Chapter 5
The Value of Information

5.1 Introduction
- Value of using any type of information technology
- Potential availability of more and more information throughout the supply chain
- Implications this availability on effective design and management of the integrated supply chain

Information Types
- Inventory levels
- Orders
- Production
- Delivery status

More Information
- Helps reduce variability in the supply chain.
- Helps suppliers make better forecasts, accounting for promotions and market changes.
- Enables the coordination of manufacturing and distribution systems and strategies.
- Enables retailers to better serve their customers by offering tools for locating desired items.
- Enables retailers to react and adapt to supply problems more rapidly.
- Enables lead time reductions.

5.2 Bullwhip Effect
- While customer demand for specific products does not vary much
- Inventory and back-order levels fluctuate considerably across their supply chain
- P&G's disposable diapers case
  - Sales quite flat
  - Distributor orders fluctuate more than retail sales
  - Supplier orders fluctuate even more

4-Stage Supply Chain

FIGURE 5-5: The supply chain
Effect of Order Variability

Factors that Contribute to the Variability - Demand Forecasting

- Periodic review policy
- Characterized by a single parameter, the base-stock level.
- Base-stock level = Average demand during lead time and review period + a multiple of the standard deviation of demand during lead time and review period (safety stock)
- Estimation of average demand and demand variability done using standard forecast smoothing techniques.
- Estimates get modified as more data becomes available
- Safety stock and base-stock level depends on these estimates
- Order quantities are changed accordingly increasing variability

Factors that Contribute to the Variability - Lead Time

- Increase in variability magnified with increasing lead time.
- Safety stock and base-stock levels have a lead time component in their estimations.
- With longer lead times:
  - a small change in the estimate of demand variability implies
  - a significant change in safety stock and base-stock level, which implies
  - significant changes in order quantities
  - leads to an increase in variability

Factors that Contribute to the Variability - Batch Ordering

- Retailer uses batch ordering, as with a (Q,R) or a min-max policy
- Wholesaler observes a large order, followed by several periods of no orders, followed by another large order, and so on.
- Wholesaler sees a distorted and highly variable pattern of orders.
- Such pattern is also a result of:
  - Transportation discounts with large orders
  - Periodic sales quotas/incentives

Factors that Contribute to the Variability - Price Fluctuations

- Retailers often attempt to stock up when prices are lower.
- Accentuated by promotions and discounts at certain times or for certain quantities.
- Such Forward Buying results in:
  - Large order during the discounts
  - Relatively small orders at other time periods

Factors that Contribute to the Variability - Inflated Orders

- Inflated orders during shortage periods
- Common when retailers and distributors suspect that a product will be in short supply and therefore anticipate receiving supply proportional to the amount ordered.
- After period of shortage, retailer goes back to its standard orders
- leads to all kinds of distortions and variations in demand estimates
Quantifying the Bullwhip

- Consider a two-stage supply chain:
  - Retailer who observes customer demand
  - Retailer places an order to a manufacturer.
- Retailer faces a fixed lead time
  - Order placed at the end of period \( t \)
  - Order received at the start of period \( t+L \).
- Retailer follows a simple periodic review policy
  - Retailer reviews inventory every period
  - Places an order to bring its inventory level up to a target level.
  - The review period is one

Quantifying the Increase in Variability

- \( \text{Var}(D) \), variance of the customer demand seen by the retailer
- \( \text{Var}(Q) \), variance of the orders placed by that retailer to the manufacturer

\[
\frac{\text{Var}(Q)}{\text{Var}(D)} \geq 1 + \frac{2L^2}{p^2}
\]

- When \( p \) is large and \( L \) is small, the bullwhip effect is negligible.
- Effect is magnified as we increase the lead time and decrease \( p \).

Impact of Variability Example

- Assume \( p = 5, L=1 \)
  \[ \frac{\text{Var}(Q)}{\text{Var}(D)} \geq 1.4 \]
- Assume \( p = 10, L=1 \)
  \[ \frac{\text{Var}(Q)}{\text{Var}(D)} \geq 1.2 \]

- Increasing the number of observations used in the moving average forecast reduces the variability of the retailer order to the manufacturer.

Quantifying the Bullwhip

- **Base-Stock Level** = \( L \times \text{AVG} + z \times \text{STD} \times \sqrt{L} \)
- **Order up-to point** =
  - If the retailer uses a moving average technique
  \[
  \mu_L = \frac{1}{p} \sum_{i=1}^{p} D_i
  \]

Lower Bound on the Increase in Variability Given as a Function of \( p \)

Impact of Centralized Information on Bullwhip Effect

- Centralize demand information within a supply chain
  - Provide each stage of supply chain with complete information on the actual customer demand
  - Creates more accurate forecasts rather than orders received from the previous stage
Variability with Centralized Information

- \( \text{Var}(D) \), variance of the customer demand seen by the retailer
- \( \text{Var}(Q_k) \), variance of the orders placed by the \( k \)th stage to its
- \( L_i \), lead time between stage \( i \) and stage \( i + 1 \)

\[
\frac{\text{Var}(Q_k)}{\text{Var}(D)} \geq 1 + \sum_{i=1}^{k} L_i + \frac{2\sum_{i=1}^{k} L_i L_{i+1}}{p^2}
\]

- Variance of the orders placed by a given stage of a supply chain is an increasing function of the total lead time between that stage and the retailer.

Variability with Decentralized Information

- Retailer does not make its forecast information available to the remainder of the supply chain.
- Other stages have to use the order information.

\[
\frac{\text{Var}(Q_k)}{\text{Var}(D)} = \prod_{i=1}^{k} (1 + \frac{2L_i}{p} + \frac{2L_i}{p^2})
\]

- Variance of the orders:
  - becomes larger up the supply chain
  - increases multiplicatively at each stage of the supply chain.

Managerial Insights

- Variance increases up the supply chain in both centralized and decentralized cases.
- Variance increases:
  - Additively with centralized case
  - Multiplicatively with decentralized case

- Centralizing demand information can significantly reduce the bullwhip effect.
  - Although not eliminate it completely!!

Increase in Variability for Centralized and Decentralized Systems

Methods for Coping with the Bullwhip

- **Reducing uncertainty.** Centralizing information
- **Reducing variability.**
  - Reducing variability inherent in the customer demand process.
  - "Everyday low pricing" (EDLP) strategy.

Methods for Coping with the Bullwhip

- **Lead-time reduction**
  - Lead times magnify the increase in variability due to demand forecasting.
  - Two components of lead times:
    - order lead times [can be reduced through the use of cross-docking]
    - Information lead times [can be reduced through the use of electronic data interchange (EDI)].
- **Strategic partnerships**
  - Changing the way information is shared and inventory is managed
  - Vendor managed inventory (VMI)
    - Manufacturer manages the inventory of its product at the retail outlet
    - VMI the manufacturer does not rely on the orders placed by a retailer, thus avoiding the bullwhip effect entirely.
5.3 Information Sharing And Incentives
- Centralizing information will reduce variability
- Upstream stages would benefit more
- Unfortunately, information sharing is a problem in many industries
- Inflated forecasts are a reality
- Forecast information is inaccurate and distorted
- Suppliers may ignore the forecasts totally

Contractual Incentives to Get True Forecasts from Buyers
- Capacity Reservation Contract
  - Buyer pays to reserve a certain level of capacity at
    the supplier
  - A menu of prices for different capacity reservations
    provided by supplier
  - Buyer signals true forecast by reserving a specific
    capacity level
- Advance Purchase Contract
  - Supplier charges special price before building
    capacity
  - When demand is realized, price charged is different
  - Buyer's commitment to paying the special price reveals
    the buyer's true forecast

5.4 Effective Forecasts
- Retailer forecasts
  - Typically based on an analysis of previous sales at the
    retailer.
  - Future customer demand influenced by pricing, promotions,
    and release of new products.
  - Including such information will make forecasts more
    accurate.
- Distributor and manufacturer forecasts
  - Influenced by factors under retailer control.
  - Promotions or pricing.
  - Retailer may introduce new products into the stores
  - Closer to actual sales – may have more information
- Cooperative forecasting systems
  - Sophisticated information systems
  - Iterative forecasting process
  - All participants in the supply chain collaborate to arrive at
    an agreed-upon forecast
  - All parties share and use the same forecasting tool

Global Optimization
- Issues:
  - Who will optimize?
  - How will the savings obtained through the
    coordinated strategy be split between the different supply chain facilities?
- Methods to address issues:
  - Supply contracts
  - Strategic partnerships

5.5 Information for the Coordination of Systems
- Many interconnected systems
  - Manufacturing, storage, transportation, and retail
    systems
  - The outputs from one system within the supply chain
    are the inputs to the next system
  - Trying to find the best set of trade-offs for any one
    stage isn't sufficient.
  - Need to consider the entire system and coordinate
    decisions
- Systems are not coordinated
  - Each facility in the supply chain does what is best for
    that facility
  - The result is local optimization.

5.6 Locating Desired Products
- Meet customer demand from available retailer inventory
- What if the item is not in stock at the retailer?
  - Being able to locate and deliver goods is sometimes
    as effective as having them in stock
  - If the item is available at the competitor, then this is a
    problem
- Other Methods
  - Inventory pooling (Chapter 7)
  - Distributor Integration (Chapter 8)
5.7 Lead-Time Reduction

- Numerous benefits:
  - The ability to quickly fill customer orders that can't be filled from stock.
  - Reduction in the bullwhip effect.
  - More accurate forecasts due to a decreased forecast horizon.
  - Reduction in finished goods inventory levels.
  - Many firms actively look for suppliers with shorter lead times.
  - Many potential customers consider lead time an important criterion for vendor selection.
  - Much of the manufacturing revolution of the past 20 years led to reduced lead times.

- Other methods:
  - Distribution network designs (Chapter 6)
  - Effective information systems (e.g., EDI)
  - Strategic partnering (Chapter 8) (Sharing point-of-sale (POS) data with supplier)

5.8 Information and Supply Chain Trade-Offs

- Conflicting objectives in the supply chains.
- Designing the supply chain with conflicting goals.

Wish-Lists of the Different Stages

- Raw material suppliers
  - Stable volume requirements and little variation in mix.
  - Flexible delivery times.
  - Large volume demands.
- Manufacturing
  - High productivity through production efficiencies and low production costs.
  - Known future demand pattern with little variability.
- Materials, warehousing, and outbound logistics
  - Minimizing transportation costs through quantity discounts, minimizing inventory levels, quickly replenishing stock.
- Retailers
  - Short order lead times and efficient, accurate order delivery.
- Customers
  - In-stock items, enormous variety, and low prices.

Trade-Offs: Inventory-Lot Size

- Manufacturers would like to have large lot sizes.
  - Per unit setup costs are reduced.
  - Manufacturing expertise for a particular product increases.
  - Processes are easier to control.
- Modern practices [Setup time reduction, Kanban and CONWIP]
  - Reduce inventories and improve system responsiveness.
  - Advanced manufacturing systems make it possible for manufacturers to meet shorter lead times and respond more rapidly to customer needs.
- Manufacturer should have as much time as possible to react to the needs of downstream supply chain members.
- Distributors/retailers can have factory status and manufacturer inventory data:
  - They can quote lead times to customers more accurately.
  - Develop an understanding of and confidence in the manufacturers' ability.
  - Allows reduction in inventory in anticipation of manufacturing problems.

Trade-offs

Inventory-Transportation Costs

- Company operates its own fleet of trucks.
  - Fixed cost of operation + variable cost.
- Carrying full truckloads minimizes transportation costs.
- Outside firm is used for shipping
  - Quantity discounts.
  - TL shipping cheaper than LTL shipping.
- In many cases
  - Demand is much less than TL.
  - Items sit for a long time before consumption leading to higher inventory costs.
  - Trade-off can't be eliminated completely.
  - Use advanced information technology to reduce this effect.
  - Distribution control systems allow combining shipments of different products from warehouses to stores.
  - Cross-docking.
  - Decision-support systems allow appropriate balance between transportation and inventory costs.

Lead Time-Transportation Costs

- Transportation costs lowest when large quantities of items are transported between stages of the supply chain.
  - Hold items to accumulate enough to combine shipments.
  - Lead times can be reduced if items are transported immediately after they are manufactured or arrive from suppliers.
  - Cannot be completely eliminated.
  - Information can be used to reduce its effect.
  - Control transportation costs reducing the need to hold items until a sufficient number accumulate.
  - Improved forecasting techniques and information systems reduce the other components of lead time.
  - May not be essential to reduce the transportation component.
Trade-Offs
Product Variety-Inventory
- Higher product variety makes supply chain decisions more complex
- Better for meeting customer demand
- Typically leads to higher inventories
- Strategies:
  - Delayed Differentiation (Chapter 6)
  - Ship generic products as far as possible down the supply chain
  - Design for logistics (Chapter 11)

Cost-Customer Service
- Reducing inventories, manufacturing costs, and transportation costs typically comes at the expense of customer service
- Customer service could mean the ability of a retailer to meet a customer's demand quickly
- Strategies:
  - Transshipping
  - Direct shipping from warehouses to customers
  - Charging price premiums for customized products

Trade-Offs
Cost-Customer Service

5.9 Decreasing Marginal Value of Information
- Obtaining and sharing information is not free.
- Many firms are struggling with exactly how to use the data they collect through loyalty programs, RFID readers, and so on.
- Cost of exchanging information versus the benefit of doing so.
  - May not be necessary to exchange all of the available information, or exchange information continuously.
  - Decreasing marginal value of additional information
- In multi-stage decentralized manufacturing supply chains many of the performance benefits of detailed information sharing can be achieved if only a small amount of information is exchanged between supply chain participants.
  - Exchanging more detailed information or more frequent information is costly.
  - Understand the costs and benefits of particular pieces of information
  - How often this information is collected
  - How much of this information needs to be stored
  - How much of this information needs to be shared
  - In what form this needs to be shared

Summary
- The bullwhip effect suggests that variability in demand increases as one moves up in the supply chain.
- Increase in variability causes significant operational inefficiencies
- Specific techniques to “counteract” bullwhip effect
  - Information sharing, i.e., centralized demand information.
  - Incentives to share credible forecasts
  - Alignments of expectations associated with the use of information.
- Interaction of various supply chain stages.
  - A series of trade-offs both within and between the different stages.
  - Information is the key enabler of integrating the different supply chain stages.
- Information can be used to reduce the necessity of many of these trade-offs

CASE: Reebok NFL Replica Jerseys: A Case for Postponement

Stephen C. Graves, John C. W. Parsons
MIT, Cambridge MA, USA
McKinsey & Co., Toronto, Ontario, Canada

Planning Question
- How should Reebok plan and manage inventory to manage costs while providing the flexibility required to meet demand for NFL Replica jerseys
Outline of Case Discussion

• Discuss business context, nature of demand, the sales cycle, key success factors, failure modes
• Discuss supply chain, planning cycle, planning challenges
• Frame as single-season planning problem; relate to newsvendor model
• Develop approach and key insights with NE Patriots example
• Report on findings for NFL
• Wrap up and summary of learnings

Nature of Consumer Demand

- Sales are highest at start of season, August – Sept.
- "Hot market" players and teams emerge over course of season
- Increase at end of season for contending teams & stars: Christmas, playoffs and Super Bowl
- Off season is slower, with demand spikes for big-name player movements

Licensed Apparel Business

<table>
<thead>
<tr>
<th>Situation</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reebok received an NFL exclusive license in 2000</td>
<td>No direct competition for product – 100% market share</td>
</tr>
<tr>
<td>Highly seasonal &amp; very uncertain demand for player jerseys</td>
<td>Demand is concentrated over five month period</td>
</tr>
<tr>
<td>Teams are more predictable, but correlated with success</td>
<td>If product is not quickly available to meet demand the opportunity is lost</td>
</tr>
<tr>
<td>Hot-market players and teams emerge during season</td>
<td>Lost sales cost more than inventory overstocks, but come with a high risk of obsolescence</td>
</tr>
<tr>
<td>High margins, fashion item</td>
<td></td>
</tr>
<tr>
<td>Demand driven by availability</td>
<td></td>
</tr>
<tr>
<td>Unsold jerseys can become instantly obsolete – trades; design changes</td>
<td></td>
</tr>
</tbody>
</table>

Annual Sales Cycle

- Retailers get discount to place pre-season orders for delivery in May
- Limited ordering by retailers to re-balance stocks; some short LT orders to respond to player movements
- Retailers order to position stock in their DC’s and stores in anticipation of season, and expect 3 – 4 week delivery LT
- Retailers order to replenish stores, chase the demand, and expect 1 – 2 week LT for Hot Market items

Supply Chain Overview

- Raw Material Suppliers
- Contract Manufacturers
- Reebok Warehouse
- Retail Distribution Centers
- Retail Outlets
- Consumers

<table>
<thead>
<tr>
<th>Normal Demand</th>
<th>Hot Market Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 16 weeks</td>
<td>1 week</td>
</tr>
<tr>
<td>4 - 8 weeks</td>
<td>1-2 weeks or less</td>
</tr>
<tr>
<td>3 - 12 weeks</td>
<td>1 week</td>
</tr>
</tbody>
</table>
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Purchasing Cycle

- Reebok places orders on CMs for April delivery; primarily orders blanks (~20% of annual buy)
- Reebok places orders for dressed jerseys based on retailers’ advance orders & remaining inventory (~15 – 20%) Reebok orders dressed & blank jerseys, based on forecasts and inventory targets
- Last purchase phase is most challenging

Single-Season Planning Problem

- What volume and mix of jerseys to purchase during March to June?
- Planning framework:
  - Given forecasts (and advanced orders) for team and players
  - Decide inventory targets for dressed and blank jerseys for season
  - Place orders guided by these targets
  - Revise forecasts (say) each month based on current information; update targets accordingly
- How should we set inventory targets?

Representative Numbers for Replica Jersey

Suggested Retail Price — more than $50
Wholesale Price = $24.00

Blank Cost = $9.50
Cost to dress at CM = + $1.40
Cost to dress at Reebok = + $2.40

Salvage Value for unsold Dressed Jersey = $7
Holding Cost for unsold Blank Jersey = $1.04

Salvage Value for unsold Blank Jersey = $9.50 - 1.04 = $8.46
2003 Forecast – As of March 1, 2003

<table>
<thead>
<tr>
<th>Name</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW ENG PATRIOT Total</td>
<td>6746</td>
<td>39211</td>
</tr>
<tr>
<td>BRADY, TOM #12</td>
<td>30763</td>
<td>73843</td>
</tr>
<tr>
<td>LOGAN, TY #34</td>
<td>10559</td>
<td>43756</td>
</tr>
<tr>
<td>BROWN, TONY #81</td>
<td>8190</td>
<td>3871</td>
</tr>
<tr>
<td>VINTONI, ALAN #2</td>
<td>7710</td>
<td>4932</td>
</tr>
<tr>
<td>DRUGGOLY, TONY #64</td>
<td>5358</td>
<td>3116</td>
</tr>
<tr>
<td>SMITH, ANTONIEN #12</td>
<td>2118</td>
<td>1271</td>
</tr>
<tr>
<td>Other Players</td>
<td>23275</td>
<td>184384</td>
</tr>
</tbody>
</table>

What should inventory target be for dressed jerseys for each player? And blank jerseys for team?

CMs have minimum order quantities of 1728

What’s the Objective?

- Expected revenue:
  
  \(24\times E[\text{Dressed Sold}]+24\times E[\text{Blanks Sold}] + 7\times E[\text{Dressed Unsold}] + 8.46\times E[\text{Blanks Unsold}]\)

- Expected Cost:
  
  \(9.50\times \text{Blanks} + 10.90\times \text{Dressed} + 2.40\times E[\text{Blanks Sold}]\)

Model Calculations: Dressed Jerseys

- \(Q = \text{order for dressed jerseys for a star player; } f(x | \mu, \sigma)\text{ is prob density function for demand}\)

\[E[\text{UnmetDemand}] = \int_{0}^{\infty} (x - Q) f(x | \mu, \sigma) \, dx\]

\[E[\text{Dressed Sold}] = \mu - E[\text{UnmetDemand}]\]

\[E[\text{Dressed Unsold}] = Q - E[\text{Dressed Sold}]\]

Model Approximation: Blank Jerseys

- \(B = \text{order for blank jerseys; } f(x | \mu_B, \sigma_B)\text{ is approx prob density function for demand for blanks}\)

\[E[\text{UnmetDemand}] = \int_{0}^{\infty} (x - B) f(x | \mu_B, \sigma_B) \, dx\]

\[E[\text{Blanks Sold}] = \mu_B - E[\text{UnmetDemand}]\]

\[E[\text{Blanks Unsold}] = B - E[\text{Blanks Sold}]\]

Newsvendor-based Approach

- Solve newsvendor for entire team to get total quantity of blanks and dressed jerseys to buy, and more importantly:
  - Get service measure for team = probability of not stocking out (critical ratio)
- Solve newsvendor for each star player to determine how many dressed jerseys to procure from CM, where underage cost reflects option to use blanks
- Given the dressed jersey quantities, re-solve newsvendor for entire team to find blank jerseys to procure

Newsvendor Model with Risk Pooling for NE Patriots

- Determine total quantity to buy, assuming blank jerseys are the marginal units to buy
- For blank jerseys:
  - Cost of overage = \(9.50 - 8.46 = 1.04\)
  - Cost of underage = \(24.00 - 11.90 = 12.10\)
- Prob. of not stocking out of blanks = 0.92
**Newsvendor Model with Risk Pooling for NE Patriots**

Given the stock-out probability for the team:

- Consider each dressed jersey (i.e. for each star player):
  - Cost of overage = $10.90 – 7.00 = 3.90
  - Cost of underage if blank available = $1.00
  - Cost of underage if blank not available = $24.00 – 10.90 = 13.10
  - Approx. cost of underage = .92*$1.00 + (1 -.92)*$13.10=$1.96
  - Critical ratio = 0.33

- Newsvendor purchases 51000 dressed jerseys

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**Results: Newsvendor with Risk Pooling**

<table>
<thead>
<tr>
<th>Purchased</th>
<th>E[sold]</th>
<th>E[unsold]</th>
<th>E[short]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dressed</td>
<td>51027</td>
<td>44265</td>
<td>6962</td>
</tr>
<tr>
<td>Blanks</td>
<td>70932</td>
<td>42712</td>
<td>28221</td>
</tr>
<tr>
<td>Total</td>
<td>122159</td>
<td>86976</td>
<td>35183</td>
</tr>
</tbody>
</table>

**Results: Simple Newsvendor**

<table>
<thead>
<tr>
<th>Purchased</th>
<th>E[sold]</th>
<th>E[unsold]</th>
<th>E[short]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dressed</td>
<td>87831</td>
<td>60244</td>
<td>27287</td>
</tr>
<tr>
<td>Blanks</td>
<td>36027</td>
<td>22948</td>
<td>15129</td>
</tr>
<tr>
<td>Total</td>
<td>125558</td>
<td>83142</td>
<td>42416</td>
</tr>
</tbody>
</table>

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**Observations from Example**

- Expected profit increases by 5 to 10% over current practice & naïve newsvendor
- Much different solution strategy: blanks used not just for “other” players but also as postponement option
- Many more jerseys dressed in Indianapolis
- Mix of leftovers is largely blanks
- Value of newsvendor perspective

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Global Comparison: Model vs. Actual
- Ex post analysis of 2003 season using model for 31 teams
- Applied model using forecast available on Mar. 1, 2003
- Only able to observe sales in 2003 and volume “pulled forward”

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Risk-Pool NV</th>
<th>Naive NV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>In-stock</td>
<td>85</td>
<td>95</td>
<td>96</td>
</tr>
<tr>
<td>Under-stock</td>
<td>15</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Over-stock</td>
<td>27</td>
<td>28</td>
<td>47</td>
</tr>
</tbody>
</table>

Global Comparison: Model vs. Actual
- Risk-pool NV increases profits by 6% (naive NV increases profits by 2%)
- Plus
  - A less risky mix of remaining jerseys at end of season

<table>
<thead>
<tr>
<th>Over-stock Profile</th>
<th>Actual</th>
<th>Risk-Pool NV</th>
<th>Naive NV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dressed jerseys</td>
<td>59%</td>
<td>17%</td>
<td>60%</td>
</tr>
<tr>
<td>Blanks jerseys</td>
<td>41%</td>
<td>83%</td>
<td>40%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

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- Discuss supply chain, planning cycle, planning challenges
- Frame as single-season planning problem; relate to newsvendor model
- Develop approach and key insights with NE Patriots example
- Report on findings for NFL
- Wrap up and summary of learnings

Conclusion
- Context – fashion items, seasonal, high uncertainty in demand
- Newsvendor with Risk Pooling provides way to plan for and exploit postponement options
- Results in higher profits, 95% service level, better mix of end-of-year inventory.
- Results in much different inventory plan – greater use of blanks and local finishing
- Project resulted in planning tool and new insights for Reebok, and a thesis! A second project focused on forecasting