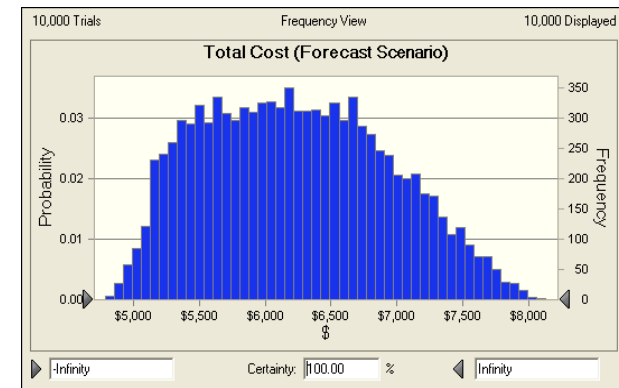
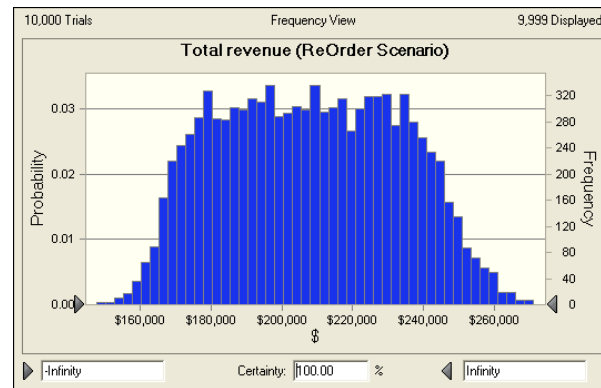
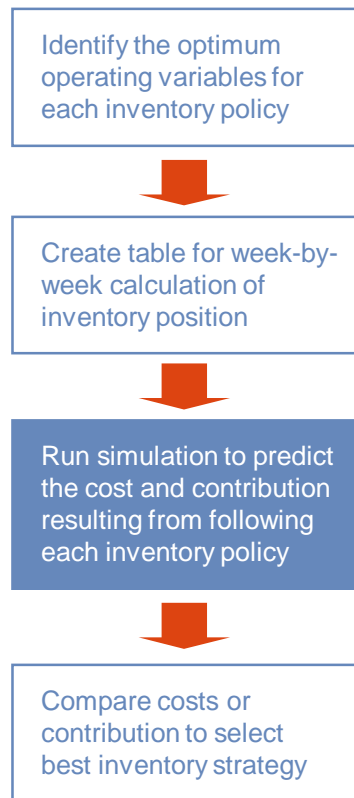
18	10	11	8MIDDLECLASS-URBAN	1WESTM	185366
18	1	19	5MIDDLECLASS-SMALLQTY	1WESTM	224513
18	10	11	8MIDDLECLASS-URBAN	1WESTM	185366
18	1	19	5MIDDLECLASS-SMALLQTY	1WESTM	224513
18	12	21	5MIDDLECLASS-SMALLQTY	1WESTM	203336
18	1	23	5MIDDLECLASS-SMALLQTY	5CENTRALM	232814
18	11	24	5MIDDLECLASS-SMALLQTY	5CENTRALM	193445
18	11	25	5MIDDLECLASS-SMALLQTY	5CENTRALM	225041
18	1	28	5MIDDLECLASS-SMALLQTY	5CENTRALM	251424
18	5	29	5MIDDLECLASS-SMALLQTY	5CENTRALM	244657
18	11	32	11AFFLUENT-SUBURBAN	2EM/NOH	246616
18	4	33	6MIDDLECLASS-SMALLTOWN	1WESTM	180897
18	2	35	7MIDDLECLASS-SUBURBAN	2EM/NOH	242055
18	7	41	6MIDDLECLASS-SMALLTOWN	1WESTM	198839
18	17	42	5MIDDLECLASS-SMALLQTY	5CENTRALM	192831
18	14	43	5MIDDLECLASS-SMALLQTY	5CENTRALM	204776
18	2	45	6MIDDLECLASS-SMALLTOWN	2EM/NOH	168800
18	1	49	6MIDDLECLASS-SMALLTOWN	6CENTRALCH	131848
18	1	50	11AFFLUENT-SUBURBAN	1WESTM	197308
18	11	51	6MIDDLECLASS-SMALLTOWN	6CENTRALCH	141577

The table would comprise inventory levels, position, and demand. It would be used to calculate all the costs that are driven by the inventory strategy.

Solution Approach – Simulation



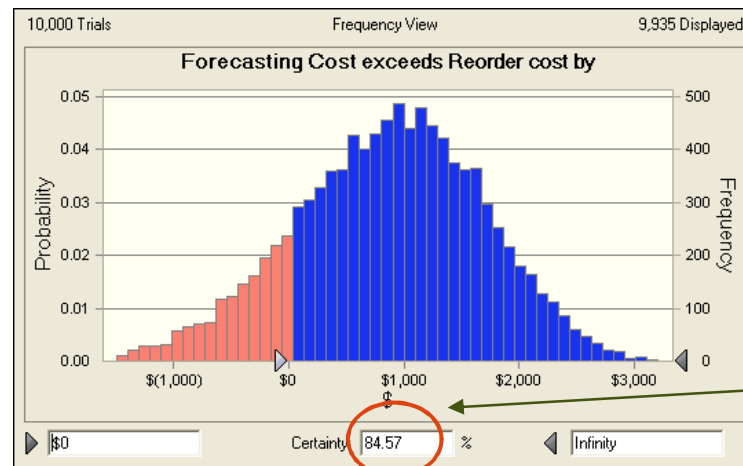
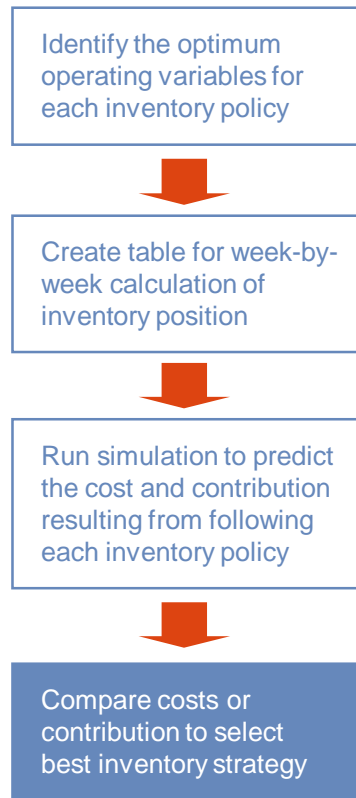
The simulation



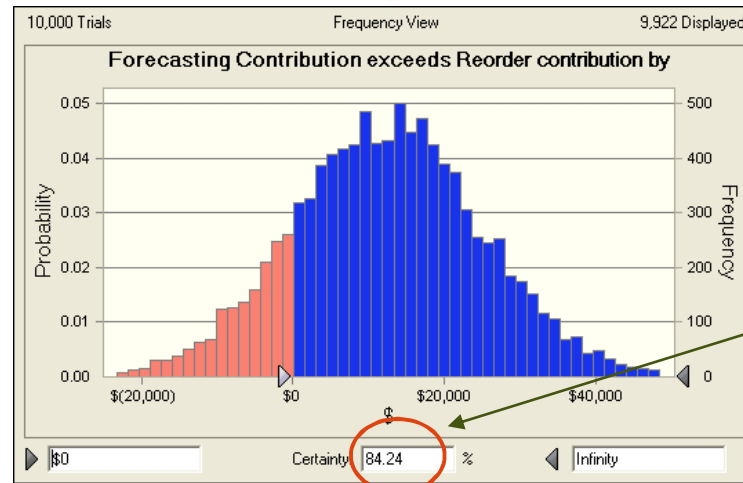
Solution Approach – Comparison



Inventory strategies can then be compared on the basis of costs or profits (contribution)



The forecast scenario cost is likely to be above the re-order scenario cost 84.57% of the times.

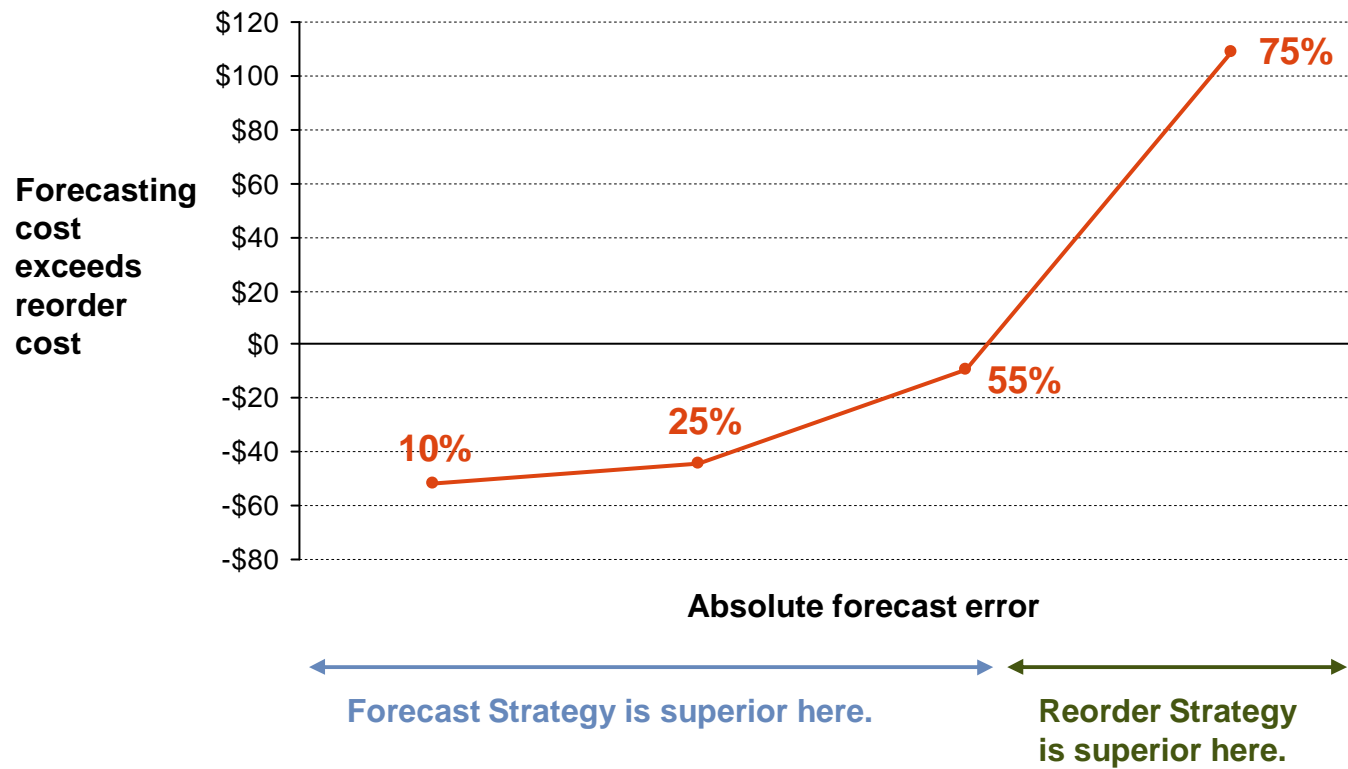


The forecast scenario contribution is likely to be above the reorder scenario contribution 84.24% of the times.

Comparison of Strategies



Value by which forecast cost exceeds reorder cost changes with the forecast error.
Ordering every week.



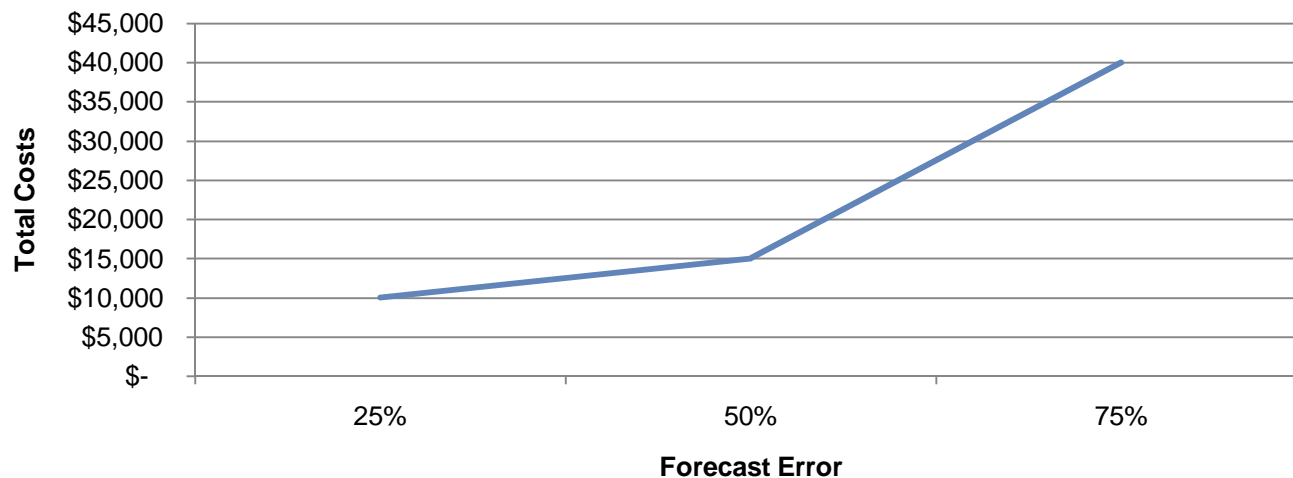
Recommendation
Use the forecasting strategy if the forecast error is less than 57%

To switch, or not to switch to a new forecasting solution?



- **Situation:** Organizations may often wonder whether they should replace their existing forecast solutions with a new one.
- **Complication (need for change):** Organizations may find it difficult to quantify the benefits that would accrue from a more accurate forecasting solution.
- **Key Question:** Is it possible to develop a method that quantifies the cost or profit expected from moving from one forecast solution to another?
- **Desired outcome:** Simplify the decision to move from one forecast solution to another (or to select between two forecast solutions) based on a quantification of associated costs or profits.

Question: How much do we gain if we improve forecast error from 75% (present) to 50% (new forecast solution)?



Answer: \$25,000 in total costs for this particular inventory part.

Reason: The solution estimates that the total costs for replenishment are \$40,000 / year with a forecast error of 75% vs. \$15,000 for a forecast error of 50%.

Identifying the key value levers for an inventory replenishment operation



- **Situation:** Organizations may often want to analyze their inventory replenishment operations to identify the most important variables that impact cost or profit.
- **Complication (need for change):** It is difficult to estimate impact of each operating variable on cost or profit- given the demand uncertainty and the various operating / financial variables involved.
- **Key Question:** Is it possible to develop a method that estimates the sensitivity of each operating and financial variable in a replenishment scenario?
- **Desired outcome:** Management is able to identify the few variables it needs to focus on for improving its costs or profits in an inventory replenishment scenario.

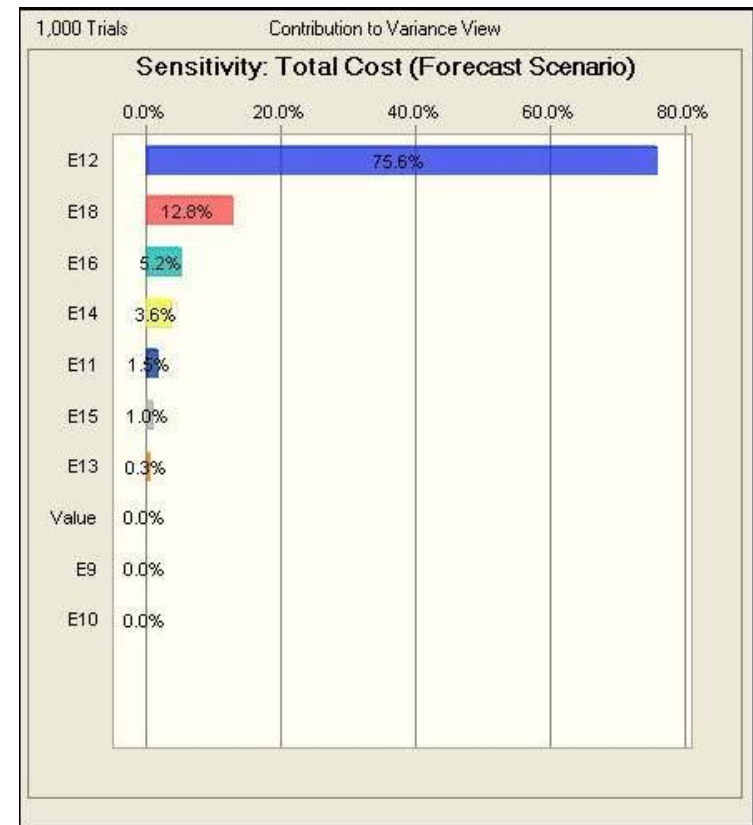
Question: If operations managers were to cut total costs related to their inventory replenishment operation, which variables should they focus on?



Answer: Inventory Holding cost and WACC.

Reason: The solution estimates the maximum variation in cost is driven by inventory holding costs and WACC (Weighted Average cost of capital).

Potential Beneficiaries: Any organization that needs identify the key value drivers in an inventory replenishment scenario.



Solution Approach – Additional Analytics



Several areas of analysis and recommendations are possible

Area

Output from the solution

Reorder vs. Forecasting
Strategy Selection

- Selection of optimum strategy
- Estimate of business performance improvement expected (cost or contribution)

Service Level Target Selection

- Cost of each service level targeted
- Operating variables needed to hit target service levels

Forecast Solution Selection

- Answers the question: How much business benefit do we derive if we improve forecast accuracy by x%?

Inventory Replenishment
Operations

- Answers the question: What would be the optimum operating variables for this inventory replenishment scenario?

Sensitivity Analysis

- Answers the question: Which controllable variables impact cost/contribution/service levels the most?

Questions

