

# Using A Newsvendor Model for Demand Planning of NFL Replica Jerseys

By

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Submitted to the Engineering Systems Division  
In partial fulfillment of the requirements for the degree of

**Master of Engineering in Logistics**

at the

**Massachusetts Institute of Technology**

**June 2004**

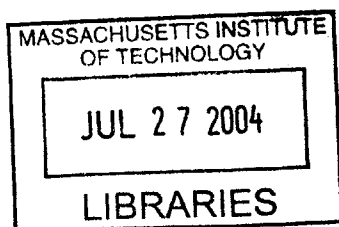
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## **Abstract:**

The thesis addresses the inventory planning process for NFL Replica jerseys. The analysis is conducted from the perspective of the manufacturer's North American distribution center, and how flexibility can be employed to meet customer demands. NFL replica jerseys can be stocked either completed with player name and number, called "dressed" or as "blank" jerseys that can be customized at the distribution center. Player demand can change drastically from year to year. The result is that common practice is to minimize inventory at year-end, and treat each season as a single period.

The approach taken utilizes the newsvendor model to determine the optimal stocking levels of replica jerseys given an expected demand forecast. Two modeling approaches were compared, the traditional newsvendor problem and a newsvendor model with risk pooling. The traditional newsvendor problem separated selected players to order as dressed jerseys and remaining demand to order as "blank" jerseys. The second approach, the newsvendor with risk pooling, provides a more flexible inventory plan that satisfies selected player demand using a combination of dressed and blank jerseys.

The newsvendor model with risk pooling resulted in the higher expected profits than the traditional newsvendor model, and comparable service levels, but at much lower inventory levels.

**Thesis Supervisor: Stephen C. Graves**  
**Title: Professor of Management Science**

## Acknowledgements

The development of the ideas and the writing of this thesis would not have been possible without the guidance and support of many people. I would like to acknowledge the contributions of my advisor Dr. Stephen C. Graves for his guidance on the risk-pooling model, for reviewing the draft versions of this thesis, and for asking the right questions to expand my thought patterns.

I would also like to thank Kai Jang and Jared Schrieber for their input and suggestions on the planning models, and for their efforts in preparing the demand forecasts that is so critical to my model testing.

I would also like to thank many employees of Reebok who took the time to share their ideas and insights. Specifically I would like to thank Lynda Moyer and Tony Feller for answering all of my questions and providing valuable feedback, and Joe Keane and Lloyd Davis for providing senior management support to this project.

## **Dedication Page**

For my mother who taught me ambition

And

For my father who taught me compassion

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## **II. Introduction**

This thesis is a requirement for the Master's of Engineering In Logistics program. The purpose is to display a clear understanding of the theoretical principles and an ability to apply these ideas in a practical situation.

This thesis is developed with the cooperation of Reebok. Reebok is an Affiliate in the Center for Transportation and Logistics Affiliates program, and has offered to participate in a thesis project for the MLOG program.

The specific focus of this thesis is to study the NFL Replica jersey business of Reebok, and to test several inventory planning models and determine which methods will allow Reebok to continue the high service levels that are expected, while maintaining a reasonable cost structure.

To achieve this goal, it is important to understand the background information related to Reebok, the NFL and the relationship between them. It is also important to understand the current operating environment at Reebok, including the drivers of customer demand, retailer behaviour, and Reebok's internal supply chain. Given all necessary information to outline the current situation, the problem is stated with the intention of presenting alternative methods for solving the problem. The model formulations are compared using expected profits, units purchased, fill rate, and remaining inventory. To provide further comparative basis, the units purchased, fill rates, and remaining inventories are also compared to actual Reebok performance against the 2003/2004 sales.

## **III. Background**

Reebok International Ltd. is headquarter in Canton, Mass on J.W. Foster Blvd. The company employs approximately 7400 people, and is widely known for their sports apparel and footwear brands. (Reebok, 2004)

The origins of Reebok started with English runner Joseph Foster invented a spiked running shoe in 1894 and then started a shoe company called JW Foster and Sons. In

1924 he supplied the shoes for the British Olympic team. Two of Foster's grandsons formed a companion company, Reebok (named for a speedy African antelope), in 1958, which eventually absorbed JW Foster and Sons. (Reebok, 2004)

Reebok was still a small British shoe company in 1979, when Paul Fireman, a distributor of fishing and camping supplies, noticed the shoes at a Chicago international trade show, and acquired the exclusive North American license to sell Reebok shoes. (Reebok, 2004) In 1985 Reebok USA acquired the original British Reebok, and Reebok International went public. Revenues for the corporation in 2002 were split between footwear and apparel, with footwear representing 2,060.7M or 66% of revenue and apparel representing 1,067.2M or 34%. Reebok brands now include, Greg Norman (men's casual wear and accessories), Ralph Lauren (athletic and fashion footwear) Reebok (athletic and casual footwear and apparel), Rockport (casual, dress, and performance footwear), Weebok (shoes and apparel for infants and toddlers) and Licensed Products. (Hoovers, 2004)

Reebok in 2003 had total revenues of \$ 3,485,300,000 and realized income from operations of \$157,300,000. The chairman and CEO continues to be Paul Fireman, the man who started Reebok in North America in 1979. (Hoover's, 2004)

### **Company Information – Reebok's Evolution to Licensed Apparel**

In 2000 Reebok signed a 10-year exclusive contract to supply the NFL with uniforms and other licensed items. Reebok bought the operating assets of bankrupt LogoAthletic (sports apparel adorned with team emblems) for about \$14 million in 2001. Reebok also signed an agreement with the NBA in 2001 to become the exclusive licensee of NBA and WNBA-branded apparel. (Gatline, 2002)

The NFL agreement signed in December 2000 between Reebok and the National Football League serves as a foundation of the NFL's restructured consumer products business. The NFL granted a 10-year exclusive license to Reebok beginning in the 2002 NFL

season to manufacture, market and sell NFL licensed merchandise to 31 or 32 NFL teams, including on-field uniforms, sideline apparel, practice apparel, footwear and an NFL-branded apparel line. (Gatline, 2002)

Beginning in the 2004-05 season, Reebok will also have the exclusive rights to supply and market all on-court apparel, including uniforms, shooting shirts, warm-ups, authentic and replica jerseys and practice gear for all NBA, WNBA and NBDL teams. Reebok will also develop, market and sell an exclusive line of NBA-branded basketball shoes and expand their line of Reebok Classic fashion products to incorporate NBA-branded apparel.

Further expanding the licenses apparel business, in February 2002, Reebok and the Indy Racing League (IRL) formed a multi-year partnership naming Reebok the official outfitter of the IRL. As part of the agreement, Reebok will provide custom-designed, co-branded Reebok-Indy Racing League apparel to IRL officials and selected teams. The Reebok brand also will receive exposure through logos on racecars, team uniforms, transporters and other IRL promotional programs included in the promotional rights agreement. (Reebok, 2004)

Reebok has expanded into licensed Apparel Business, and has been successful in part because of the expertise and experience of their company. Reebok purchased a relatively small licensed apparel business, located in Indianapolis Indiana, in 2001. LogoAthletic was a company dedicated to sports apparel. The company has experience with many leagues, including Major League Baseball, NHL, NCAA, NBA and NFL. Because of the experience and expertise of LogoAthletic, and the past relationships that were established with the NFL, it was decided to centralize all Licensed Apparel management at the former LogoAthletic facilities in Indianapolis. (Reebok, 2004)

## **Licensed Apparel Business**

The Licensed Apparel Business is a high margin, and lucrative business. However, the risk associated with tying a product to on-field performance, and the sports business, is that your demand is influenced by uncontrollable factors. When the NFL decided to sign an exclusive contract with Reebok in 2002, they consolidated suppliers from five down to one. From a manufacturer's point of view, this aggregates the demand to one source, and should allow Reebok to service customer demands and forecast sales more accurately than the combined efforts of the former suppliers (Nike, Puma, LogoAthletic, and others). The NFL believes that it will be able to offer retailers premium product from one source that will provide standard product quality. However, industry players are concerned about the majority of the licensed business belonging to a single company. It is important for Reebok and for the relationship with the NFL and the retailers that inventory be delivered on time, without increasing prices for Reebok goods.

Reebok has a history of delivering quality products. As one retailer states, "The Reebok line is great. We're excited and anxious at the same time. [In the past] the fear was that one team jersey could be found from five different manufacturers at five different stores in the mall. Now the [question] is, will the consumer have to pay an extra \$20 for a team jersey because it is from Reebok?" (Griffin, 2002)

It is very important for Reebok to control the costs and to deliver products when required. For retailers heavily reliant on NFL sales, there are other concerns. "As a top-tier retailer in apparel, we'll only have access to that one brand," says another retailer. "I think that Reebok makes great product. We just hope they can deliver because we won't have options B, C or D to go to." (Griffin, 2002)

Of particular importance will be Reebok's ability to deliver hot-market items, a concern for retailers in all areas of the licensed business. "I think with one major partner in Reebok we are in a better position for hot-market items," says Holtzman. "Reebok will be able to take a larger position in blanks on jerseys and fleece and feel more confident that

they can meet the demands of retailers." The unpredictability of sports means 'hot market' issues will never cease to exist completely. (Griffin, 2002)

A 'hot market' item, in the context of the NFL replica jersey business, is an item that was either not expected to sell well before the season or an unknown item that had no prior sales expectations. For example, in the 2003/2004 NFL season the Kansas City Chiefs outperformed all expectations and became a 'hot market' item. Demand was high, but original team forecasts were modest, resulting in shortages in the 'hot market'. Specific players on the team sold extremely well even if they had no prior sales. For example, Dante Hall, the kick returner, made outstanding plays in the first four games of the season, creating "hot market" demand for his jersey.

Early reviews of Reebok show that their performance has been satisfactory. "To be fair, in hot markets delivery is always going to be an issue. Whether you have 12 companies or one, it will always be an issue. And I have to say, this year, Reebok has been pretty much on-time with their deliveries." (Griffin, 2002)

Reebok is building an expertise in Licensed Apparel through acquisition and expansion. Professional sports leagues demand high quality products that are available to meet the consumer demand. The long-term success of Reebok's apparel business will depend on their ability to maintain high service levels over the life of the current 10-year agreements.

## **NFL Information**

The National Football League is the premier professional league for American Football in the World. It consists of 32 teams, located in the United States. Teams are organized in two conferences, the American Football Conference (AFC) and the National Football Conference (NFC), and in Four Divisions within each conference. AFC – East, North, South and West.

**Figure 1 - NFL Division Structure**

American Football Conference			
AFC West	AFC South	AFC North	AFC East
Oakland Raiders	Indianapolis Colts	Baltimore Ravens	New England Patriots
Kansas City Chiefs	Tennessee Titans	Cincinnati Bengals	Buffalo Bills
San Diego Chargers	Jacksonville Jaguars	Cleveland Browns	New York Jets
Denver Broncos	Houston Texans	Pittsburgh Steelers	Miami Dolphins
National Football Conference			
NFC West	NFC South	NFC North	NFC East
St. Louis Rams	Carolina Panthers	Green Bay Packers	Philadelphia Eagles
Seattle Seahawks	New Orleans Saints	Minnesota Vikings	Dallas Cowboys
Arizona Cardinals	Tampa Bay Buccaneers	Detroit Lions	Washington Redskins
San Francisco 49ers	Atlanta Falcons	Chicago Bears	New York Giants

The history of American Football traces back to 1869, and even today current NFL teams have historical ties back as far as 1899. In 1899 Chris O'Brien formed a neighbourhood team, which played under the name the Morgan Athletic Club, on the south side of Chicago. The team later became known as the Normals, then the Racine Cardinals, Chicago Cardinals, St. Louis Cardinals, Phoenix Cardinals, and presently the Arizona Cardinals. The team remains the oldest continuing operation in pro football. (NFL, 2004)

In 1922 the American Professional Football Association changed its name to the National Football League, boasting 18 teams, including the Chicago Bears and the Green Bay Packers. The league continued to develop, drawing crowds in excess of 70K people as early as 1925. In 1933, the league was divided into East and West divisions, with the top team from each division to meet in the league championship. That year the Chicago Bears played the New York Giants at Wrigley Field. (NFL, 2004)

In 1959 a new league to rival the NFL was created and called the American Football League. Original AFL teams that started play in 1960 included Dallas, Denver, Houston, Los Angeles, Minneapolis, New York, Buffalo and Boston. 1963 NFL Properties Inc was created as the licensing arm of the NFL. Late in 1966 a series of meetings between the NFL and AFL resulted in the creation of a new 24-team league. Initial stages

included a joint draft, and annual championship game, with eventual complete merger in 1970. Super Bowl I was held in 1967.

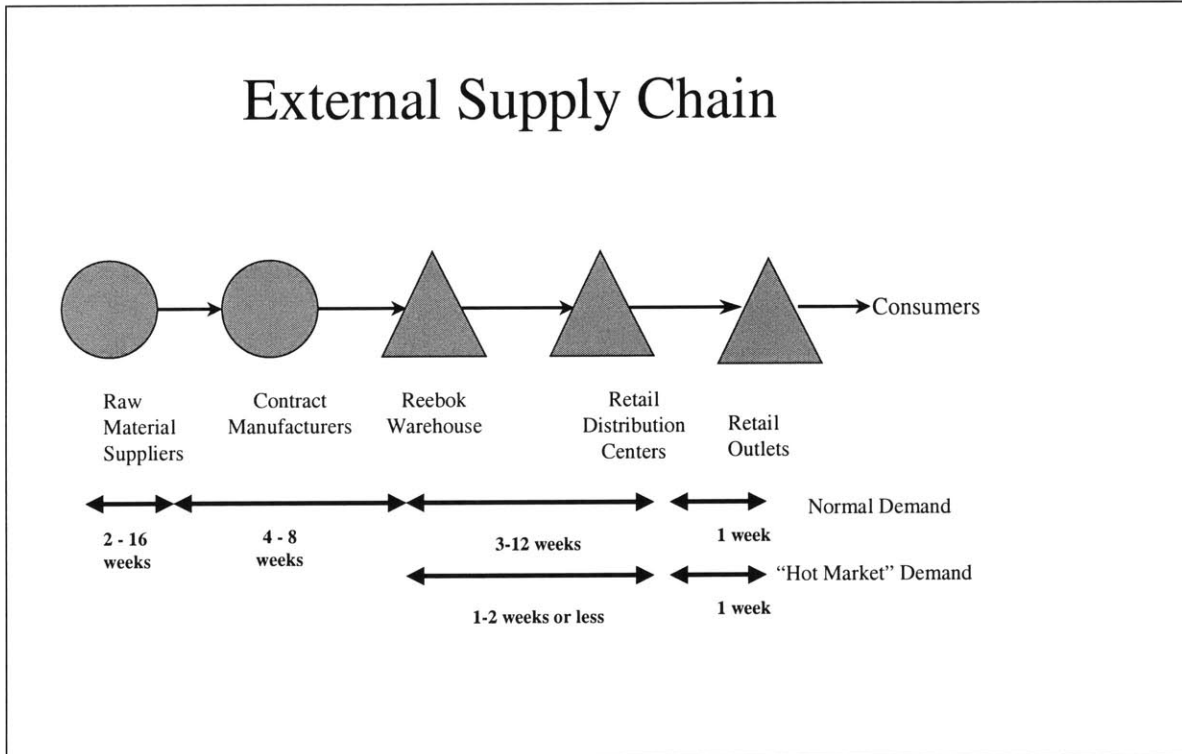
In 2003, the Super bowl between the Tampa Bay Buccaneers and the Oakland Raiders received over 139M viewers, making it the most watched television program in history. (NFL, 2004)

From its humble beginnings the NFL has grown into a very successful league. The creation of NFL properties in 1963 continued with licensing agreements awarded since that time to multiple companies. The decision in 2002 to award licensing to a single company is an attempt to provide better availability and service to the fans and to increase licensing revenue.

## IV. Inventory Management and Logistics System

### Overview The NFL Replica Jersey Supply Chain

Figure 2 - External Supply Chain



Consumer demand for NFL replica jerseys is driven by the excitement and passion fans feel for the game. Like all sports fans, football fans enjoy the game and proudly support their teams. One way to express this support is by adorning the jersey of your favourite player on your favourite team. The entire football season is played between September and January and only has 16 regular season games for each team. Every game represents an important portion of the season; every game is a significant event.

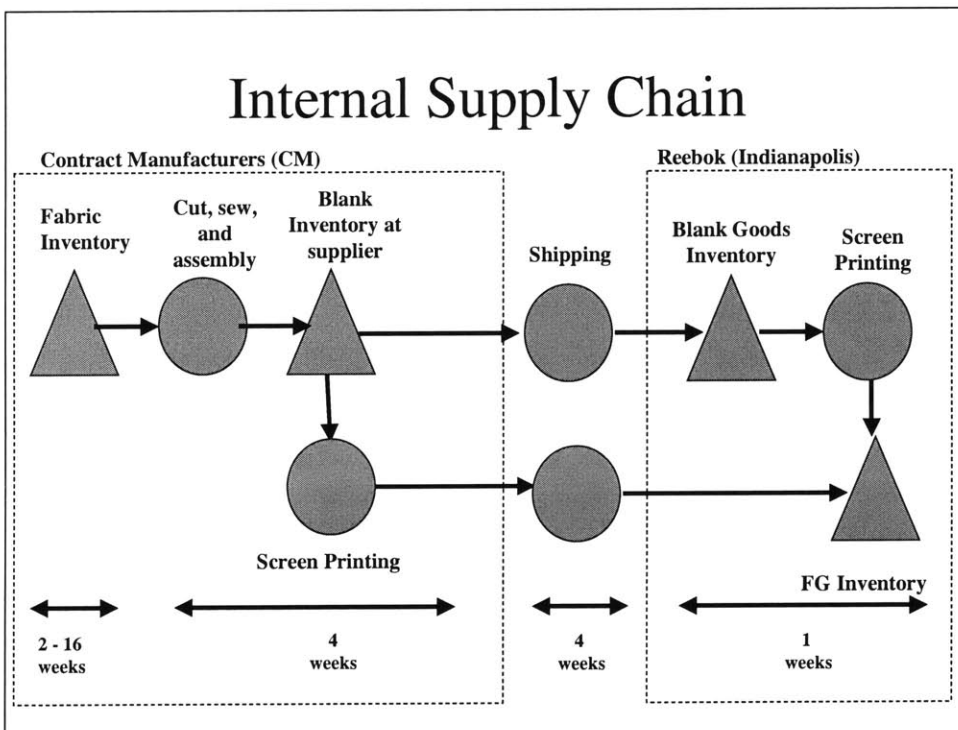
NFL Replica jersey sales are highest in August/September when consumers/fans are preparing for the upcoming season. Off-season moves and trades will drive a significant portion of demand, as does player and team performance from the previous season, and expectations for the coming season. Consumers visit retailers and expect to find the

team, player, and style of jersey that they want when they want to purchase. (O'Donnell, 2004)

The external supply chain is shown in Figure 2. Retailers, such as Foot Locker, Champs, Olympia Sports and others, provide that demanded jerseys are available by anticipating what teams and which players will be popular this season, and ensuring they have inventory on “the wall” and in their regional distribution center for replenishment purposes. In store inventory is typically replenished as required on a weekly basis from the retailer’s DC. Orders are fulfilled from inventory held at the DC by the retailers. (O'Donnell, 2004)

The inventory at a retailer’s DC in August was supplied from Reebok’s Distribution center between May and July. The retailers expect lead times between 3 to 12 weeks for normal demand, but when faced with “hot market” demand, expected lead-times are 1 to 2 weeks. Reebok must anticipate the demand they will see from retailers and ensure they have sufficient inventory in place to fill early season demand. (Feller, Reebok, 2004)

**Figure 3 - Internal Supply Chain**



The supply chain for Reebok (Figure 3) has two alternative routes. Fabric and raw materials for jerseys are procured and held in inventory by the contract manufacturers (CM). Internal contracts are in place to ensure sufficient levels of raw material inventory to provide capability to produce any team on demand, if required. (Feller, Reebok, 2004)

The contract manufacturers cut, sew, and assemble a finished team jersey without a player name or number. This is called “Team Finished” or “Blank”. The jersey then has two possible paths to reach finished goods inventory. For some orders, the CM will print the player name and number on the jersey before shipping to the distribution center. Reebok also places orders for “blank” jerseys to be shipped directly to the distribution center with no player name or number. These jerseys are held in inventory in Indianapolis. (Feller, Reebok, 2004)

The facility in Indianapolis contains the North American Distribution Center and a finishing center capable of transforming a blank jersey into a dressed jersey. The inventory of blank jerseys in Indianapolis has two primary purposes. To fill demand for players that are ordered in small quantities, and to provide an ability to quickly respond to higher than expected demand for star players. The CM and Reebok have an agreed minimum order level of at least 1728 units of the same player. Any player with an order quantity lower than this level will be supplied through the use of blank jerseys and printed at the DC in Indianapolis. When demand for star-players, typically ordered as dressed jerseys from the CM, exceeds the in stock supply, blank jerseys can be transformed into dressed jerseys to meet demand. (Feller and Gill, 2004)

Blank jerseys are also used during the off-season to meet immediate demand for star players that change teams through the various forms of player movement. For example, Warren Sapp signed with the Oakland Raiders in March 2004. Consumers, and retailers demand that player’s jersey be available immediately, but the lead-time from the CM is at least 30 days, and normally 90 days. Only through the use of blank jerseys is Reebok able to provide product to the retailers in a timely manner. (Feller and Gill, 2004)

## **Manufacturing Planning**

Reebok sources all Jerseys from suppliers, located in Honduras, El Salvador, and Guatemala, with a manufacturing lead-time of 30 days. These suppliers are independent companies that accept production orders from Reebok and will produce the finished goods.

The manufacturers are able to ship, either completely finished goods, known as Dressed Jerseys, or Jerseys that are Team finished, but do not have the player name or numbers added. The name and number for each player is screen-printed on a finished Jersey. The player number is printed on the front, back and each sleeve of the jersey, and the player name is printed across the top back of the player. Shipping takes one month for ocean shipping or one week via air. The transportation route via ship is to land on the west coast and take rail to Chicago and then a truck to the Distribution Center in Indianapolis.

The NFL Replica Jersey (7009A/H) is a 5 oz Nylon Diamond Back Mesh Body and Nylon Dazzle Sleeves/Yoke for Team Colour and White plus a 8.6 oz Polyester Flat Knit Rib Collar, and stripe knit inserts for select teams. Each team's Jersey is a distinct combination of style, cuts and colours (Team Colour, White, and alternate) before the Team Logo is applied and cannot be substituted for other teams. The only possible exception is the White Oakland Raider's jersey that has no distinctive markings, and can be modified to create some additional team jerseys. (Moyer, 2004)

Jerseys that are shipped from the suppliers to the distribution center in Indianapolis in the blank form will be completed at a Reebok owned screen printing facility, also located on-site in Indianapolis. (Feller, 2004)

The Finishing Facilities in Indianapolis consist of many sewing and screen-printing machines, capable of embroidering and printing to the highest commercial standards. The screen-printing facility is the second largest in the United States. The facility is used

for screen-printing of NFL and NBA jerseys, as well as T-shirts, sweatshirts, and other apparel items that require screen-printing. (Feller and Gill, 2004)

**Figure 4 - Examples of NFL Replica Jerseys**



## **Consumer Demand Pattern**

Consumers purchase jerseys for several reasons. Reaction to big player moves and drafted players, in support of well performing team and players, for Christmas presents, and finally during the excitement of the play-offs

During the “off season” of February – April, most significant player trades and free agent signings occur. Consumers react to these player movements by demanding the newest superstar jersey for their favourite team. The annual NFL Draft occurs in April, when the top college players are selected. The top three to five players, depending on the year, will be popular enough to create immediate demand for jerseys, as consumers begin to place hope that this new superstar player will improve their team. (O’Donnell, 2004)

Consumers purchase jerseys during the early part of the season in reaction to team and player performance. In 2003 the Kansas City Chiefs started the season with a series of wins, causing much excitement and increased demand for their jerseys. Players such as Priest Holmes and Dante Hall had exceptional seasons that resulted in increased demand for their jerseys.

Christmas season drives a significant portion of sales, as jerseys are purchased and given as gifts. The Christmas spike is the last opportunity to clear inventory of teams that are not expected to make the play-offs. (O’Donnell, 2004)

During the NFL play-offs the consumer demand is related to weekly performance. A team that loses and is eliminated will see sales disappear, while a team that wins and continues to play the following week will experience significant sales increases. The excitement generated intensifies as the team progresses further into the play-offs, with the two teams that ultimately reach the Super bowl selling much higher than normal. The Super bowl winner will continue to experience high sales for one to two weeks following the championship, but then sales will decline rapidly until the start of the next season. (O’Donnell, 2004)

## **Sales Cycle**

Retailers start placing orders for the next season near the end of December (See Figure 5). Retailers are offered an incentive discount to place orders before a specified cut off date. For the 2003/2004 season, the cut/off date was January 15, 2003. However, for the 2004/2005 season, this was moved forward to December 20, 2003. This incentive package results in retailers placing approximately 20% of annual orders for planned delivery in May. Larger retailers will also place additional “soft orders” for delivery at specified times during the season, that require further confirmation before shipment.

Reebok uses the advance order information to plan their purchases for the upcoming season. These pre-season orders provide Reebok with enough information to confidently plan purchase orders for several months. In addition to the sales incentive provided, Reebok also provides a guarantee to the retailers, that any soft orders they place by the cut/off date will be in-stock on the requested delivery date. Any inventory being held against “soft” orders that have not been confirmed by October, is released to unrestricted inventory. (Feller, 2004)

There is limited ordering between February and April, except for some order adjustments and orders to react to player movements. Retailers will monitor player movements in March and April and place orders to reflect any significant player movements. Since consumers expect these jerseys to be available in April when the event occurs, the retailers also expect that these orders be filled as quickly as possible.

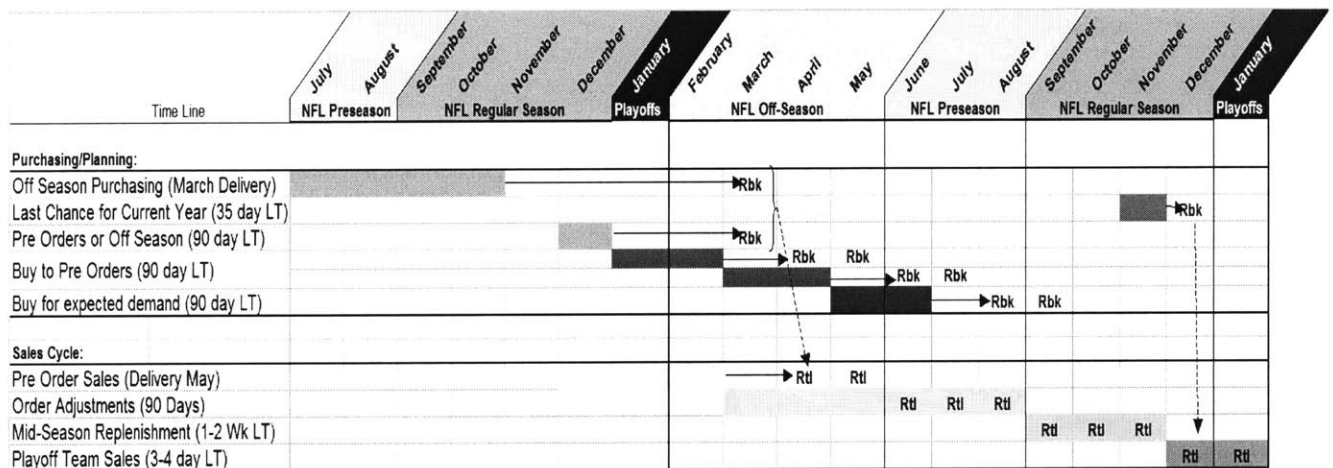
Orders placed between May and August are primarily to position inventory in the retail distribution centers to meet in-season replenishment requirements from the retail outlets. Any orders placed after June are normally to replenish low stock of high demand items. Lead-time expectations at this point are 3 to 4 weeks. At the end of August, the start of the NFL season, 50% of sales have been shipped to retailers.

The Mid Season Replenishment period between September and January (See Figure 4) is known as “The Chase”. In store stock of jerseys that are in line with expected sales are

replenished from the retailer’s distribution center. Some replenishment orders are placed with Reebok for strong sellers to restock the distribution center inventories. This is also the time of year when consumers react to player and team performance and create “hot markets”. Retailers need to adjust their inventories to “chase” the hot market items, and expect Reebok to supply product to “chase” the “hot markets”. Unknown players become superstars, and former superstars become non-factor players.

There is an opportunity for retailers to sell through high volumes of product if they can stock the correct players to match the consumer demand. Retailers will benefit from quick response to orders placed during “The Chase”.

**Figure 5 - Purchasing and Sales Timeline**



### Purchase Planning

As is shown in Figure 5, the planning and purchasing cycle starts much before the sales cycle. The sales cycle, as illustrated here, is the sale of jerseys by Reebok to retailers. The buying cycle starts in July, 14 months before the target NFL season begins. For example, the buying cycle for the September 2004 Season started in July 2003.

Purchase Orders are placed for approximately 75,000 jerseys twice per month for the months of July, August, September, and October. All Jerseys ordered during this time are typically for blank jerseys, with delivery planned for April. Only blank jerseys are ordered at this time, due to upcoming player movements and roster uncertainty, to minimize the risk of stocking products that will not be sold.

This 600 K orders allow the production to be maintained at a minimal level during the low season, and is part of an agreement between Reebok and their suppliers. Although the orders placed in July and August have planned delivery of April, the planning decision is partly influenced by information related to the immediate season. It is expected that the contract manufacturer will manufacturer the jerseys immediately and hold the blank jerseys in inventory. If Reebok requires the jerseys in the current year, then a request can be made to expedite those jerseys for immediate delivery.

September through November is used by Reebok to purchase jerseys for those teams that are winning in the current season. As part of the chase, a winning team is likely to be selling higher then expected, so orders are placed to cover the expected increased demand that will come in December and January.

In early December orders are placed for blank jerseys for delivery in April. Starting in January, orders are placed by Reebok against known demand; the early retailer orders placed by December 20<sup>th</sup>. Buys made during January and February, typically dressed jerseys, are matched to retailer orders. Purchases made during March and April are placed against a combination of known orders and forecasted sales. Purchase orders placed in May and June are made to position inventory at the distribution center in Indianapolis in anticipation of Retailer orders for the coming season. This is the most difficult time of year for Reebok. Outstanding retail orders have been filled, but inventory must be purchased in anticipation of the demand starting in June and continuing through the season. (Feller, 2004)

## **Forecasting:**

The current practice is that there are no "official" expected sales forecasts developed at a team or player level. The purchasing department does consider the historical data, free agency, and trade rumours in determining target stock levels. Generally the approach for replica jerseys is to consider team level demand and estimate 70-80% to the top two or three players. A sales forecast is also received from the largest customers, such as Champs, Footlocker and Modells, who expect to have the indicated jerseys available in a "virtual" warehouse. Approximately 25% of annual sales are known through early sales, or through forecasts received from large customers. (Feller, 2004)

The large retail forecasts are usually for a 5-6 month period, May-Oct. Reebok holds inventory against these "soft" orders until October, when all inventory is released to use against other hard customer orders. Since retailers are not required to buy everything they forecast, the jerseys normally left at the end of the year are the teams / players that underperformed.

## **Capacity Constraints in Indianapolis:**

The process to transform a blank jersey into a completed player jersey starts with the creation of the screens. The screen making shop uses a stock blank screen to create the name that must be applied to the jersey, and matches it to the appropriate number. Smaller numbers are used for the sleeve print and large numbers for the front and back of the jersey.

A screen-printing machine is set up with the screens and the appropriate colour paints. Only one surface can be printed on for each set-up. For example, a jersey is loaded into the machine so that the back surface can be processed and the large player numbers and the player's name are printed. The jersey is removed from the machine, reloaded with the front surface showing and the process is repeated. The jersey must be loaded separately for each sleeve too. Thus it takes a total of 4 impression set ups for a completed NFL jersey to be transformed from Blank to Dressed.

The maximum capacity of the Indianapolis Facility for NFL jerseys is approximately 40,000 impressions per day. This number assumes 80% utilization of the facility for NFL jerseys. For NFL Jerseys, this is 4 impressions per jersey, or 10,000 jerseys per day. The actual yield of the facility is reduced, due to multiple machine requirements, timing issues, and changeover times.

An NFL jersey requires two different machines, so coordinating timing issues, lowers the yield. Screen-printing equipment is set up to hold and print on either a large surface, such as the front and back of the jersey, or smaller surfaces, such as the sleeves. Due to this, different machines are required to print the front/back then the sleeve numbers. As Monty Gill, Production manager of LogoAthletic said “Since it take two different machines to print a completed jersey you have timing issues so you are not getting 10,000 completed jersey on day one. My guess is that you are getting half that completed and the other half is some state of decoration which would increase the number of completed jerseys that next day to more than half of 10,000.” (Feller and Gill, 2004)

Dressed jerseys are held in a finished goods inventory, to await shipments. Production orders to transform jerseys from blank to dressed at the facility in Indianapolis are normally done to satisfy customer orders or to replenish low finished goods inventory on high demand players.

Jersey Printing is conducted year round. In February and March, immediately following the NFL season, approximately 30% of the capacity is used for NFL Jerseys. April – July are the busiest months for screen-printing, using up to 80%, or max NFL capacity. Aug through to January ranges between 65 and 75% for NFL jerseys.

**Figure 6 - Capacity Constraints**

Month	Capacity	Daily Capacity			Completed Jerseys
	Mix (% NFL)	Impressions	Jerseys	Yield	
Feb	30%	19200	4800	0.6	2880
Mar	30%	19200	4800	0.6	2880
April	60%	38400	9600	0.6	5760
May	70%	44800	11200	0.6	6720
June	75%	48000	12000	0.6	7200
July	75%	48000	12000	0.6	7200
August	75%	48000	12000	0.6	7200
September	65%	41600	10400	0.6	6240
October	65%	41600	10400	0.6	6240
November	65%	41600	10400	0.6	6240
December	70%	44800	11200	0.6	6720
January	70%	44800	11200	0.6	6720
<b>Annual</b>	<b>63%</b>	<b>40000</b>	<b>10000</b>	<b>0.6</b>	<b>6000</b>

The annual average capacity for blanks (assuming 5 days per week and 50 weeks per year) is 30,000 jerseys/week, or 1.5 million jerseys per year. If the immediate requirements exceed this capacity within the required service time, there is virtually unlimited capacity to outsource, but at some additional cost. It is desirable not to outsource, since the cost is approximately 10% higher than the internal decorating cost.

## V. Problem Statement

The NFL Replica Jersey business has the potential to be a very profitable business. Each jersey sold offers a generous margin. However, the inventory profile is extremely fragmented with eight sizes and hundreds of players available. Consumer demand is tied to the performance of professional football teams and is therefore subject to unexpected player and team performance, and faces the risk of unpredictable player transactions.

How should Reebok plan and manage inventory to manage costs while providing the flexibility required to meet demand for NFL Replica jerseys? Which type of inventory strategy can Reebok employ to determine annual procurement volumes, and how should these volumes be allocated between dressed and blank jerseys to maximize profits and satisfy customers' expectations of a high service-level.

## **VI. Literature Review**

The literature review for this thesis spanned several general areas. Primary research related to the history of the NFL, Reebok and the relationship between Reebok and licensed apparel was conducted to better understand the industry and the organizations involved. A more formal review of inventory planning techniques, specifically the newsvendor model, was also necessary when applying this technique.

The primary source for historical information on the NFL was the NFL website (NFL.Com). This website provided a detailed history of the NFL as an organization, and specifically highlighted the development of licensing apparel as an important source of revenue. Reebok's corporate website also provided important history on the development of the Licensed apparel business. Another source of general and financial information on Reebok was the Reuter's News Service and Hoovers On-Line. General research on NFL teams and players was complimented by news articles related to the Licensed Apparel agreement between Reebok and the NFL. These articles offered some background information, as well as retailer expectations and service requirements.

There is a wide assortment of research related to the newsvendor or newsboy model. Included in my review were articles related to make to stock vs. assemble to order strategies (Rudi, 2000) as well as background on the newsvendor problem (Pyke and Rudi, 2000). Other articles reviewed included "A note on the Newsboy Problem with an Emergency Supply Option" (Khouja, 1996), which is applicable if the blank jersey availability is considered to be an Emergency Supply Option.

To gain insight into possible recommendations for actual purchasing against the plan, some research was reviewed related to multiple ordering opportunities and mid period replenishment. (Lau and Lau, 1997).

Although primarily used in developing the forecast, insights were also gained from the article entitled “Reducing the cost of demand uncertainty through accurate response to early sales” (Fisher and Raman, 1996).

## **VII. Solution Methods**

### **Data Collection and Definition**

Data was primarily collected through a series of interviews. Initial interviews and background information were collected during conference calls with Reebok management in Canton and Indianapolis. Further research was conducted during a site visit to the Indianapolis facility. A complete list of the personnel interviewed and brief summary of purpose of the discussion can be found in Appendix II.

Follow up meetings were also conducted via conference call to clarify and validate findings, as well as conclude one on one interviews that were not possible during the initial site visit. The information provided was the basis for the sales, purchasing, and manufacturing processes presented in the introduction to this analysis. These interviews are also listed in Appendix II.

Each team has slightly different costs for blank jerseys and dressed jerseys. The variation stems from two sources, the design for each jersey and the landed cost differences between suppliers. An example of team specific jersey costs is listed in Figure 7. (This data is disguised to protect Reebok’s actual cost information)

Designs for jerseys are different for each team. The Raiders jersey is a single colour (black or white) with standard cuts, thus it is the lowest cost blank jersey. The Atlanta Falcons have three colours including a multi cut pattern on the sleeve that requires additional manufacturing effort.

Reebok has multiple suppliers that have slightly different costs. The capabilities of each supplier impact the cost for specific colours or patterns. The mix of capacity that is assigned to each supplier for each team jersey impacts the average costs.

**Figure 7 - Team Jersey Costs**

<b>Team</b>	<b>Avg Blank Cost</b>	<b>Dressed Jersey</b>	<b>Discounted Wholesale Price</b>
<b>Team 1</b>	\$ 10.00	\$ 11.40	\$ 24.0
<b>Team 2</b>	\$ 11.00	\$ 12.40	\$ 24.0
<b>Team 3</b>	\$ 10.00	\$ 11.40	\$ 24.0
<b>Team 4</b>	\$ 9.00	\$ 10.40	\$ 24.0
<b>Team 5</b>	\$ 9.00	\$ 10.40	\$ 24.0
<b>Team 6</b>	\$ 8.00	\$ 9.40	\$ 24.0
<b>Team 7</b>	\$ 9.00	\$ 10.40	\$ 24.0
<b>Team 8</b>	\$ 9.00	\$ 10.40	\$ 24.0
<b>Team 9</b>	\$ 10.00	\$ 11.40	\$ 24.0
<b>Team 10</b>	\$ 10.00	\$ 11.40	\$ 24.0
<b>Average</b>	\$ 9.50	\$ 10.90	\$ 24.0

Other general cost parameters that apply to all jerseys are:

- Price – Suggested Retail Price of \$65
- \$1 more per jersey to ship via air
- \$2.40 to “dress” jersey in Indianapolis
- Min Order Quantity - 144 dozen or 1728
- Salvage value - Approximately \$7-10

Minimum order quantities are applied to determine if a player jersey will be ordered from the supplier or if the jersey will be printed at the distribution center in Indianapolis. In some cases, an order could be placed for half the minimum order quantity, or 864 jerseys, but only in conjunction with another order of 864 jerseys, for players on the same team, in the same jersey color, and only if the player had been previously ordered from the supplier. This exception to the minimum order quantity allows Reebok some flexibility in purchase plan execution, but does not impact the analysis presented.

The following notations are used to represent the variables that are used in the following analysis.

**Variable Notation and Description:**

$C_b$  - Cost of Blank Jersey

$C_{sd}$  - Cost to decorate at Supplier

$C_{nad}$  - Cost to decorate at DC in North America

$S_d$  - Salvage Value for "Dressed" Jersey

$S_b$  - Salvage Value for "Blank" Jersey

$P$  - Wholesale Selling Price of Completed Jersey

$h$  - Annual Holding Cost – 15%

$\lambda$  - Cost of Capacity for decorating jerseys at DC

$\pi$  = profit

$D_o$  = realized demand for blank jerseys

$D_i$  = realized demand from for player  $i$ .

$Q_o^*$  – optimal quantity of blank jerseys to purchase, based on forecast

$Q_i^*$  – optimal quantity of player "i" jerseys based on forecast

## Modeling Alternatives

Demand for professional sports apparel is tied closely to the performance of the sports team and individual players. In today's professional sports business it is common practice for players to be traded, retire, or suffer career-ending injuries. Even the best Analysts and Insiders of the sport cannot accurately predict upcoming sports transactions. Player popularity and associated demand can change significantly from year to year. The following list of factors were identified as possible contributors to risk and uncertainty of demand:

### Team Variables:

- Franchise
  - Years in League
  - Years in Location
- Jersey's Style
  - Fashion Appeal
  - Last Changed
  - Upcoming Change
- Performance
  - Performance History
  - Current Year
- Fan Base
  - Metro Size
  - TV Ratings
  - Team Value
  - Sell-out Ratio

### Player Variables:

- Experience
  - Years in League / Rookie Draft Spot
  - Years on Team
- Odds of Being w/ Team Next Year
  - Contract Expire Date
  - Salary Cap Burden
- Performance
  - Health / Legal Status
  - Fantasy League Value
  - All-Pro Selections
- Popularity
  - Endorsement Deals
  - Sports Card Value
  - Popularity on Team (% of Team)
  - Sentimental Favorite
  - Ethnicity

Many of these factors are time-based factors that change significantly from one year to the next. Due to the enormous uncertainty associated with player demand Reebok has chosen to follow a strategy of single season buying. Buying plans are made on a per season basis with a target to carry very low level of finished goods inventory past the end of the regular season. Considering the current purchasing pattern of Reebok and the objective to minimize end of season inventory, it is best to approach this problem as a single period problem. The objective is to determine a planning approach that will maximize profit and minimize end of season inventory.

Given the stated objective, it was identified that a possible modeling approach for this problem is to use a newsvendor model. The newsvendor model is applied to the problem in two different methods. Modelling Approach #1 separates the demand for player jerseys and blank jerseys into two separate problems and solves for each independently. Modelling Approach #2 solves for player volumes dependent upon the availability of blank jerseys, which is determined by the solution to the blank jersey problem. The approach is to assign any unmet demand for players to the demand for blank jerseys and solve for the optimal quantity.

The input into both models is an expected demand and standard deviation of forecast error, for each team and selected players on each team. Close examination of past sales shows that overall demand is driven by key team players, and that the rest of the team comprises a very small volume. The standard newsvendor idea for the “rest” of the team is to use the model to purchase blank jerseys, thus pooling the highly fragmented low volume player demand. The process to generate the forecast is fully discussed in a note that can be found in Appendix III with the results of a forecast generated as of March 1<sup>st</sup> 2003, shown in Appendix IV.

Following a detailed description and formulation of each approach, the solution is demonstrated for each approach and the results compared using the demand data for one team, as the model inputs.

## Modeling Approach #1 – Simple Newsvendor Model

The first approach considers demand for the selected players separately from demand for blank jerseys. Considering a single team, the selected players are those players who have expected demand that is greater than the minimum order quantity of 1728. The summation of all other demand for non-selected players is presented as expected demand for blank jerseys. This approach treats each selected player as a separate problem and ignores the possibility of using blank jerseys to meet demand. For each player an optimal quantity of jerseys to hold in inventory is calculated. All demand for that player is satisfied with the inventory for that specific player. It is assumed that blank jerseys are only ordered to meet demand for non-selected players.

To apply the newsvendor model, the cost inputs presented earlier are used, including sales price, jersey cost, royalties and salvage value. Using this data the overage and underage values are calculated. The underage cost is the lost profit that is foregone by not stocking enough jerseys. This is the sale price minus the cost of the jersey minus the royalties that must be paid. (See Equation 2). Overage cost is the cost of stocking too many jerseys. If a jersey is not sold then the overage cost is equal to the cost of the jersey minus whatever value can be extracted by selling the jersey through closeouts (see Equation 3). The target stocking level is to stock the correct quantity of jerseys that will result in an incremental expected net benefit of \$0 for stocking one additional jersey. This target level, also called the Critical Ratio, can be established for blank jerseys by using the formula in Equation 1.

$$\Pr(D_0 \leq Q_0) = \text{Underage} / (\text{Underage} + \text{Overage}) \quad (1)$$

$$\text{Underage} = \text{cost of not stocking enough units} = P - C_b - C_{nad} - \lambda \quad (2)$$

$$\text{Overage} = \text{cost of stocking too many units} = C_b - S_b \quad (3)$$

$$Q^* = F^{-1}[\text{Underage} / (\text{Underage} + \text{Overage})] \quad (4)$$

$$Q^* = \text{NORMINV}[\text{Underage} / (\text{Underage} + \text{Overage})] \quad (5)$$

For selected players on each team, a separate forecast is generated. The cost variables for player jerseys were used to determine the critical ratio for player jerseys for that team, and then applied to determine the required purchasing volume. To determine the critical ratio for selected players, use equations 1 to 3, but replace the blank jersey cost variables with the cost variables for dressed jerseys. For equation 2, replace cost to decorate in North America ( $C_{nad}$ ) with cost to decorate at the suppliers ( $C_{sd}$ ) and ignore the cost of capacity. For equation 3, add the cost to decorate at the suppliers ( $C_{sd}$ ) to the cost of blank jersey ( $C_b$ ) and replace the blank salvage value ( $S_b$ ) with the dressed jersey salvage value ( $S_d$ ). Once the critical ratio is calculated for both selected players and blank jerseys; Equation 4 can be used to determine the optimal order quantity if the demand distribution is known. It is assumed that the provided forecast is normally distributed, thus equation 5 is used to establish the optimal order quantity. The optimal order quantity is determined separately for each selected player and for blank jerseys.

In this approach sufficient volume of player jerseys are ordered to cover demand “up-to” the critical ratio. Additional demand beyond the ordered quantity could be met through the use of blank jerseys, although the quantity of blank jerseys ordered is intended to cover demand for “other players” up-to the calculated critical ratio for blank jerseys. If the team has a better than expected season, all blanks and player jerseys will be consumed and additional demand will not be satisfied.

## Modeling Approach #2 – Newsvendor Model with Risk Pooling

The second modelling strategy also utilizes the newsvendor model, but attempts to take advantage of the risk pooling opportunity and flexibility that blank jerseys provide. This model will consider the benefits available from manufacturing flexibility and postponement of the decoration decision. For each selected player, the optimal order quantity is also calculated using the demand forecast, but also considers the opportunity to utilize a blank jersey to fill demand, and the likelihood that a blank jersey will be available for use. Blank jerseys are stocked to fill demand for both non-selected players and selected players. Any demand for selected players beyond the planned in-stock levels will be satisfied using blank jerseys, if available.

The newsvendor problem starts by establishing the objective function; in this case the objective is to maximize profits. For blank jerseys, the expected profits are maximized when the expected profit that can be realized for buying quantity  $Q_0$  is equal to the profits that are expected from purchasing quantity  $Q_0$  plus one additional blank jersey. This function, as shown in equation 6a, can be used to determine the quantity of blank jerseys  $Q_0$  where the incremental value of ordering  $Q_0+1$  is \$0.

The underage cost for blank jerseys is the profit that would be lost if not enough jerseys were ordered. In equation 8 below, this is represented as  $\text{Netprofit}_1$  and represents the underage cost as the sales price of the jersey minus the cost of a blank jersey, the cost to decorate that jersey in North America, and the cost of capacity required to decorate that jersey.

The equation for blank jerseys is shown in equations 6a and 6b. The Overage cost has been substituted into equation 6b using equation 9. The overage is equal to the cost of the blank jersey minus the salvage value.

$$\pi(Q_0 + 1) - \pi(Q_0) = 0 \quad (6a)$$

$$\text{Pr}(\text{use } Q_0 + 1\text{st blank}) \times \text{Netprofit}_1 - (1 - \text{Pr}(\text{use } Q_0 + 1\text{st blank})) \times (C_b - S_b) = 0 \quad (6b)$$

$$1 - \Pr(\text{use } Q_0 + 1^{\text{st}} \text{ blank}) = \Pr(D_0 \leq Q_0) = \text{Netprofit}_1 / (\text{Netprofit}_1 + \text{Overage}_1) \quad (7)$$

$$\text{NetProfit}_1 = P - C_b - C_{nad} - \lambda \quad (8)$$

$$\text{Overage}_1 = C_b - S_b \quad (9)$$

$$S_b = C_b \times (1 - h) \quad (10)$$

The cost of capacity was installed into equation 8 as a non-real variable that can be adjusted to limit the total volume of blank jerseys that are required for processing. This may be necessary, as there is currently limited capacity within the Indianapolis facility to transform blank jerseys into finished goods.

The Critical Ratio is then calculated using the netprofit1 (revenue lost from not stocking enough jerseys) and the Overage1 (cost of ordering too many jerseys) as shown in equation 7. For blank jerseys the cost of salvage is deemed to be the value of the jersey, minus the cost of carrying the jersey for one year, as is formulated in equation 10. This assumption holds for all blank jerseys that will remain unchanged in the next season. If Reebok is aware that the team jersey will be changed starting the following year the salvage value becomes equal to the salvage value of a dressed jersey.

$$Q_0^* = F^{-1}[\text{Netprofit}_1 / (\text{Netprofit}_1 + \text{Overage}_1)] \quad (11)$$

$$Q_0^* = \text{NORMINV}[\text{Netprofit}_1 / (\text{Netprofit}_1 + \text{Overage}_1)] \quad (12)$$

Once the critical ratio is known for blank jerseys, the optimal quantity of blank jerseys can be calculated, assuming normal distribution, using the known expected mean and standard deviation of demand and using equations 11 and 12. The expected mean and standard deviation of demand for blanks is not fully understood until we explore the solution for player jerseys. To better understand the expected shortfall or expected unmet demand for dressed jerseys, it is important to explore the value of ordering dressed jerseys and establish the value of having a dressed jersey available.

To set up the profit function for player jerseys and determine the critical ratio for dressed jerseys it is also possible to use the newsvendor model, such that expected profit from  $Q_{i+1}$  is equal to the expected profit of  $Q_i$ . Or profit ( $Q_{i+1}$ ) – profit ( $Q_i$ ) = 0. The expected profit from  $Q_{i+1}$  can be calculated as is shown in equation 13.

$$\pi(Q_i + 1) - \pi(Q_i) = \Pr(D_i > Q_i) \times \text{NetProfit}_2 - (1 - \Pr(D_i > Q_i)) \times (C_b + C_{sd} - S_d) \quad (13)$$

$$\text{NetProfit}_2 = \Pr(\text{blank available}) \times (C_{nad} - C_{sd}) + (1 - \Pr(\text{blank available})) \times (P - C_b - C_{sd}) \quad (14)$$

$$\Pr(\text{blank available}) = \Pr(D_0 \leq Q_0) = \text{Netprofit}_1 / (\text{Netprofit}_1 + \text{Overage}_1) \quad (15)$$

The term Netprofit2 is used here to represent the profit that is foregone if too few player jerseys are ordered, or the quantity is under the demand. The Netprofit2 equation in the traditional newsvendor is equal to the wholesale price – minus the cost of the jersey from the supplier and royalties paid. However, this equation holds only if there are no blank jerseys available. With the introduction of a blank jersey that can be transformed into a player jersey, an opportunity is presented to pool the risk of all player demand and postpone the decision to customize. The Netprofit2 equation can be thought to be the probability that a blank jersey is available multiplied by the decoration savings of printing the jersey at the CM verse printing the jersey at the domestic distribution center, plus the probability that a blank jersey is not available multiplied by the Underage cost. This is shown in equation 14.

This supports the intuitive rationalization that if a blank jersey is available to satisfy demand for a specific player, the only lost opportunity or additional cost of not having a dressed jersey available is the additional cost of decorating the jersey in North America and the cost of capacity to perform the customization.

We know the critical ratio for blank jerseys and it is known that the plan is to order enough blank jerseys to cover demand up to the critical ratio. Thus, the probability that

a blank is available is the previously calculated, critical ratio for blank jerseys, shown in Equation 15. Using this information a value for  $netprofit_2$  can be calculated, and therefore the critical ratio can be established to determine the stocking policy for dressed jerseys.

$$Q_i^* = F^{-1}[Netprofit_2 / (Netprofit_2 + Overage_2)] \quad (16)$$

$$Q_i^* = NORMINV[Netprofit_2 / (Netprofit_2 + Overage_2)] \quad (17)$$

Using the critical ratio for player jerseys, and the demand parameters provided with the forecast, the optimal quantity  $Q_i^*$  for each player that a forecast is available can be calculated using equation 16. Assuming that demand is normally distributed, the  $Q_i^*$  is calculated using equation 17. From the  $Q^*$ , we can continue and calculate the expected sales, expected unsold, and expected unmet demand, as follows in equations 18-20.

$$E[Sales] = Q^* - \sigma(z \cdot \Phi(z) + \phi(z)) \quad (18)$$

$$\text{s.t. } z = [(Q - \mu) / \sigma]$$

$\Phi(z)$  = cumulative normal distribution function for  $z$

$\phi(z)$  = probability density function for normal distribution function for  $z$

$\phi(z)$  = prob. density function for normal distribution function for  $z$

$\mu$  = forecasted mean demand

$\sigma$  = forecasted standard deviation of demand

$$E[unsold] = Q - E[Sales] \quad (19)$$

$$E[Unmet Demand] = \mu - E[Sales] \quad (20)$$

Calculating the expected sales, unsold, and unmet demand for each player (i) we can begin to create the new parameters for the demand of blank jerseys in order to determine the volume of blank jerseys to stock. Using  $E[unmet\ demand]$  we can determine the expected volume of jerseys that will be required from each player that can potentially be satisfied using blanks. It is now possible to calculate the “new” demand mean for blanks using equation 21.

$$E[\text{Demand for blanks}] = \mu_0 + \sum_i (E[\text{Unmet Demand}]) \quad (21)$$

$$\text{Variation}[\text{Demand for blanks}] = \sigma_0^2 + \sum_i (\delta_i^2 * E[\text{Unmet Demand}]_i^2) \quad (22)$$

$$\delta_i = \sigma_i / \mu_i \quad (22a)$$

Using the original Coefficient of Variance  $\delta_i = \sigma_i / \mu_i$  for the player's demand, and multiplying the CV\*E[unmet demand] it is possible to approximate the variance for the total demand of blank jerseys. The variation of demand is approximated using equation 22. This will result in a  $\mu$  and  $\sigma$  for demand for all blank jerseys, including the player demand that will only be met through the usage of blank jerseys and a planned amount of blank jerseys to meet demand for player jerseys where the stocking policy for dressed jerseys did not stock enough jerseys to meet the actual demand. Applying the blank jersey critical ratio, an optimal Q of blank jerseys can be determined using previously explained equations 11 and 12.

### **Expected Profits:**

The expected profits from the sales of player jerseys and from the sales of jerseys that are ordered in blank, can be determined by applying equation 23 to each item.

$$E[\text{Profits}] = P \bullet E[\text{Sales}] + S \bullet E[\text{Unsold}] - C \bullet Q^* \quad (23)$$

Where P is the revenue from each sale, S is the salvage value for each unsold jersey, and C is the cost for each jersey. The revenue is the sales price, the salvage will depend if the unsold jersey is a player decorated or blank jersey, and the cost will depend on if the jersey was decorated at the manufacturer or at the distribution center.

## Application of the Model

To better illustrate the application of both the simple newsvendor model and the newsvendor model with risk pooling, the following section provides an example using the demand and sample cost parameters for the New England Patriots.

### Given Information:

The following pricing and cost information is known for the New England Patriots:

Wholesale Sales Price (P) = \$24  
Cost of Blank (Cb) = \$9.50  
Cost of Dressed (Cd) = \$10.90  
Cost to Decorate in North America (Cnad) = \$2.40  
Salvage Value for Blank (Sb) = \$8.46  
Salvage value for dressed (Sd) = \$7  
Cost of Capacity ( $\lambda$ ) = \$0

The following forecast is provided:

2003 Fcst - As of March 1st			
Notation	Desc	Mean	Stdev
Q <sub>T</sub> (t)	NEW ENG PATRIOT Total	87679.5	19211.26701
Q1	BRADY, TOM #12	30763.2	13843.44
Q2	LAW, TY #24	10569	4756.05
Q3	BROWN, TROY #80	8158.8	3671.46
Q4	VINATIERI, ADAM #04	7269.6	4361.76
Q5	BRUSCHI, TEDY #54	5526.3	3315.78
Q6	SMITH, ANTOWAIN #32	2117.7	1270.62
Q <sub>0</sub>	Other Players	23274.9	10473.705

## Modeling Approach #1 – Simple Newsvendor Model

The first step is to calculate the Overage and Underage costs for both Blank and Dressed Jerseys using equations 2 and 3:

$$\text{Overage for Blanks} = C_b - S_b = \$9.50 - \$8.46 = \$1.04$$

$$\text{Underage for Blanks} = P - C_b - C_{nad} - \lambda = \$24 - \$9.5 - \$2.40 = \$12.10$$

$$\text{Overage for Dressed} = C_d - S_d = \$10.90 - \$7 = \$3.90$$

$$\text{Underage for Dressed} = P - C_d = \$24 - \$10.90 = \$13.10$$

The next step is to calculate the critical ratios using equation 1.

$$\text{CR - Blanks} = \text{Underage}/(\text{underage} + \text{Overage}) = 12.10/(12.10 + 1.04) = .92$$

$$\text{CR - Dressed} = \text{Underage}/(\text{Underage} + \text{Overage}) = 12.70/(12.70+3.48) = .77$$

To calculate the optimal quantities, assume the provided forecasts are normally distributed, and use equation 5 for both blank and dressed jerseys

$$Q_0^* = \text{NORMINV}[\text{CR-Blanks}, \text{Mean}, \text{Stdev}]$$

$$Q_i^* = \text{NORMINV}[\text{CR-Dressed}, \text{Mean}, \text{Stdev}]$$

The results are shown in the following chart.

Notation	Desc	Q*
Q1	BRADY, TOM #12	41018
Q2	LAW, TY #24	14092
Q3	BROWN, TROY #80	10879
Q4	VINATIERI, ADAM #04	10501
Q5	BRUSCHI, TEDY #54	7983
Q6	SMITH, ANTOWAIN #32	3059
Qo	Other Players	38027

Once the order quantities have been established for each selected player, and the planned order quantity of blank jerseys it is expected that these quantities would be ordered into inventory to meet demand for the entire selling season.

Following this purchase plan, Reebok can expected the following sales results:

Team Player Detail	Q	E[Sold]	E[unsold]	E[unmet]	E[Profit]
NEW ENG PATRIOT Total					
BRADY, TOM #12	41018	28918	12100	1,845	\$ 331,640.24
LAW, TY #24	14092	9935	4157	634	\$ 113,938.27
BROWN, TROY #80	10879	7670	3209	489	\$ 87,955.30
VINATIERI, ADAM #04	10501	6688	3812	581	\$ 72,748.54
BRUSCHI, TEDY #54	7983	5084	2898	442	\$ 55,302.94
SMITH, ANTOWAIN #32	3059	1948	1111	169	\$ 21,192.31
Other Players	38027	22898	15129	377	\$ 224,946.72
<b>Total:</b>	<b>125558</b>	<b>83142</b>	<b>42416</b>	<b>4537</b>	<b>\$ 907,724.33</b>

The expected units sold for all of New England would be 83,142 units, based on a stocking plan of 125,558 units. The net profit would be \$907,724.

However, this assumes that blank jerseys would never be used to meet unmet demand from selected players. In reality, if blank jerseys were available, as indicated by the quantity shown as E[unsold], then the extra blanks would be used to meet the unmet demand. The best-case situation would be that jerseys were available to satisfy all unmet demand for all player jerseys, as shown below.

Team Player Detail	Q	E[Sold]	E[unsold]	E[met w/blanks]	E[unmet]	E[Profit]
NEW ENG PATRIOT Total						
BRADY, TOM #12	41018	28918	12100	1,845	0	\$ 331,640.24
LAW, TY #24	14092	9935	4157	634	0	\$ 113,938.27
BROWN, TROY #80	10879	7670	3209	489	0	\$ 87,955.30
VINATIERI, ADAM #04	10501	6688	3812	581	0	\$ 72,748.54
BRUSCHI, TEDY #54	7983	5084	2898	442	0	\$ 55,302.94
SMITH, ANTOWAIN #32	3059	1948	1111	169	0	\$ 21,192.31
Other Players	38027	22898	15129	0	377	\$ 289,621.82
<b>Total:</b>	<b>125558</b>	<b>87303</b>	<b>38255</b>	<b>4,161</b>	<b>377</b>	<b>\$ 972,399.43</b>

The expected total units sold increases by the 4161 units met with blanks to 87,303 and total expected profits increases to \$972,399.

## Modeling Approach #2 – Newsvendor Model with Risk Pooling

To apply the Newsvendor model with Risk Pooling, the first step is also to establish the critical ratio for Blank Jerseys. From Equations 7-9 we see that the formulation is the same as for the Simple Newsvendor Model.

$$\text{Overage for Blanks} = C_b - S_b = \$9.50 - \$8.46 = \$1.04$$

$$\text{Underage for Blanks} = P - C_b - C_{nad} - \lambda = \$24 - \$9.50 - \$2.40 = \$12.10$$

$$\text{Critical Ratio Blanks} = \text{Underage}/(\text{underage} + \text{Overage}) = 12.10/(12.10 + 1.04) = .92$$

The next step is to calculate the critical ratio for dressed jerseys. The Overage cost for dressed player jerseys is

$$\text{Overage for Dressed} = C_d = S_d = \$10.90 - \$7 = \$3.90$$

As we see in equation 14, the Underage value for dressed jerseys (called Netprofit2) is calculated as follows:

$$C_{sd} = \text{Cost of Supplier decoration} = C_d - C_b = 1.40$$

$$\begin{aligned} \text{NetProfit}_2 &= \text{Pr}(\text{blank available}) \times (C_{nad} - C_{sd}) + (1 - \text{Pr}(\text{blank available})) \times (P - C_b - C_{sd}) \quad (14) \\ &= \text{Pr}(\text{blank available}) \times (2.4 - 1.40) + (1 - \text{Pr}(\text{blank available})) \times (24 - 9.50 - 1.4) \end{aligned}$$

The probability of a blank available is the critical ratio calculated earlier for blank jerseys. Thus,

$$\text{Pr}(\text{blank available}) = .92$$

$$\text{NetProfit}_2 \text{ or Underage} = (.92)(1.00) + (.08)(13.10) = \$1.96$$

$$\text{CR - dressed jerseys} = 1.96/(1.96+3.90) = .33$$

Now that we know the critical ratio for dressed jerseys, we can use the provided demand distributions, again assuming normal distribution, and determine the following order quantities:

Notation	Desc	Q*
Q1	BRADY, TOM #12	24852
Q2	LAW, TY #24	8538
Q3	BROWN, TROY #80	6591
Q4	VINATIERI, ADAM #04	5407
Q5	BRUSCHI, TEDY #54	4110
Q6	SMITH, ANTOWAIN #32	1575

These quantities are much lower than the proposed quantities for the simple newsvendor model. Next we need to understand the expected sales profile, including the level of demand that will not be met, due to the low inventory proposal. The sales results are as follows:

Desc	Q*	E[Sold]	E[Unsold]	E[Unmet Demand]
BRADY, TOM #12	24852	21789	3063	8974
LAW, TY #24	8538	7486	1052	3083
BROWN, TROY #80	6591	5779	812	2380
VINATIERI, ADAM #04	5407	4442	965	2828
BRUSCHI, TEDY #54	4110	3377	734	2150
SMITH, ANTOWAIN #32	1575	1294	281	824

To take advantage of the risk pooling opportunity we need to include the expected unmet demand shown in the right hand column with the demand for blank jerseys to generate new demand parameters for blank jerseys. Using equations (21) we see the new expected demand for blank jerseys:

$$\begin{aligned}
 E[\text{Demand for Blanks}] &= \text{Mean Blanks} + \text{Sum}(E[\text{Unmet Demand}] \text{ for dressed}) \\
 &= 23275 + 8974 + 3083 + 2380 + 2828 + 2150 + 824 = 43514
 \end{aligned}$$

The variation for this demand is approximated using equation 22, where the original coefficient of variance for each selected player's demand is calculated by dividing the standard deviation by the mean ( $CV = \delta = \sigma/\mu$ )

$$\text{Variance} [\text{Demand for Blanks}] = (10474)^2 + \text{Sum}(\delta * E[\text{Unmet Demand}])^2$$

The results are shown in the following chart:

Player	CV	Mean	Stdev	Variance
Other Players	0.45	23275	10474	109698496
BRADY, TOM #12	0.45	8974	4038.43	16308888
LAW, TY #24	0.45	3083	1387.44	1924993
BROWN, TROY #80	0.45	2380	1071.04	1147133
VINATIERI, ADAM #04	0.60	2828	1696.56	2878308
BRUSCHI, TEDY #54	0.60	2150	1289.71	1663356
SMITH, ANTOWAIN #32	0.60	824	494.22	244256
<b>TOTAL DEMAND FOR BLANKS</b>		<b>43513</b>	<b>11570.0</b>	<b>133865431</b>

The standard deviation for the total demand for blanks is the square root of the total variance. This new distribution for blank jerseys can now be used, along with the critical ratio calculated previously to determine the optimal order quantity for blank jerseys.

$$Q_0^* = \text{NORMINV}(.92, 43513, 11570) = 59,809$$

Following this purchasing plan, Reebok can expect the following sales results:

Profit Summary Name	Quantity	E[Sold]	E[Unsold]	Expected Unmet Demand	Profit
BLANKS	59809	43097	16712	416	\$ 504,008
BRADY, TOM #12	24852	21789	3063	0	\$ 273,489
LAW, TY #24	8538	7486	1052	0	\$ 93,960
BROWN, TROY #80	6591	5779	812	0	\$ 72,533
VINATIERI, ADAM	5407	4442	965	0	\$ 54,426
BRUSCHI, TEDY #54	4110	3377	734	0	\$ 41,374
SMITH, ANTOWAIN #32	1575	1294	281	0	\$ 15,855
<b>Totals</b>	<b>110883</b>	<b>87263</b>	<b>23620</b>	<b>416</b>	<b>\$ 1,055,645</b>

Using the Newsvendor Model with Risk Pooling approach, the expected profits rise to \$1,055,645 or an increase of 16% over the simple newsvendor model that does not use blanks, and a 9% improvement over the simple newsvendor that uses available blank jerseys to satisfy otherwise unmet demand. Also important to note is that the risk pooling approach achieves this result with 12% fewer jerseys ordered, and 38% fewer jerseys left unsold. Of the unsold jerseys only 40% in the simple newsvendor model are blank jerseys, while in the risk-pooling model, 70% of unsold jerseys are blank. There is less risk associated with carrying blank jerseys since they have a higher likelihood of being sold in the following season.

## **VIII. Numerical Model - Test and Results**

### **Critical Ratio Calculations:**

The first step in both models was to calculate the critical ratio for blank jerseys. Since the same cost parameters were used in both models, the critical ratio for blank jerseys will be identical. For the 31 teams evaluated the results varied from .95 to .91, as can be seen in Figure 8.

The critical ratio for dressed jerseys was calculated directly in the simple newsvendor model. For the Newsvendor with Risk Pooling Model, the critical ratio for dressed jerseys was dependent on the availability of blank jerseys. As can be seen in the following chart, the difference between the two policies is significant. For example, the critical ratio for dressed jerseys for the New England patriots was .79 for the simple newsvendor model, but only .37 with risk pooling. Complete results are listed in Fig. 8:

Given these differences in critical ratio, it is clear that the stocking policies for the simple newsvendor will result in much greater volumes of dressed jerseys compared to the model with risk pooling, and that the volumes of blank jerseys will be less in the first model than in risk pooling model.

To continue the evaluation of the two methods, we must consider the total volume of jerseys ordered, both dressed and blank, and evaluate the stocking plan against the actual sales for the 2003/04 selling season. It is also necessary to understand the volume of blank jerseys required by each plan, and to determine if the current capacity constraint becomes a factor. If so, then a cost of capacity factor will be included. This will allow for a comparison of total expected profits with and without the capacity cost. The difference can be interpreted as the value of adding additional capacity at the North American distribution center

**Figure 8 - Critical Ratios**

Team	Newsvendor with Risk Pooling		Simple Newsvendor	
	CR Blanks	CR Dressed	CR Blanks	CR Dressed
49ers	0.94	0.50	0.94	0.88
Bears	0.93	0.46	0.93	0.85
Bengals	0.93	0.41	0.93	0.84
Bills	0.92	0.38	0.92	0.79
Broncos	0.93	0.40	0.93	0.82
Browns	0.94	0.47	0.94	0.87
Buccaneers	0.93	0.32	0.93	0.80
Cardinals	0.94	0.30	0.94	0.82
Chargers	0.92	0.35	0.92	0.79
Chiefs	0.93	0.43	0.93	0.83
Colts	0.92	0.35	0.92	0.79
Dolphins	0.93	0.35	0.93	0.80
Eagles	0.94	0.47	0.94	0.87
Falcons	0.91	0.34	0.91	0.76
Giants	0.94	0.47	0.94	0.87
Jaguars	0.93	0.38	0.93	0.82
Jets	0.92	0.37	0.92	0.80
Lions	0.93	0.35	0.93	0.82
Packers	0.94	0.45	0.94	0.86
Panthers	0.94	0.46	0.94	0.86
Patriots	0.92	0.37	0.92	0.79
Raiders	0.95	0.58	0.95	0.92
Rams	0.93	0.44	0.93	0.84
Ravens	0.94	0.48	0.94	0.87
Redskins	0.93	0.43	0.93	0.85
Saints	0.94	0.48	0.94	0.86
Seahawks	0.93	0.48	0.93	0.86
Steelers	0.93	0.36	0.93	0.82
Texans	0.94	0.47	0.94	0.87
Titans	0.93	0.39	0.93	0.83
Vikings	0.93	0.36	0.93	0.81

**Model Test**

To test the model, a forecast was generated, based on information that was available and known on March 1, 2003. The forecast is used as the basis of the planning models to generate the stocking policy for the 2003/04 season and can be found in Appendix IV.

Sales information for the 2003/04 season is compared to the results of the two different approaches and Reebok’s actual purchases for the year. The validity of this comparison is compromised by the limitation that the sales figures do not truly represent the entire

demand. It is possible that sales could have been higher if product had been available during a critical period. Sales figures do not include back orders or unmet demand.

It is also important to note that the stocking policies generated by the two models are based on known information as of March 1<sup>st</sup>, and would be updated and revised as new information becomes available. The actual performance of Reebok during the 2003/2004 season is a result of periodic inventory management against demand. As new information became available during the off-season, through the draft, and during summer camp, the experts at Reebok would have adjusted inventory to meet higher than anticipated demand.

Team performance early in the season can have a significant impact on sales. Early season success would be a signal for Reebok to adjust inventory positions in anticipation of the potential increase in post-season sales.

### **The Results:**

The results of each modelling approach will be compared and evaluated based on expected profit, total inventory requirements for blank and dressed jerseys, and fill rate. All numbers are indexed to protect confidential information.

The total expected profit realized using the Newsvendor with Risk Pooling Model is 8% higher than the total using the Simple Newsvendor Model. For the Simple Newsvendor modeling approach, the optimal order quantity for all dressed jerseys is shown in figure 9 as 71, or 71% of the total jerseys ordered. The total number of blank jerseys required is 29% of the total required stock. Using the Newsvendor with Risk Pooling method, the number of dressed jerseys is reduced to only 44 and blank jersey 42, for a total requirement of 86 jerseys, or 86% of the volume using the Simple Newsvendor Model.

In either case the capacity constraint for blank jerseys was not reached. During the 2003/04 season Reebok actual purchasing totalled 3 million jerseys, roughly split 50/50

between dressed and blank jerseys, but as can be seen in Figure 10, there is an opportunity to improve the mix of jerseys that Reebok purchases.

**Figure 9 - Results Comparison**

	News vendor w/ Risk Pooling	Simple News vendor
Dressed Jerseys	44	71
Blank Jerseys	42	29
Total Jerseys	86	100
Expected Profits	108	100

**Figure 10 - Service Levels Comparison**

	News vendor w/ Risk Pooling	Simple News vendor	Actual Results	
Sales	100	100	100	Index Sales 2003/2004
Instock	95	96	86	Demand Satisfied from Planned Stock
Overstock	28	47	27	End of Season remaining inventory
Understock	5	4	15	Volume "pulled forward" from suppliers

To compare the service performance of the two proposed models and Reebok for 2003/04, the models were compared to the actual sales data for 2003/04. Total sales are indexed to 100. When the purchasing plans that results from the two models are compared on a player-to-player and team-by-team basis, it is possible to see how each model would have performed. In Figure 10, the In-stock line represents the relative proportion of jerseys that were sold that were planned to be In-stock. Overstock represents the total number of jerseys that were purchased that were not sold by the end of the year. The Under-stock line shows jerseys that were sold, but were not planned, meaning they would have been expedited from supplier inventory. In the model presented earlier, this is represented by the E[unmet] demand. These results are indexed to show the relative results compared to Reebok's operating performance during the 2003/04 season.

The Simple News vendor model was best able to satisfy demand from stock. Of the total sales for the year, 96% of jerseys were available from in-stock inventory. This is compared to 95% for the News vendor with Risk Pooling model and 86% under the current practice.

**Figure 11 – End of Year Inventory Profile**

Overstock Profile	News vendor w/ Risk Pooling	Simple News vendor	Actual Results
Blank Jerseys	83%	40%	41%
Dressed Jerseys	17%	60%	59%
Total	100%	100%	100%

At the end of the season the Simple News vendor model, to reach the high level of fulfillment, had a significant inventory burden. As is shown in Figure 10 - 47% of sales, would be held in inventory at the end of the year. This is compared to 28%, to achieve 95% fill rate for the News vendor with Risk Pooling method. The current practice had the lowest end of year inventory of 27%. Figure 11 shows the profile of the end of year inventory. The inventory with risk pooling is heavily weighted towards Blank Jerseys, so will likely be used in the next season. The Simple news vendor model has a much higher inventory burden of dressed jerseys, which as explained earlier pose a much greater risk of obsolescence.

The final measurement that can be compared is the number of under-stock. These numbers are based on March 1<sup>st</sup> estimates and would likely be updated during the season. What this means is that the numbers presented are the worse case if no further adjustments were made to the purchasing plan after the initial calculations. The News vendor with Risk Pooling would result in a 5% of jerseys under-stocked, or not in the original inventory plan. This is compared to only 4% for the simple news vendor model. Reebok’s current process relies on the ability to “pull” inventory from suppliers early if required. In 2003/2004 demand for over 15% of jersey sales were satisfied, not from planned inventory, but by pulling the inventory from the suppliers. This amount can be seen as under-stock compared to a plan created on March 1<sup>st</sup>. As explained during the section on purchase planning, orders for approximately 600,000 jerseys are placed between July and October, with a planned delivery date in April. The suppliers manufacture these jerseys upon receipt of the orders, and hold the finished goods in inventory until the planned shipment date. In the case of 2003/04, to meet customer demand, Reebok had to contact the supplier and request immediate shipping of a portion

of these jerseys. The immediate consequence of this action is that the shipping cost for expedited delivery is about \$1 more per jersey. The longer-term impact is felt in April, when instead of 600,000 blank jerseys arriving to position inventory fewer are available to send. Increased ordering will eventually erase this deficit, but having a thin inventory position in April increases the potential for late customer deliveries in May and June.

**Figure 12 – Estimated Profits including Expedited Orders**

	Q	Sold	Unsold	Expedited	Profits
Actual Reebok Results	100	79	21	11.7	100
Simple Newsvendor	112	79	37	3.1	102
Newsvendor w/ Risk Pooling	97	79	22	4.1	106

Figure 12 looks at what the potential profits were for the 2003/04 season depending on which inventory model was followed. The columns for Quantity, Sold, Unsold, and Expedited are all indexed to Actual Reebok Orders = 100, and the Profit column is indexed to Actual Reebok Profits = 100. Included in the profit calculations is the additional cost of expediting jerseys to meet customer demands. The simple newsvendor model has a slight profit advantage over the actual performance, but also results in a high inventory burden. The newsvendor with Risk pooling has the highest profits and an inventory that is primarily blank jerseys.

## **Model Use, Recommendations and Limitations**

Referring to the planning cycle presented earlier, it is my recommendation that Reebok use the newsvendor model with risk pooling to plan their annual purchasing.

The purchasing cycle starts in July, 14 months prior to the NFL season starting. At this time limited information is known, but a forecast can be generated at a team level.

Planning can be done to purchase the jerseys that are most likely, or have the highest probability of being sold during the season.

In February, following the initial order placement of retailers, enough information is available to generate a team and player level forecast. Using this forecast on March 1<sup>st</sup>, the Planning Manager can determine an optimal quantity for each player and team blank jersey. Over the next several months, purchasing can be conducted to target these optimal quantities.

As new information is available, the forecast, and the model, must be updated. Player movements, increased early sales, or heightened expectations must all be incorporated into the forecast and managed to ensure that proper planning is conducted.

By June, the end of the planning cycle, all inventory positions should be met. Any “holes” can be filled through final orders. As spring training/camp starts in July the planning season is starting for the following year. However, the current year planning model should be maintained, so that any major changes in player expectations, team status, etc can be analyzed for inventory impact. If a player is suspended or released or retires, or traded then the impact could be enormous on the team jersey sales.

The capacity constraints did not impact the results of these models. Enough annual capacity currently exists to process all jerseys. However, this assumes that demand upon the printing capacity is placed at a constant rate. Spikes in demand for the printing

capacity could out pace capacity over a one or two week period. Further investigation into the usage pattern for printing capacity would be useful to determine if a capacity expansion is required.

The use of this model is to provide a statistical and quantitative analysis of the Replica Jersey problem. It cannot and should not entirely replace the experience, gut feeling, and art that every member of the Reebok team must have to understand and react in the professional sports business.

## **IX. Conclusions**

Customer demand for NFL Replica jerseys is tied to many factors, both at the individual level and the team level. This variability requires an ability to respond quickly to changes in customer demand. Reebok cannot accurately predict all demand, but they can be prepared to respond by ensuring sufficient domestic screen-printing capacity, working to reduce supply and order fulfillment cycle times, and properly assessing the value of holding inventory of blank jerseys.

There is currently no capacity constraint in Indianapolis for screen-printing, but replica jersey market growth or growth in demand for printing capacity from other products, will require capacity expansion. The impact of new contracts with major hockey leagues (NHL, AHL, ECHL and CHL) and growing business with the NBA and IRL will have an impact on capacity available to dedicate to the NFL jerseys. Reebok should fully understand the demand pattern for screen-printing capacity to assess if capacity is required. Current capacity is sufficient on average, but may not be able to meet peak demands without delay.

Reducing cycle times will improve responsiveness and reduce inventory requirements. Reducing order fulfillment cycle-times will allow Reebok to better respond to customer demand. If a retail customer is confident they can get hot players in stock quickly, then orders will increase to take advantage of short selling opportunities to end consumer.

Reebok's planning cycle currently runs from July to June for the NFL season starting the following September. The current practice is to consider the immediate demand and inventory when making buy decisions in July, but officially place orders for April delivery. Shifting the planning cycle by two months to start in September and end in August, would allow Reebok to make buying decision for about 300K jerseys one or two months before the season, rather than current practice of 14 months before the season.

Ultimately Reebok must maintain a high level of customer service to meet the requirements of the NFL Licensing agreement. The basis for this analysis was to maximize profits by finding the balance between blank jerseys and dressed jerseys. If Reebok management decides to increase overall service levels it is possible to do so by increasing the inventory of blank jerseys. This will have a negative impact on profits and likely require capacity expansion at the distribution center in Indianapolis. The solution outlined in the previous section recommends holding relatively more blank jerseys than dressed jerseys, as an approach to pool risk, and postpone the final manufacturing decision until real demand is known. The value of a blank jersey is the flexibility that a blank jersey provides to satisfy customers.

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## XI. Appendices

### APPENDIX I - Key Decisions for Purchasing and Planning

	Buy Decisions	Jersey Type	Vol.	Info Available	Alternate Criteria
1	Pre-Buy (July – Oct '03) – Planned Delivery April '04	Blank Jersey	600K	Pre-Season Sales '02 (40-50% of Demand) Current Inventory Position	Possible to “pull forward” delivery date to Oct-Dec '03 or Jan '04
2	Pre-Buy (December '03) – Planned Delivery April '04	Blank Jersey	75K	2002 sales to end of November (80%), and likely play-off teams 2002/03 play-offs	Target April Inventory = 50% of 2002/2003 sales for team or player
3	Buy against demand (Late December '03 – Feb '04) 90 Day LT	Dressed Jersey	425K	Retail Pre Orders (~20% of annual demand)	Target June Inventory = 50% of 2002/2003 demand
4	Buy against Forecast target inventory (March, April, May, June) 90 Day LT	Mix of Dressed and Blank	1900 K	Forecasted Demand at Team Level and pre-season sales at Player Level	On going retail orders

## **APPENDIX II - Research Interviews:**

### **Initial Conference Calls:**

1. Joe Keane, Lloyd Davis, Lynda Moyer. Project scoping.
  - Review Project Scope and Set Objectives
  - Introduce Lynda as contact in Indianapolis
  - Establish time for initial Indy conference call
  
2. Lynda Moyer, Tony Feller, Sonny Short, Jeff Boruvka, Kick Off
  - Introduction to key personal at Indy
  - Review project objectives
  - Understand business process and cost parameters
  - High Level understanding of Reebok Apparel business

### **Indianapolis Visit:**

3. Lynda Moyer, Tony Feller – Purchasing Manager
4. Kim Kehoe – Planning Manager
5. Sonny Short – Vice President Purchasing
6. Tom Shine – Senior Vice President, Sports & Entertainment Marketing Worldwide
7. Blake E. Lundberg, Vice President & General Manager Group Athletica
8. Eddie White – Vice President, Team Properties & Sports Marketing
9. David Wray – Director, Sales Operations
10. Tony Feller – Purchasing Manager
11. Monthly Sales Meeting – Sales Team, Purchasing, Inventory

### **Follow Up Meetings:**

12. Lynda Moyer, Tony Feller – status review via conference call
13. Joe Keane – Reebok headquarters
14. Tony Feller, Monte Gill – Production Manager, via conference call
  - Capacity constraints
  - Understand production process and printing capabilities
  - Confirm that general direction is helpful to Tony

### **Retail Perspective**

15. Jack O'Donnell, Olympia Sports, march 30, 2004
  - Understand Retail Buying Patterns and delivery expectations
  - What are key demand drivers eg. Free Agent signings
  - Discuss the Chase and “hot market” sellers
  - Inventory measure - Target 80-90% sell through, 10-20% carry over to next season
  - Informal stocking policy looking at service levels depending on player rate of demand

## **APPENDIX III – Forecasting Methods by Jared Schrieber**

### **Outline to Forecasting portion of Reebok Thesis**

#### **I. Introduction**

The difficulties in forecasting demand for fashion apparel are well documented and the challenges associated with licensed sports apparel are no less significant. In addition to the common fashion variables of style, color and size, demand for Reebok's licensed products is heavily influenced by seemingly unpredictable swings in team performance, player popularity, trades, free agency, and draft selections. Members of Reebok's staff that have been involved with the licensed apparel industry for a number of years unanimously agree that it is impossible to accurately forecast demand for these products. Perhaps this is one reason why documented forecasts do not exist for this business unit.

In developing an appropriate forecasting process, it is important to understand when new information can be incorporated into a forecast, when decisions are to be made based upon forecasts, and how sensitive those decisions are to the forecasts' accuracy at various levels of detail. For example, Reebok's procurement decisions from July through November for the following NFL season do not require player-level details. This allows the forecasting process to focus on rough team-level forecasts that can be used to guide the initial procurement of blank jerseys for each team. During December, January and February, a forecast is not necessary because retailers begin placing orders for the following season. These orders are sufficient in quantity and lead-time for Reebok to purchase directly from its suppliers and completely meet the suppliers' quota expectations during this period. It is not until March and April when Reebok must again rely on forecasts – at the team and player level – to guide procurement decisions. By this time in the sales season, sufficient demand information exists to simply extrapolate forecasts for the entire season based on the mix and quantity of initial customer orders.

Finally, May and June purchasing decisions are guided by the large volume of retail shipments that take place during this time. These shipments create 'holes' in the on-hand inventory that are to be replenished to safety-stock levels during the NFL season. Since Reebok has no visibility to its retailers Point-of-Sale (POS) data, it must wait for the retailers to submit orders based upon initial retail sales and team performances. These mid-season orders must typically be filled from Reebok's on-hand inventory, or risk forfeiture. Thus, mapping Reebok's decision making processes led us to conclude that a team-level forecast in July (a year prior to the season), as well as a team and player-level forecasts (for the upcoming season) on March 1<sup>st</sup> and again on April 1<sup>st</sup> would be sufficient. These forecasts, which are comprised of mean estimates and error distributions, feed into a planning model that can be used to guide procurement decisions throughout the year.

The objectives of this paper are three-fold:

1. To provide insight into the drivers of demand for NFL Replica Jerseys throughout each season;

2. To propose a simple and robust methodology for demand forecasting; and,
3. To offer suggestions that may lead to improved forecast accuracy and a reduced forecast horizon.

The following section, Section II, Demand Drivers and Indicators, provides a brief overview of the variables influencing demand for NFL Replica Jerseys. Section III, Analysis of Sales Data, explores the most important of these variables to identify potentially actionable patterns and correlations. Section IV, Proposed Methodology, describes the recommended forecasting approaches and evaluates their performance. The paper concludes with Section V, Recommendations for Further Improvement, which describes some opportunities that Reebok may explore to improve forecast accuracy and decrease the forecasting horizon.

## II. Demand Drivers and Indicators

Those most familiar with Reebok's licensed apparel business were interviewed to identify important variables that may be correlated with, or causal to, demand. The results of these interviews are summarized in the table below.

### Team Variables:

- Franchise
  - Years in League
  - Years in Location
- Jersey's Style
  - Fashion Appeal
  - Last Changed
  - Upcoming Change
- Performance
  - Performance History
  - Current Year
- Fan Base
  - Metro Size
  - TV Ratings
  - Team Value
  - Sell-out Ratio

### Player Variables:

- Experience
  - Years in League / Rookie Draft Spot
  - Years on Team
- Odds of Being w/ Team Next Year
  - Contract Expire Date
  - Salary Cap Burden
- Performance
  - Health / Legal Status
  - Fantasy League Value
  - All-Pro Selections
- Popularity
  - Endorsement Deals
  - Sports Card Value
  - Popularity on Team (% of Team)
  - Sentimental Favorite
  - Ethnicity

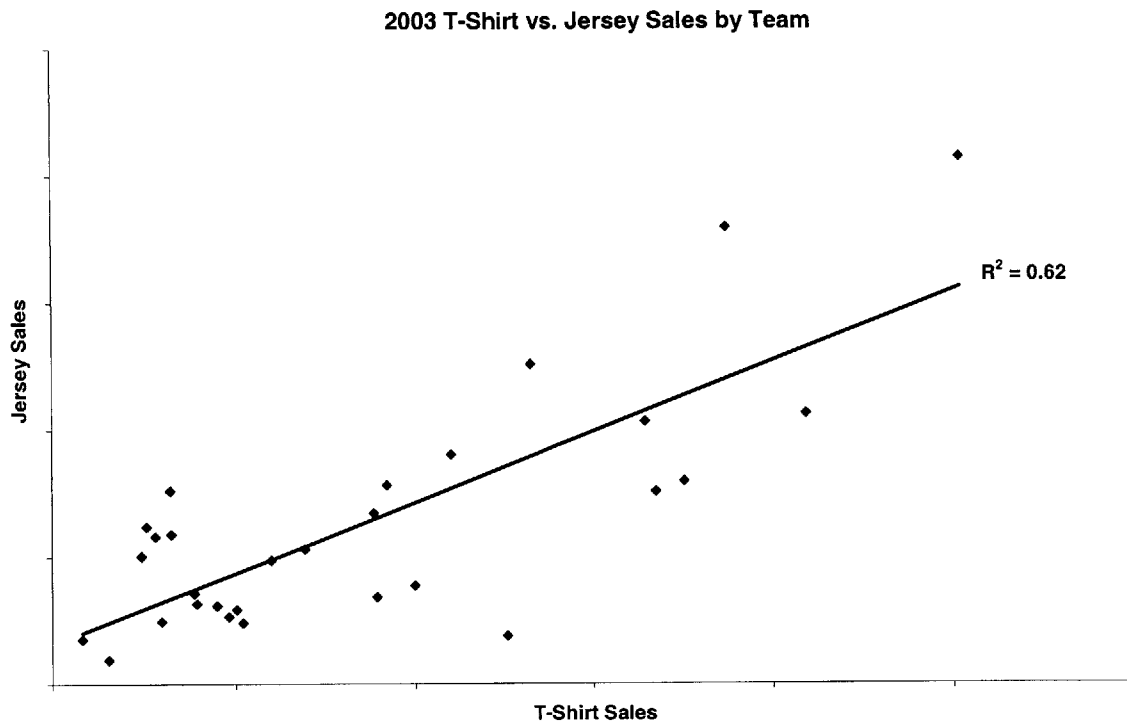
The complete set of variables that contribute to fluctuations in demand is potentially staggering. Unfortunately, data for many of the variables listed are not readily available. In addition, much of the data is qualitative in nature and would require careful methods to consistently aggregate it in a statistical model. Finally, with only two seasons of sales data there is not enough history to conclusively calibrate many of these variables to their correlation with demand. Thus, efforts were focused on a few key variables, whose readily accessible data were thought to have the strongest correlations with changes in demand. (In this case, it is not necessary to use a forecasting model to completely reconstruct demand from the ground-up, but instead to assist in understanding and predicting changes in demand from one season to another.)

### III. Analysis of Sales Data

#### *Team Factors Drive Majority of Sales*

The first objective in understanding the drivers of demand was to get a sense for whether team variables or player variables have a greater impact on sales. One method used to measure this was a comparison of team-logo t-shirt sales (no player names) and the sum of jersey sales for each team (Figure 1). If customer purchases are driven to buy a particular player's jersey, regardless of that player's team, then the correlation between t-shirt sales and jersey sales should be low.

**Figure 1**

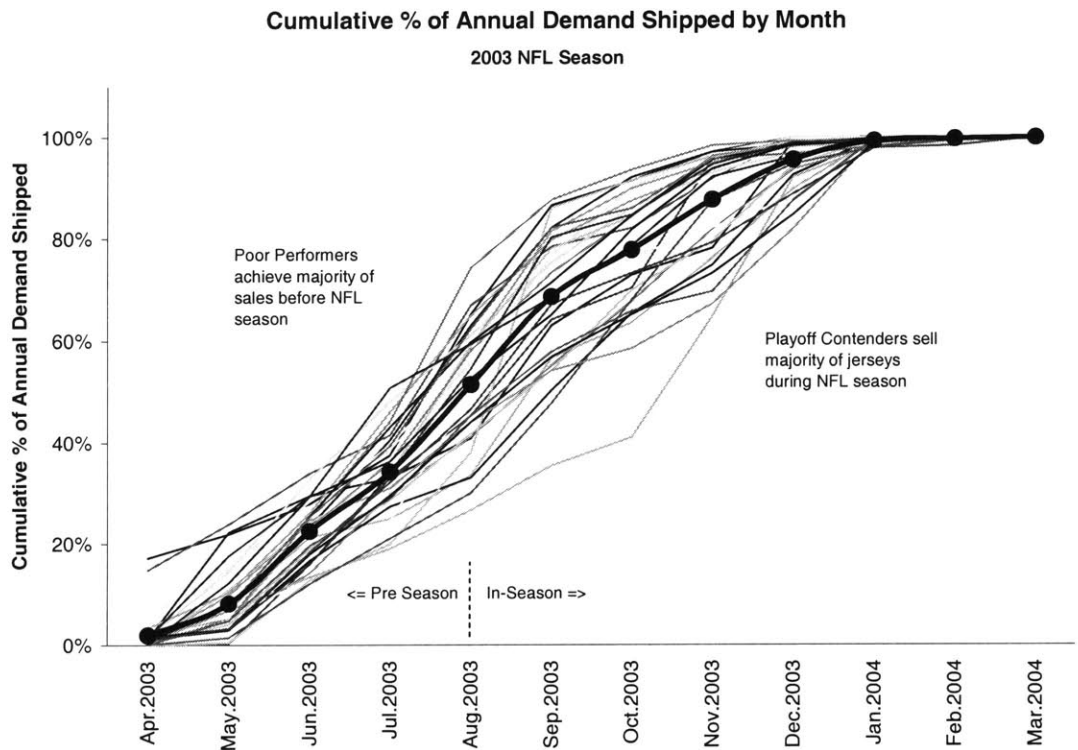


In the chart above, we see a meaningful correlation ( $R^2 = .62$ ) between the sales of t-shirts and jerseys by team. The major outliers in this chart are explained by the prominence of 'super-star' players that drive strong nation-wide demand for their jerseys, but not of their team's t-shirts. Likewise, we find that those teams with a high proportion of t-shirt sales to jersey sales tend not to contain 'super-star' players. Finally, a deeper analysis revealed that 'super-star' players on small market teams sell significantly fewer jerseys than players of equal (or lesser) caliber on teams that are more widely followed. This confirms that team-level factors are the primary determinant of jersey sales and that the popularity of player jerseys is highly dependent on which team they play for.

#### *Team Performance Drives Timing of Sales*

Reebok employees familiar with the NFL Replica Jersey business felt very strongly that team performance was a major factor in driving sales. In particular, teams that perform well during the NFL season were known to drive ‘chase’ demand from the time that the NFL season begins in early September through the playoffs in January. In total, 50% of jerseys ship prior to the NFL season (1H – 1<sup>st</sup> Half), while the remaining 50% ships during the NFL season (2H – 2<sup>nd</sup> Half). The annual sales cycle for all NFL Replica Jerseys is depicted by the thick line in the chart below (Figure 2), while thin lines represent the sales patterns of individual teams.

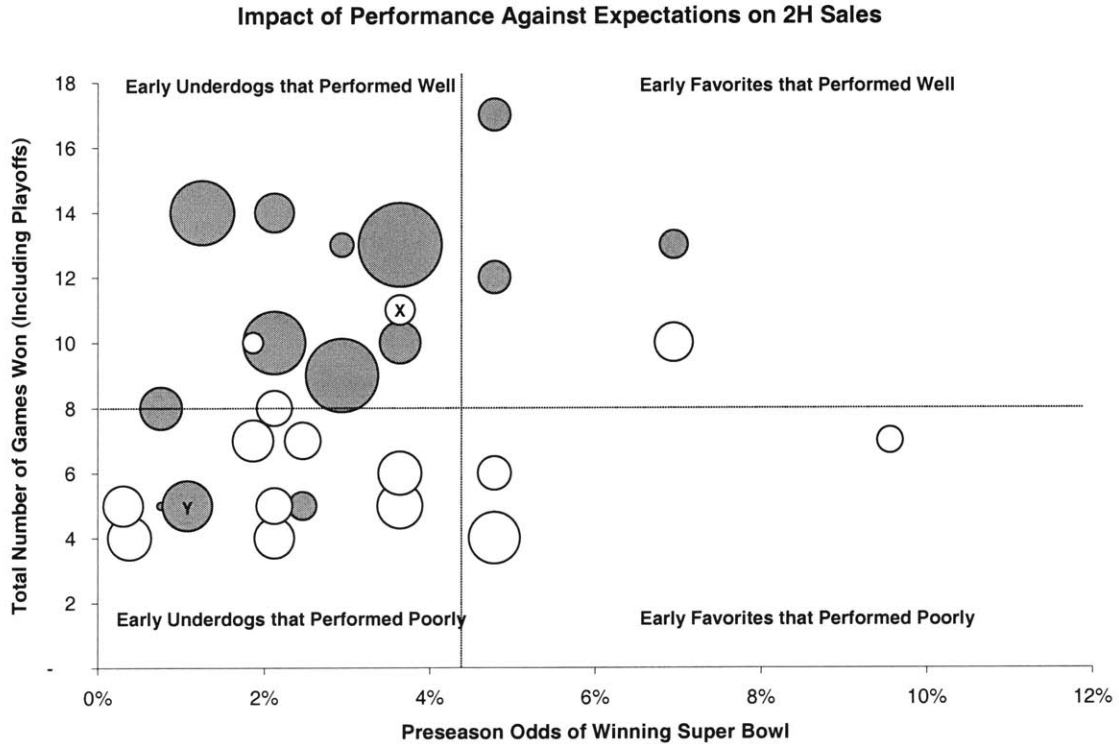
**Figure 2**



This chart demonstrates that ‘Playoff Contenders’ do experience the vast majority (> 65%) of their jersey sales after the NFL season begins. In contrast, teams that do not perform well in the NFL season may only sell one-third of their total demand after the season begins. A thorough analysis of the data in a broader context began to reveal that while team performance was an important driver of in-season demand, the team’s performance against preseason fan expectations may be just as important.

The following chart (Figure 3) attempts to depict the impact of team performance against expectations on in-season (2H) demand during 2003. Shaded dots represent teams with increases in demand from the 1H to 2H, while hollow dots represent decreases in demand. The size of each dot reflects the magnitude of the percent change in sales from the 1H to 2H.

**Figure 3**



The above chart (Figure 3) is divided into four quadrants based upon a combination of preseason expectations and actual performance:

**Early Underdogs that Performed Well** – The large shaded dots in this quadrant suggest that teams with the largest increases in demand did more than perform well; they also exceeded the preseason expectations of their performance. The two teams in this quadrant that experienced a drop in sales either did not make the playoffs or miraculously squeaked-in at the very end of the season after an otherwise disappointing year (e.g, Team ‘X’).

**Early Favorites that Performed Well** – These teams tend to sell well in the preseason, but no matter how well they perform, there sales are not likely to increase much during the NFL season. This runs contrary to the natural expectation that if an early favorite performs well, its sales will take-off.

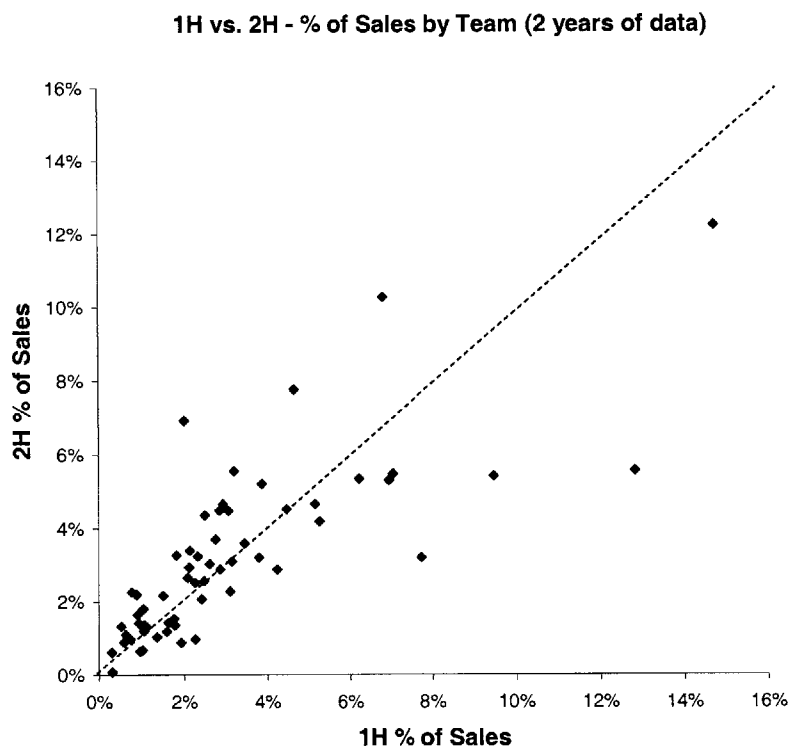
**Early Favorites that Performed Poorly** – As expected, these teams experienced a drop-off in sales from the 1H to 2H of the sales season.

**Early Underdogs that Performed Poorly** – Here we see a fairly consistent reduction in sales across eight teams. Although the large percentage increase in sales for Team ‘Y’ is difficult to explain, it is a small market team whose absolute increase in jersey sales was quite miniscule.

Clearly, team performance against expectations is an important driver of sales during the NFL season. Therefore, preseason odds can be used as criteria for determining which teams pose the greatest risk of surges in demand mid-season.

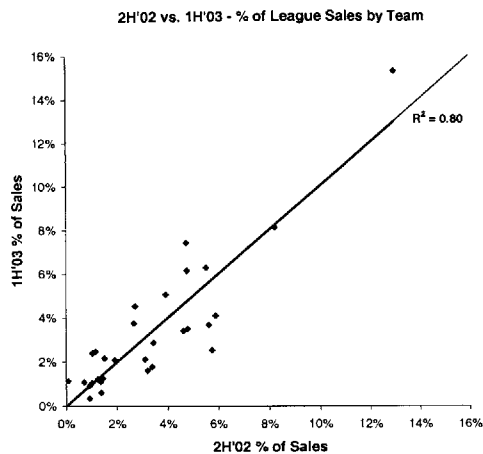
In a related analysis (Figure 4), we found that the more jerseys a team sells in the preseason (1H), the more likely it is to experience a drop in sales during the NFL season (2H). Only one of the top-ten selling teams during the preseason achieved a higher market share during the NFL season. This also suggests that performance against preseason expectations is an important factor contributing to 'chase' demand in-season and that Reebok should avoid the tendency to simply stock-up on jerseys for teams that sell well in the preseason.

**Figure 4**

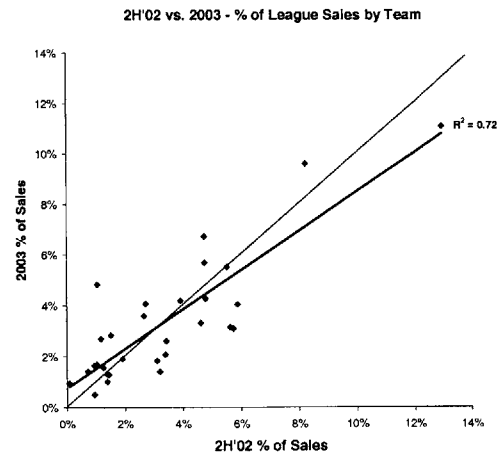


Finally, in order to more fully understand the dynamics of team-level demand, we analyzed the correlation of jersey sales from season-to-season. In doing so, we found that in-season jersey shipments from September through March (2H) are a good indicator of sales for both the 1H (Figure 5) and entirety of the next season (Figure 6). (October through March was the only time-period that offered an equivalent indicator of demand for the following season, thus we continued to use 2H sales as our primary indicator.)

**Figure 5**



**Figure 6**

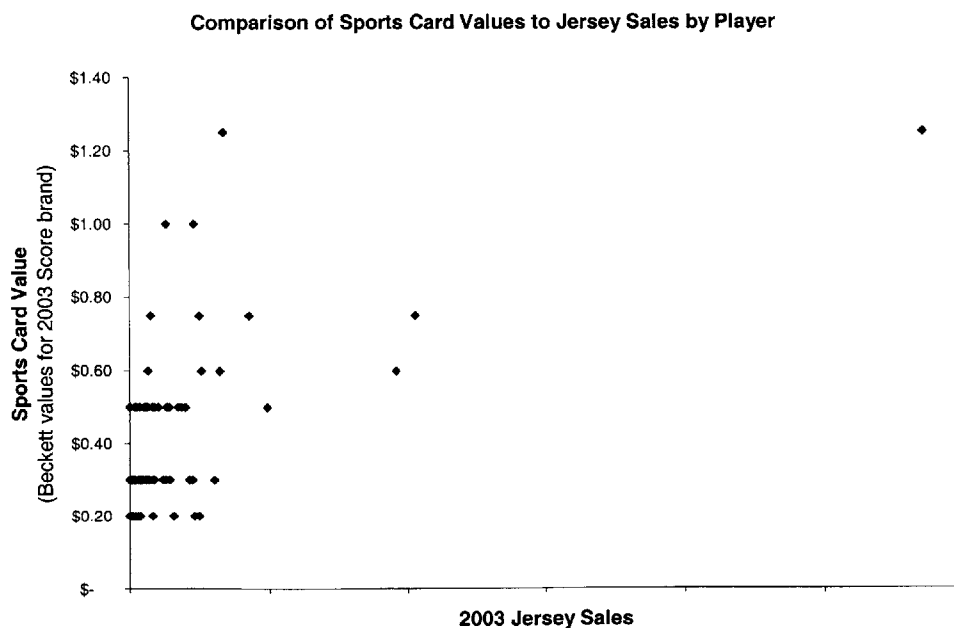


(Note: The above charts were normalized to reflect the removal of a team that underwent a major jersey style change in 2003, impacting its demand between the two sales periods.)

### ***Drivers of Player Demand are Complex***

After obtaining a feel for demand at the league and team levels, the focus of our analysis turned to the player level of detail. In particular, we hoped to find an indicator of player popularity that could be used to gauge changes in player demand over time. Sports card values and Fantasy League player values seemed to be the most natural and readily accessible of various player popularity metrics. Surprisingly, very little came from these analyses. Sports cards do not exist for many players whose jerseys sell well, and card values have very few price-points that create very large groups of equally valued players. This results in poor correlations between player jersey sales and sports card values both within teams and across the league (Figure 7).

**Figure 7**



Fantasy League values were also found to be poor indicators of jersey demand by player. Although these values have finer granularity (i.e., 100 different values), differences in player values were not reflective of differences in jersey sales among players (even on the same team). Some of this could be reconciled by assigning weights to the values of different positions (e.g., quarterback, tight-end, linebacker, etc.), but the added effort provided few useful insights. Finally, since Fantasy League values only change during the NFL season, they cannot effectively be used as a timely indicator of retail orders.

Fortunately, player jersey sales in the upcoming season are correlated to their sales towards the end of the prior season. The following charts depict the 100 best selling players in the 2H'02 (accounting for ~ 85% of 2003 demand), relative to their sales in the 1H'03 (Figure 8) and all of the 2003 selling season (Figure 9).

**Figure 8**

**Top 100 Players in 2H'02 vs. 1H'03 Sales**

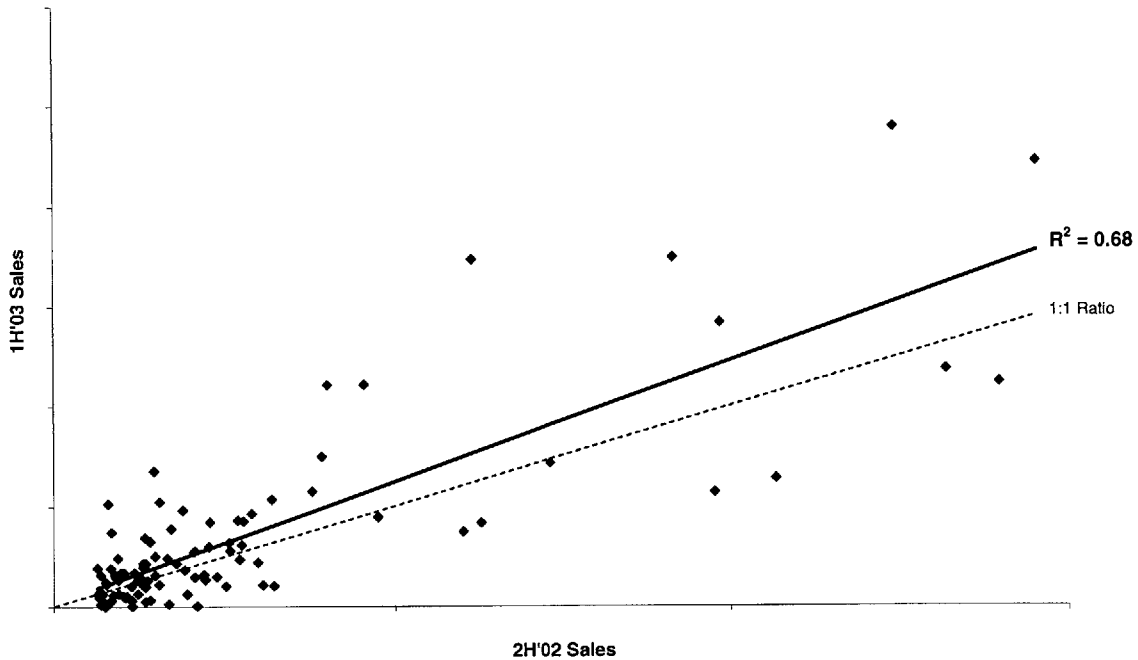
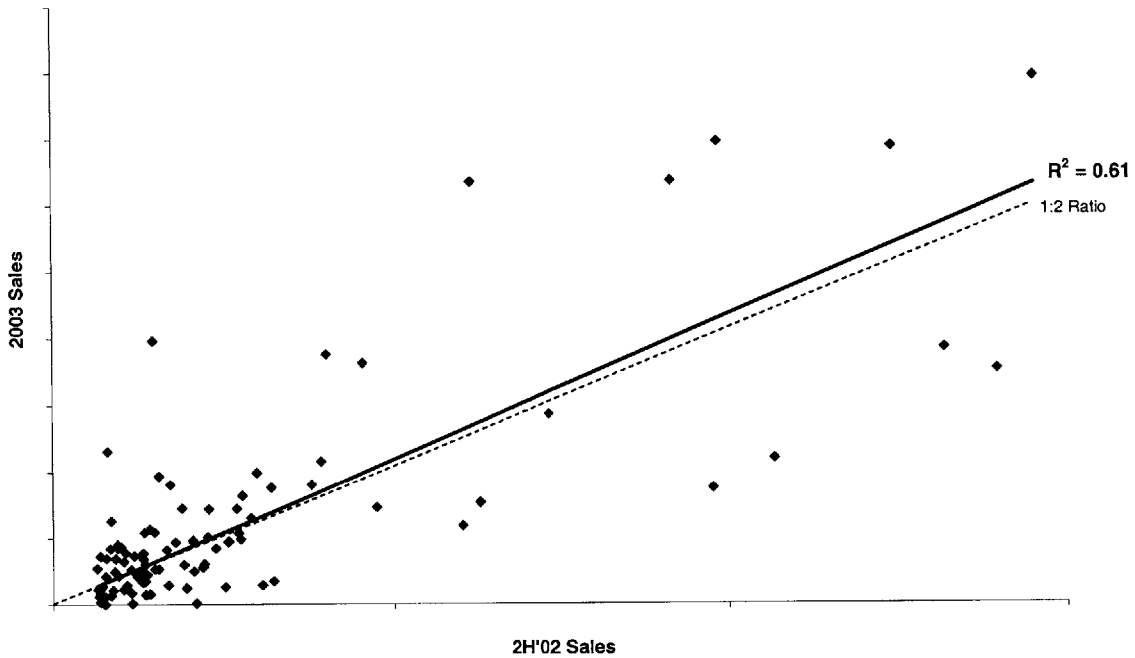


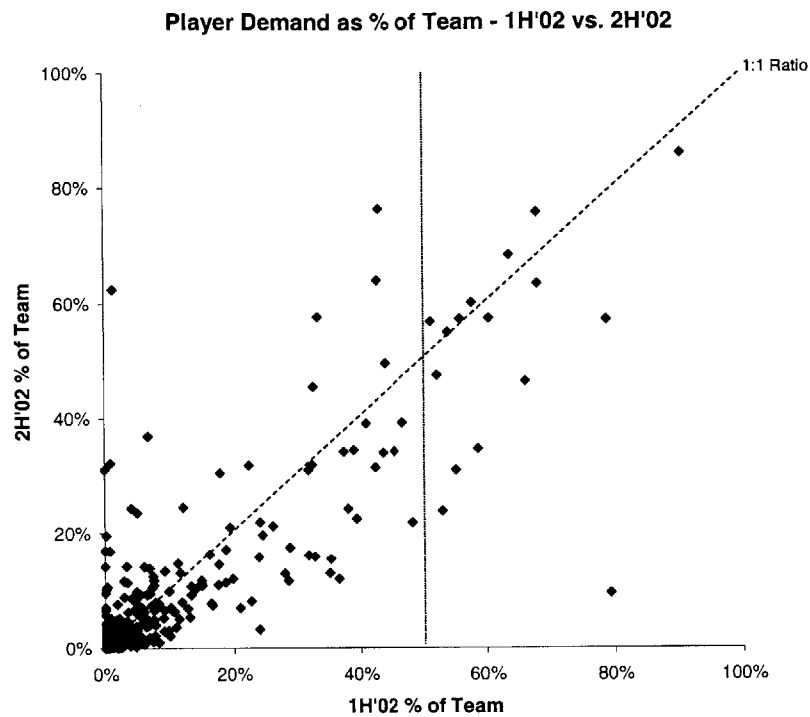
Figure 9

Top 100 Players in 2H'02 vs. 2003 Sales



Once the NFL season begins, retail demand picks up and retailers must respond both to what is selling and what customers are asking for as a result of game performances early in the season. While team performance drives the majority of these sales, customers purchase specific players and will generally opt for the 'hottest' players in the early season. This can lead to some significant shifts in demand between players on the same team. Of the players that had at least a 50% share of their team's preseason volume (right side of Figure 10), none of them significantly increased their share of team sales during the NFL season, while many lost a significant share of their team's volume (i.e., they are near or well below the '1:1 Ratio' line). This demand is often transferred to players that are new to their team and exceed fan expectations. In 2002, several players went from less than 5% of their team's sales in the 1H to more than 25% once the NFL season began.

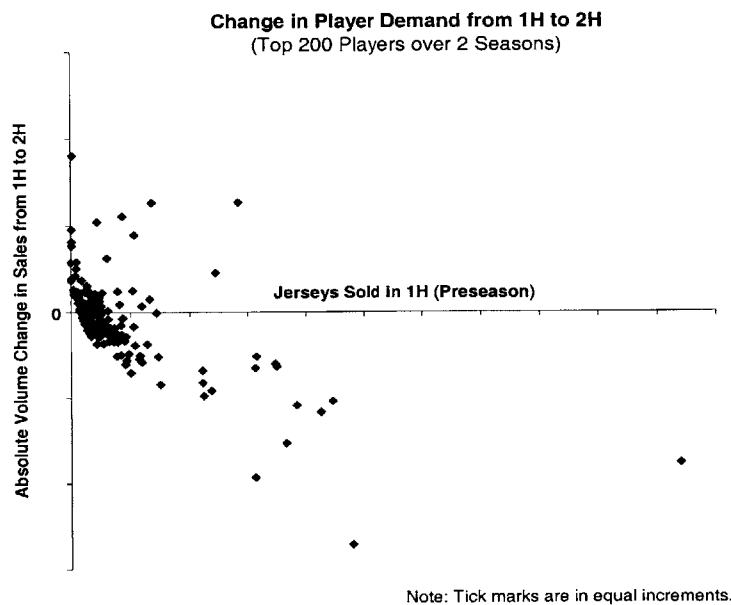
Figure 10



*Best Sellers Disappoint In-Season*

The more (in absolute terms) jerseys of a particular player sold in the preseason, the more likely it is that demand for the player's jersey will experience a significant drop during the NFL season (Figure 11). (Keep in mind, that overall jersey demand is roughly equal in the 1H and 2H of the sales season.)

Figure 11



Potentially the most concerning aspect of the prior chart (Figure 11) is the risk of some players experiencing significant demand after the season begins, even though their historical sales were almost nothing. This belies the importance of Reebok maintaining adequate quick response capabilities (blank jerseys and postponement capacity) to support in-season 'chase' demand. Finally, although adequate forecasts could be developed by correlating sales from one period to the next, we found that pre-orders from retailers best support Reebok's forecasting needs in the March and April buying periods.

#### **IV. Proposed Methodology**

In the end, we found that methods similar to those employed by Fisher and Raman (1996) in their work with Sport Obermeyer yielded the best results (and with minimal forecasting effort). Their method requires a survey-based forecasting approach until early orders from retailers begin to arrive. Fisher and Raman found that these early orders from retailers were a strong indicator of what total annual demand for each product would be. The combination of these approaches allows apparel manufacturers to smooth their production throughout the year, while enabling them to more accurately respond to early demand signals.

##### ***July Forecast***

The July forecast is used to guide the initial procurement of blank jerseys for the NFL season one full year away. With only two seasons of historical data to work with, it is quite challenging to confidently forecast team-level demand for not the upcoming NFL season, but the one after it! The NFL is also known for having the greatest parity among America's professional sports leagues, which only adds to the challenge of predicting the performance of each team and its jersey sales. Using average demand from the previous two seasons as a forecast was considered insufficient because some teams experienced extraordinary events that influenced demand. For example, the Houston Texans joined the NFL in 2002, the Atlanta Falcons changed their jersey style, and some teams made blockbuster acquisitions.

Instead, a panel of experts from sales and procurement will be provided with historical sales data and be asked to provide an expected demand figure for each team in the NFL sales season one-year away. The averages of these predictions create mean forecasts for each team. In order to create the complete forecast distribution for each team, these mean forecasts are then compared to the historical sales volumes to establish the coefficient of variation (CoV) for the forecast. This is slightly different from the approach taken by Fisher and Raman, in that they used the standard deviation among the experts' forecasts to establish the CoV. Since there was no opportunity to calibrate the deviation of the expert forecasts to actual results, we chose an alternative method to calculate CoV for the initial<sup>1</sup> application of this forecasting method.

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<sup>1</sup> Once Reebok has applied this survey-based forecasting approach for one season, it can apply the Fisher & Raman method to calibrate the standard deviation of the expert forecasts with the standard deviation of the actual error in their forecasts. This approach is described in Section IV - Proposed Methodology.

The table below (Table 1) uses random numbers to demonstrate this approach. The initial survey is comprised of the first four columns of information and allows the expert respondents to enter their forecast in the '2005 Fcst' field. Since no-one can predict team performance two seasons away, the respondents' forecasts represent the expected long-term average demand for each team. Once the survey responses are averaged, the percentage error versus prior years' sales is taken (last two columns). The standard deviation of these forecast error percentages becomes the coefficient of variation (CoV), which is multiplied by each team's forecast to calculate their standard deviations. This method works best when team demand does not experience major shifts (e.g., style changes) from year-to-year.

**Table 1**

Team Name	2002	2003	2yr Avg	2005 Fcst Avg	Std. Dev.	02 % Err	03 % Err
Team A	22,000	13,000	17,500	20,000	10,000	-10%	35%
Team B	8,000	4,000	6,000	10,000	5,000	20%	60%
Team C	9,000	26,000	17,500	11,000	5,500	18%	-136%
Team D	47,000	67,000	57,000	50,000	25,000	6%	-34%
Team E	24,000	10,000	17,000	15,000	7,500	-60%	33%
Team F	55,000	37,000	46,000	30,000	15,000	-83%	-23%
Team G	12,000	23,000	17,500	20,000	10,000	40%	-15%
Team H	33,000	80,000	56,500	70,000	35,000	53%	-14%
Team I	33,000	53,000	43,000	65,000	32,500	49%	18%
Team J	174,000	169,000	171,500	125,000	62,500	-39%	-35%
						CoV =>	50%

In practice, low-volume teams and high-volume teams will use separate coefficients of variation due to their different risk profiles. For example, we found that the CoV for high-volume teams (defined by team sales exceeding a set threshold) was only 37%, compared to a 73% CoV for low-volume teams.

As Reebok collects a couple more years of sales data, it may be appropriate to switch from this survey-based method to a simple or weighted average approach to forecasting. However, to avoid the several hundred-million dollar blunder that Nike encountered as a result of strict adherence to statistical forecasts, Reebok should always evaluate statistical forecasts in light of known expectations about the future.

***March 1st Forecast***

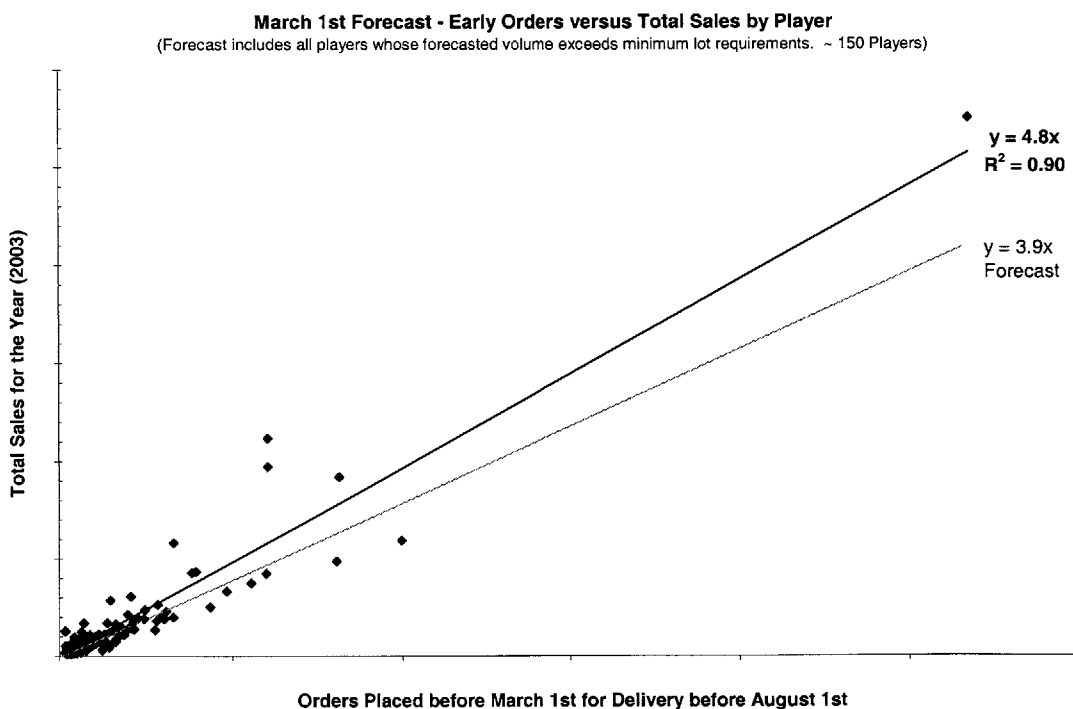
The March 1<sup>st</sup> forecast is used to guide procurement of fully decorated jerseys directly from Reebok's suppliers during the month of March for consumption in the upcoming season. These decisions require both team and player-level forecasts, with the player forecasts focused on the higher volume players that account for more than 80% of total demand. This, however, does not imply that demand for all remaining players will be fulfilled from blank jerseys at Reebok's postponement facility. A fair portion of that demand comes with sufficient order quantities and lead-times such that Reebok can procure-to-order and expedite delivery from their suppliers.

By the end of February, Reebok has received orders for more than one-third of the total jerseys it will ship throughout the upcoming sales season (April through March).

Unfortunately, these orders are ‘soft’ and may be cancelled or undergo changes in product, quantity, and/or delivery date before being shipped. Reebok’s information systems do not support the reporting of such cancellations and changes; they only provide the original order entry date and the final delivery information – nothing in-between. This prevents clear conclusions from being drawn about the validity of early demand signals as a predictor of the entire season’s sales.

After considerable deliberation among Reebok employees familiar with retail order behavior, it was determined that orders shipped to retailers before the NFL regular season begins very rarely undergo changes. (i.e., - Retailers rarely change orders until jerseys begin selling and team performance begins to deviate from expectations. This was confirmed in an interview with a major retailer’s buyer.) To be safe, we only considered orders with shipment dates prior to August 1<sup>st</sup>; just before the NFL Preseason begins. Orders received prior to March 1<sup>st</sup> having delivery dates before August 1<sup>st</sup> have a very strong correlation with sales for the entire year ( $R^2 = .90$ ).

**Figure 12**



In the chart above (Figure 12), we see that the least-squares regression line ( $y = 4.8x$ ) differed significantly from the line that yielded that the lowest absolute error in the forecast ( $y = 3.9x$ ). This will typically be the case due to the under forecasting of demand for players that become over-night superstars once the NFL season begins. The multiple of 3.9 times early orders was chosen as the forecast rule over the formula indicated by the regression for a number of reasons:

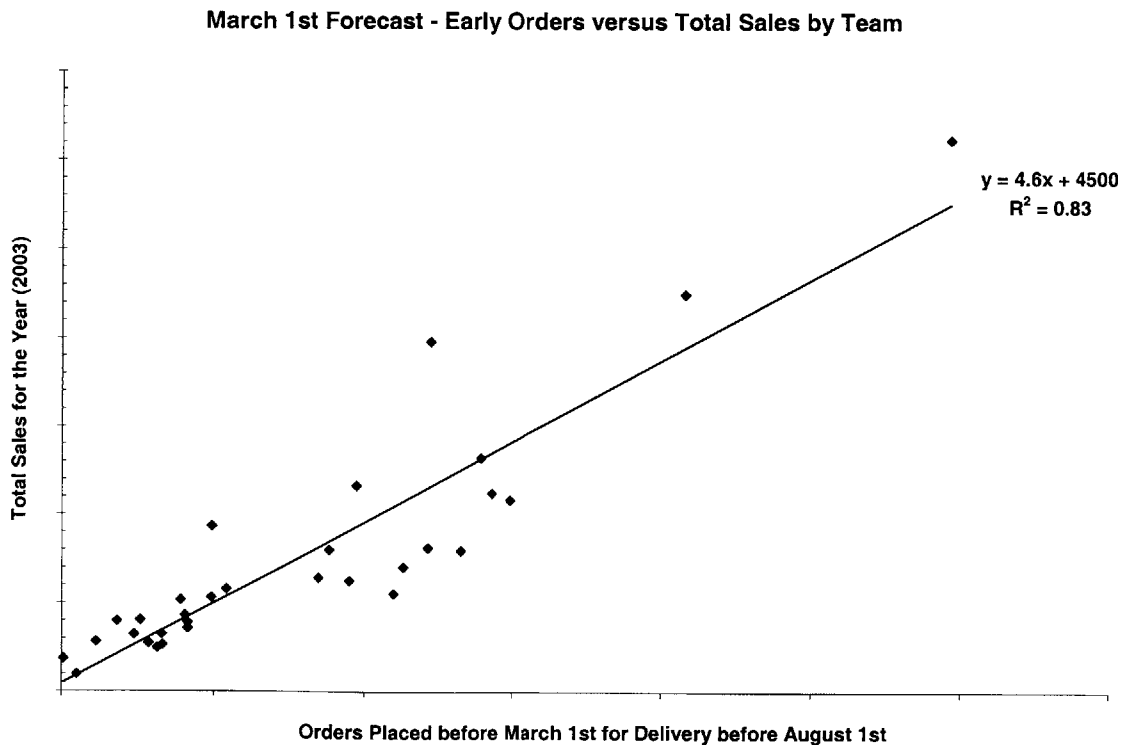
- The regression line’s slope differs significantly from year-to-year, while the chosen forecast slope of 3.9 nearly minimizes absolute error in both years; and,

- Reebok’s business is not penalized exponentially for making larger errors than smaller ones; and,
- Under-forecasting player demand can be compensated for by pulling from blank team jerseys.

One benefit of this forecasting method is that it does not consistently over predict demand for higher-volume players, which was a potential risk, given that demand for these players is biased towards the first-half of the sales season and typically drops off thereafter (refer back to Figure 11). Had we blindly assumed 2H sales would equal 1H sales for all players, as it does for the league as a whole, then we would experience over-forecasting of high-volume players. Instead, the proposed method acknowledges the correlation between 1H and 2H sales, but uses the min-absolute-error slope that reflects the different timing of sales experienced by high and low-volume players.

Team-level forecasts were developed using the same methodology, with one important exception. Rather than attempting to minimize absolute error, we used the least-squares regression line to forecast demand (Figure 13). This mitigates the risk of over procuring decorated jerseys while providing security against stock-outs in the form of additional blanks. The minimum forecast (Y-intercept) of 4500 is necessary because some small market teams have almost no orders placed against them until after the NFL draft in April.

**Figure 13**



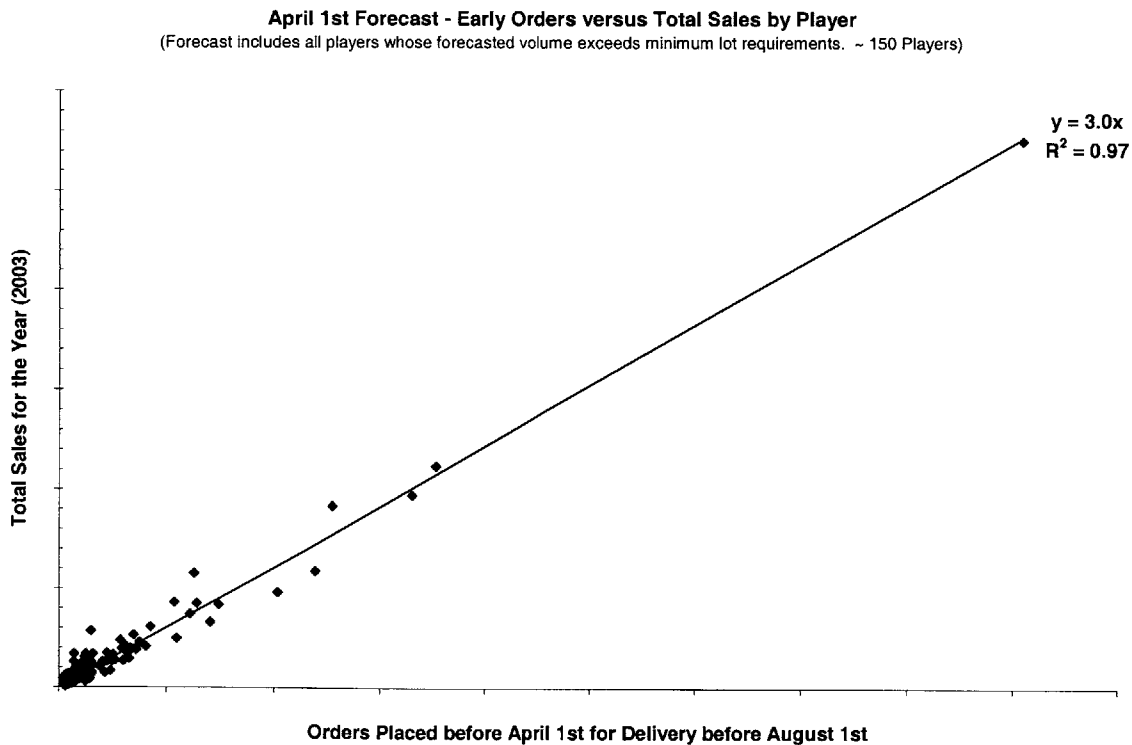
Thus far, we have only discussed a proposed methodology for establishing a mean forecast for each player and team. However, our approach would be incomplete without

a methodology to identify the distribution of potential outcomes around the mean forecasts. This can be achieved by following a method almost identical to the one used in the July Forecast and depicted in Table 1. Fortunately, we had sufficient historical data to analyze the performance of our forecasting methodology in both the 2002 and 2003 sales seasons. Every mean forecast was compared to actual sales to calculate its percentage error. The standard deviation of these percentage errors was then taken to derive a coefficient of variation. Both teams and players were divided into low and high-volume categories, based on the level of early orders, before performing this calculation. In 2003 for example, the high-volume players (accounting for 2/3 of annual volume) had a combined CoV of 37%, while the CoV for low-volume players was a bit higher at 60%.

***April 1st Forecast***

Retail orders continue to arrive throughout March, providing Reebok with greater visibility to the coming season’s demand. Many of these orders reflect retailer responses to late trades and free agency moves that generally occur in March each year. This information can be incorporated into the same forecasting methodology described above to significantly improve Reebok’s overall forecast accuracy.

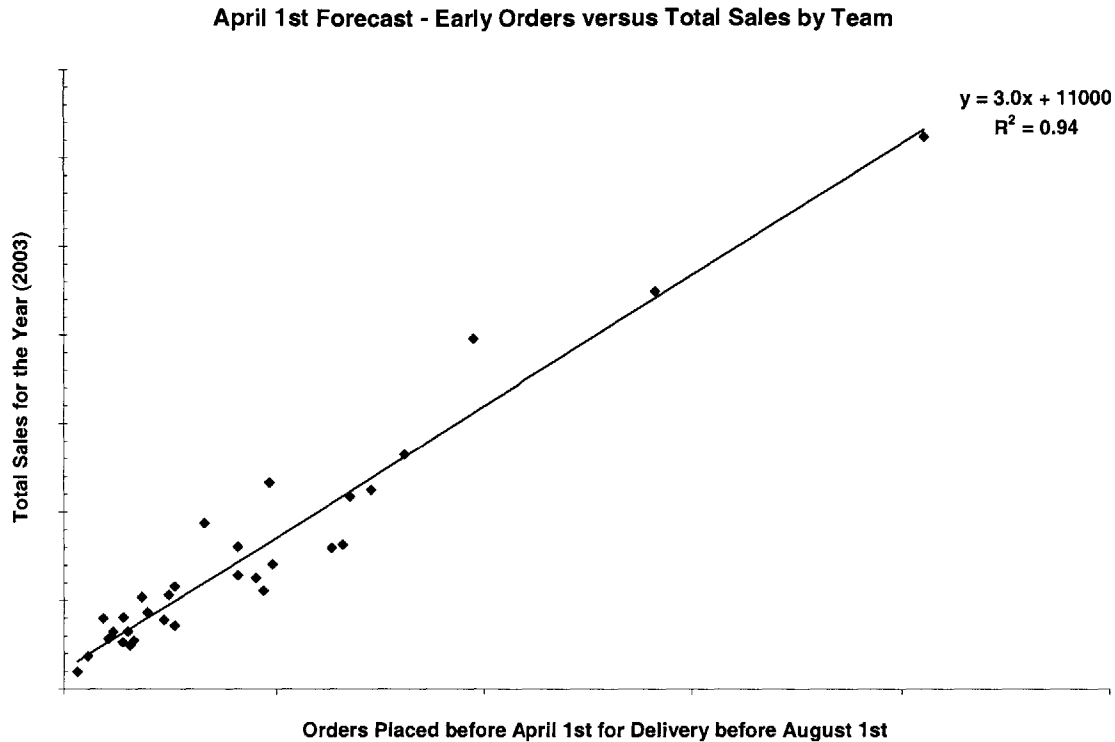
**Figure 14**



In the chart above (Figure 14), we see that the incorporation of retail orders placed in March results in a new  $R^2$  of .97, compared to the prior  $R^2$  of .90. In addition, the regression line has converged to the same slope ( $y = 3.0x$ ) as the line that achieves the minimum absolute forecast error for the time period. This phenomenon holds true for both the 2002 and 2003 NFL sales seasons. Finally, we see even greater improvements

in forecast accuracy at the team-level resulting from the inclusion of March orders (Figure 15).

**Figure 15**



## V. Recommendations for Further Improvements

The use of early season orders as a detailed indicator of product mix and volumes seems to have great promise for use as a forecasting approach. Unfortunately, Reebok's current information systems provide little historical information about when orders may have changed or been cancelled prior to shipment. It is for this reason that we could not use orders scheduled for delivery after August begins as an input to our forecasts. In addition, the accuracy of our forecasts may be optimistic if Reebok finds that retailers do make significant order changes or cancellations prior to August. (e.g., Offering price discounts to retailers that order early, without holding them to those orders, could lead to overbuying followed by late cancellations.) As an interim solution, it is recommended that a snapshot of all future orders be taken at the end of each month and checked for consistency. Longer term, Reebok should consider capturing additional order information – such as the last date that the specific product and quantity of an order line item were modified - to better understand customer behavior and improve forecast accuracy.

Once Reebok uses the survey-based forecasting process for the July Forecast and collects actual demand data for its forecasting horizon, then it may employ the Fisher & Raman method for establishing forecast distributions. Under this method, the standard deviation

of each team's forecast is the sample standard deviation of the experts' forecasts for the team multiplied by a scale factor  $\theta$ . The scale factor  $\theta$  is chosen to equate the average predicted standard deviation for the next season to the sample standard deviation of the previous season's observation of forecast errors (see Table 2). Once again, low and high-volume teams should be evaluated separately.

**Table 2**

<b>Team Name</b>	<b>Std Dev of Fcsts for 2005</b>	<b>July 2003 Avg Fcst for 2005</b>	<b>Actual Demand in 2005</b>	<b>Error in July 2003 Forecast</b>
<b>Team A</b>	2,000	10,000	9,000	1,000
<b>Team B</b>	8,000	30,000	40,000	(10,000)
<b>Team C</b>	5,000	20,000	15,000	5,000
<b>Team D</b>	15,000	65,000	95,000	(30,000)
<b>Team E</b>	20,000	150,000	125,000	25,000
<b>Avg Std Dev =&gt;</b>	<b>10,000</b>	<b>Std Dev of Error =&gt;</b>	<b>20,216</b>	

$$\theta = 20,216 / 10,000 = 2.02$$

In working with Reebok there were a number of examples where forecasts-by-committee were determined by debate. In these cases, dominant personalities clearly biased the forecasts chosen. It is recommended that Reebok adopt a blind survey or Delphi<sup>2</sup> method for forecasting in such situations. This should improve forecast accuracy, help quantify the uncertainty in the forecast, and give less dominant personalities the opportunity to have their opinions heard. Next year, Reebok should be able to use Fisher and Raman's method for determining an appropriate scale factor to equate the standard deviation of panelist forecasts to the actual variance of demand relative to those forecasts. In the case of the July Forecast, this means that the panelist forecasts alone (without comparison to historical sales) should be sufficient to determine the appropriate coefficient of variation used to create the forecast distribution.

Reebok may also improve its forecasting (and responsiveness) abilities by creating closer relationships (i.e., Collaborative Planning Forecasting & Replenishment) with some of its key customers. For example, a quarterly meeting between Reebok's planning personnel and a few key retail buyers may help both parties proactively identify key risks and opportunities throughout the sales season. One of Reebok's important customers suggested that it is willing to share its point-of-sale (POS) data in exchange for insights into Reebok's overall mix of jersey sales by player.

Besides improving its forecasting and planning capabilities, there are a few other opportunities for Reebok to improve the performance of its NFL Replica Jersey business. It seems reasonable to offer jerseys of low volume players in just a single color. This may also help Reebok achieve the economies of scale that result from procuring decorated jerseys directly from their suppliers. Finally, perhaps the single greatest

<sup>2</sup> For an introduction to the Delphi method, see: <http://www.iit.edu/~it/delphi.html>  
A more thorough treatment of Delphi can be found at: <http://www.is.njit.edu/pubs/delphibook/>

opportunity for Reebok is to improve its ability to respond to shifts in demand through shorter lead-times. One suggestion is to offer more business to fewer suppliers in exchange for shorter lead-times and fewer off-season orders. It is recommended that a study be undertaken to value the potential increased sales and lower obsolescence costs that would result from improved responsiveness.

## References

Fisher, M., A. Raman. 1996. Reducing the cost of demand uncertainty through accurate response to early sales. *Operations Research* 44(1) 87-99