Inventory Optimization Model for NIKE's Long Lifecycle Highly Seasonal Replenishment Products

by

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Abstract

Currently, demand and inventory planners at NIKE Always Available (NIKE's replenishment business) experience difficulty in managing long-lifecycle highly-seasonal products like soccer equipment and fleece apparel. Very often items are either stocked out at retailers or piling up at Distribution Centers (DCs). NIKE manages inventory to a 95% item fill rate for all replenishment products. Highly seasonal products generally have unpredictable demand patterns which lead to either stock outs or excess inventory. These imbalances in inventory occur without fully understanding the cost and benefit of holding the inventory.

To understand the cost and benefit of holding inventory for long lifecycle highly seasonal products, the author analyzed the current profitability, revenue, service level, and inventory position of soccer equipment, sandals, and fleece apparel. From these results, the author modeled the benefits to the above metrics of managing inventory via a dynamic service level approach that varies the service level over the season. Next, the author modeled the benefits of managing inventory via dual-sourcing. Lastly, the author modeled the profitability impact of reducing lead times for these items.

These models have shown that long lead times and high seasonality are key drivers of large safety stock quantities. Also, with highly seasonal long lead time products, dynamically managing the service level by increasing the service level at the beginning of a product's life and lowering it in its last season of life offers greater profitability than managing to a static service level. Lastly, there is an opportunity to increase the profitability of these products by changing the supply chain to enable dual-sourcing or by reducing lead times.

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This thesis is dedicated to my wife, Susan Kang, and my two sons, Isaac and Jonah, for supporting me in this LGO journey. From numerous cross-country moves to learning new areas of the country, my family has joyfully embraced the challenges of the LGO program.

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Note on Proprietary Information

In order to protect proprietary NIKE information, the data presented throughout this thesis has been altered and does not represent actual values used by NIKE. Any dollar values, product names or logistic network data has been disguised, altered, or converted to percentages in order to protect competitive information.

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List of Abbreviations and Definitions

FOB	Freight on Board
LGO	Leaders for Global Operations, a MIT dual-degree program focused on operations
Tableau	Data Visualization Software
AA	Always Available
DP	Demand Planner
DC	Distribution Center
DTC	Direct to consumer
COTS	Commercial Off-The-Shelf
PO	Purchase order
NA	North America
NFS	NIKE Factory Stores
SKU	Stock Keeping Unit
Season	Spring, Summer, Fall, and Winter seasons make up a year
FGI	Finished Goods Inventory
CM	Contract Manufacturer
POS	Point-of-sale
IFR	Item Fill Rate
COE	Center of Excellence
IT	Information Technology
USD	US Dollars
WIP	Work in Progress
POS	Point of sale
P&L	Profit and loss

1 Introduction

The research for this project was conducted during an LGO internship at NIKE. The objective of the project was to increase the profitability of highly seasonal long lifecycle products by using the appropriate inventory strategies that correspond with the characteristics of the various products on replenishment at NIKE.

1.1 NIKE, Inc. summary

NIKE, Inc., incorporated in 1968 under the laws of the State of Oregon, designs, develops, markets, and sells athletic footwear, apparel, equipment, accessories, and services. NIKE is the largest seller of athletic footwear and athletic apparel in the world.[1] NIKE's corporate headquarters are located in Beaverton, Oregon, but NIKE's products are sold throughout the world through NIKE-owned stores (through NIKE's Direct to Consumer business) and via third party retailers and independent distributors.

In fiscal year 2014 NIKE's revenues were approximately $28 billion USD which was a growth of approximately 10% from fiscal year 2013 (approximately $25 billion USD). This growth necessitates an effective supply chain function as NIKE relies on contract manufacturers for the manufacturing of most of its products. In 2014 NIKE was supplied by approximately 150 footwear factories located across 14 different countries and approximately 430 apparel factories in 41 different countries.[2] Contract Manufacturers (CMs) in Vietnam, China, and Indonesia manufactured approximately 43%, 28%, and 25% of NIKE's footwear. CMs in China, Vietnam, Thailand, Indonesia, Sri Lanka, Pakistan, and Malaysia supplied most of the apparel marketed and sold through NIKE. Footwear and apparel production is sourced in Asia due to the low labor factor costs in this area of the world and the expertise of CMs in this area of the world in manufacturing footwear and apparel products.

1.2 Organizational Assessment (Three Lens Analysis)

NIKE's replenishment business, Always Available, is a small but growing portion of NIKE's revenues. NIKE has to bear the inventory risk of unsold inventory in this business and is still learning how to optimize the management of safety stock amongst its products to reduce the risk of stock outs and excess inventory. This project takes a look at a portion of this problem, seasonal products, which require not only a technical approach but also an understanding of the NIKE organization. The below three sub-sections will detail the author's perspective on NIKE's unique organizational structure and how it impacts this project. The author will use the Three Lens Analysis, pioneered at MIT Sloan, to understand NIKE's organization.[1] The three lenses looks at an organization from the strategic, political, and cultural points of view. The two most relevant lenses for this thesis are the strategic and cultural lenses. The strategic lens is used to understand how an organization has been designed to achieve its goals to carry out tasks. The cultural lens is used to understand how an organization assigns meaning to the symbols and history of the organization.

[1] NIKE, Inc. SEC Form 10-K Filing, May 31st, 2014
[2] Ibid.

1.2.1 Strategic Design Analysis

Three of the five key components of the Always Available 2015-2017 (Fiscal Year) strategic plan that are most relevant for this analysis are: growth accelerated (profitability), response reliable, and supply flexible. This project fit into helping achieve three out of the five key initiatives for some of the most troublesome products for Always Available. Highly seasonal long lifecycle products similar to fleece, sandals, and soccer equipment are difficult to manage because they do not sell at a predictable cadence, thus the products are either stocked out or stacked up in the distribution centers which eventually lead to the company writing off products.

NIKE's matrix organization presents unique challenges because the organizations that the author influenced sat at the intersection of different aspects of the matrix. It is difficult in this type of organizational structure to determine who 'owns' a particular process. For instance, when trying to determine the price that value chain partners pay for off-season soccer shin guards, the author met with a Demand Planner (support function) for Soccer Equipment (product engine) in North America (Geography). This Demand Planner referred the author to a NIKE employee in Merchandising. This employee could not answer the question, so the author was finally referred to someone in closeout sales for North America.

NIKE is cut into geographies, product engines, categories, and support functions. Most employees fit into the intersection of two or more of these aspects of the NIKE matrix. The geographies individually sell, ship, forecast, and provide customer service to their regions. Product engines are responsible for production planning of their respective products. Categories design and launch products. Lastly, support functions support the entire organization.

The Global Always Available business directs this project, which operates differently than the larger NIKE business, but the NIKE supervisor for this project resided in the Safety Stock Center of Excellence, which spans outside of Always Available. This means that this project was focused on solving a problem for Always Available products, but that the findings had to be applicable for non-Always Available products. The matrix slows down communication and decision-making because of the number of people impacted by this project. This necessitated frequent small group meetings to ensure that the author received the proper buy-in for this project. The matrix is helpful in that it allows messages to spread rapidly throughout the organization because of both the formal and informal reporting structures. Once the management team supporting this project bought into the results, this buy-in rapidly propagated to the rest of the organization.

1.2.2 Cultural Analysis

Stories, artifacts, and symbols tie the employees to NIKE's consumers. NIKE's mission is "To bring inspiration and innovation to every athlete in the world; if you have a body you are an athlete." One example of the strong sense of culture is that NIKE's museum has the original waffle iron that Bill Bowerman used to prototype the first NIKE shoe soles. The culture of sport and athleticism seeps into every NIKE employee through many avenues. Many employees exercise during the day at NIKE and most employees wear NIKE products to work every day. This project's focus on serving the customer reliably resonates with the cultural aspect of serving the consumer.

Two product symbols inform the history of this project: fleece apparel and soccer shin guards. NIKE has had both stock outs and excess inventory for both of the before mentioned products.

NIKE has had to air-freight (NIKE prefers to ocean-ship) and write-off large amounts of product due to the seasonality of these products. The inventory, demand, and supply planners all hope that this project will fix the frustration of either stock outs or excess inventory for these products. Also, a previous LGO author investigated the possibility of multi-echelon inventory management of fleece apparel that has a lead time greater than the peak selling season within a year. This project found that inventory holding costs could be substantially reduced by decreasing the lead time for these products.[2] Fleece in particular is of particular concern to this analysis because it is representative of other seasonal products the author studied.

1.2.3 Organizational Assessment Summary

NIKE's customers value the Always Available business because it reduces their inventory risk and increases the profitability of NIKE products they carry (by reducing the incidence of stock outs and excess inventory). NIKE values this business because it serves to increase their market share by ensuring their products are on the shelves in the right size, style, and color that their end consumers want. This project demonstrates value to the different layers of NIKE's matrix (geographies, product engines, and categories) by seeking to improve the profitability of these products while ensuring the products are on the shelf when consumers want the products. Also, it supports NIKE's culture of sport and support to their athletes by helping to ensure the right product is on the shelf when NIKE's consumer/athlete needs it.

1.3 Problem Statement and Motivation

NIKE operates a replenishment business (called Always Available) in order to increase margins, decrease the number of products offered at discount to customers, and as a competitive move (competitors offer replenishment for some of their products so NIKE must do so to ensure their products are on the shelf alongside their competitor products). A customer is defined as a retail channel (like a Dick's or Footlocker) and a consumer is the person who purchases the product from one of NIKE's customers. The Always Available (AA) business, NIKE's replenishment business, provides retailers the option of ordering products weekly from NIKE with a one week Purchase order (PO) to delivery in North America (NA). Customer demand is fulfilled from an on-hand inventory position which is built up using a forecast-driven make-to-stock supply chain. NIKE's target replenishment to its customers is one week from order receipt to delivery. Most of NIKE's products are produced off-shore, thus the company takes an inventory position with its products in a distribution center (DC) to enable a one-week replenishment lead time because NIKE's front end replenishment lead time is at least two months or longer. The target item fill rate is 95% for NIKE's customers. This means that on average only 5 units of product is ever unable to be promised to be delivered to a customer. For instance, during any given month for any given product, Nike would like to be able to fulfill all customer replenishment order quantities 95% of the time. So, for example, if Nike's customer's on replenishment order 100 units of a given product during a given time period, Nike would like to be able to fulfill 95 or more units of product that was placed on order.

NIKE's SKU's, called style-colors at NIKE, that are offered to customers through Always Available have target minimum volumes per season, 10,000, and a minimum lifecycle duration, 18 months (so not all products NIKE sells are available for order on replenishment through AA). In addition, these products should be considered an essential product that needs to be available for NIKE's customers. Generally, Always Available products conform to these characteristics, but if NIKE is using a product for strategic reasons (defined as blocking a competitor, serving a

strategic account, or serving a strategic market) then the above concerns do not have to be met. NIKE's target item fill rate is generally 95% for products offered on the Always Available business. Determining this fill rate was out of scope for this project and was used as a given target for this project.

Subsets of products, highly seasonal products, are put onto the Always Available product portfolio due to strategic purposes. NIKE defines highly seasonal products as products that have a large percentage (over 40% of sales for a year within one three month period) of sales within a concentrated time period. These products are difficult to plan and generally lead to three negative consequences for NIKE and NIKE's customers:

1. The target item fill rate of 95% is difficult to achieve for seasonal products due to inaccurate forecasts.
2. On-hand inventory levels are high due to the inaccurate forecasts, leading to decreased profit margins due to closeouts where NIKE discounts products during seasonal closeouts.
3. Stock outs occur regularly due to inaccurate forecasts, which lead to reduced service levels and reduced confidence from customers in the ability of Always Available to fulfill their orders. NIKE believes that this weakened confidence in NIKE's ability to deliver products from its customers can drive erratic buying behavior as customers order more product than they need to as a hedge against stock outs.

In summary, seasonal products are difficult to plan for the Always Available business. This thesis addresses different methods for improving the profitability of seasonal products on the Always Available business. These seasonal products must be long lifecycle, meaning that they must be on the Always Available product line for at least a year, to be included in this analysis. To improve the profitability of these products, NIKE must reduce the percentage of finished goods inventory that is stocked out (stock outs) when a customer orders and the percentage of finished goods inventory that is held by NIKE at the end of a product's life (excess).

1.4 Project Goals

The primary goal of the project was to increase the profitability of highly seasonal products on the Always Available business product line. This increase in profit corresponded with lower levels of closeouts and stock outs for these products. The scope of this project was limited to the inventory strategy of these products, thus different inventory strategies were used to increase the profitability of highly seasonal products. This means that the author did not investigate other strategies to increase these products like obtaining point of sale (POS) data to improve forecast accuracy or finding new suppliers with shorter lead times.

1.5 Approach

The three phases of work the author conducted to scope, analyze, and recommend solutions for this project are: Current State Analysis, Inventory Modeling, and Implementation of the results of the Model.

The Current State Analysis phase consisted of understanding the systems, processes, and data used by NIKE to plan, purchase, store, and distribute long lifecycle highly seasonal products

from the Always Available business. This included analyzing the profitability of long lifecycle highly seasonal products. The Current State Analysis focused on three different product families: sandals, soccer shin-guards, and fleece apparel. These three product families were chosen because they were representative of seasonal products on Always Available.

The Inventory Modeling phase involved modeling various inventory buy policies. The first policy is the current method of buying inventory to target a 95% item fill rate. The second is a new method of buying inventory to maximize profitability via a dynamic service level approach. This service level depends on balancing the costs of shortage vs. overage of finished goods inventory. The third method involved buying inventory to target a 95% item fill rate and with the added complexity of introducing a second source of product with shorter lead times but higher costs. The fourth method involved decreasing the lead times of the original source to develop an understanding of the potential profitability increase of reducing lead times for these products. These four models were simulated using actual demand and compared to the historic inventory performance. The simulations were given as inputs the product forecasts with the standard deviation of product forecast errors; the simulations then used these inputs to vary the demand faced by these products, to compare the performance of these models versus the current method of buying inventory to target a 95% item fill rate.

Finally, the Implementation of the Model phase focused on integrating this new inventory buy policy into the Always Available business. This included potential strategies for integration into NIKE's planning systems and recommendations for next steps for the Always Available business and for the larger NIKE business. The three key recommendations range in difficulty of implementation from easy and fast, for modifying how safety stock is planned, to difficult and slow, for dual sourcing and reducing lead times.

The scope of this project focused primarily on the North American geography for Always Available. The three product families that were studied were soccer shin-guards, fleece apparel, and sandals. These product families were selected due to how representative they were of the seasonal products on the Always Available product line. However, the model was built with the intention of expanding beyond North America and Always Available products to other long lifecycle highly seasonal products. The models used for this analysis were built and validated using calendar year 2013 data for demand, costs, and lead times. Calendar year 2012 data was used to understand the calendar year 2013 data, but the analysis was primarily conducted using 2013 data.

1.6 Thesis Overview

This document is divided into 7 chapters. Chapter 2 provides a description of the Always Available supply chain. Chapter 3 reviews relevant academic literature and analytical tools utilized during this project. Chapter 4 describes the methodology of how data was collected and analyzed. Chapter 5 details the models used to increase the inventory profitability of seasonal products. Chapter 6 outlines the implementation strategy from the results of the inventory modeling. Chapter 7 provides recommendations and conclusions for NIKE.

2 Supply Chain Operations at NIKE

2.1 Background of the Company

NIKE is organized into a three-dimensional matrix. The first layer is the geographies. Managers in the geographies have profit and loss (P&L) responsibilities and oversee all functions in a region, including supply chain and distribution operations. The second layer is the product engines; footwear, apparel, and equipment. These three organizations are responsible for product design and creation, material sourcing, and finished goods manufacturing. The last layer is the categories. This layer aligns product design, creation, and marketing within a consumer segment (like running, men's training, women's training, etc.).

NIKE's organizational structure impacts supply chain operations. Most decisions in the supply chain affect multiple layers. For example, if apparel (product engine) wants to establish an additional near-shore factory, the category will be concerned that the products from this new factory may not meet the quality standards of the category's consumers.

2.2 The Always Available Business within the context of NIKE's business models

The bulk of NIKE's revenue comes from the Futures business model. The Futures business model is a make-to-order business model. NIKE receives orders from retailers four to six months prior to delivery and constitutes the bulk of NIKE's revenue. Most of the inventory risk is pushed to the retailer as the retailer must accurately forecast product demand. One implication is that often retailers have stock outs of NIKE products or excess products at the end of the last major selling season for that product. Stock outs or excess products hurt NIKE and the retailer, thus NIKE started the Always Available replenishment business model to mitigate these two negative effects of the Futures business model.

NIKE developed the Always Available business to ensure consumers have the product they want in their desired color/size when/where they shop. The Always Available business is one form of fulfilling customer demand within NIKE and is also a supply chain model for NIKE. The products on Always Available should be 'category essential" meaning that they are foundational products to a category which are easily substitutable with a competitor's product. For category essential products on Always Available, retailers can place weekly orders to NIKE that are fulfilled from an on-hand inventory position in a DC. These products ideally have low seasonality of demand because Always Available products should be foundational for consumers. This means that consumers should be purchasing these products year round on a consistent basis.

This replenishment business model is attractive to NIKE's customers because most of the inventory risk of carrying excess finished goods inventory is borne by NIKE. Customers can hold smaller levels of inventory of these products, which reduces the risk of markdowns and closeouts. This leads to higher profit margins for customers. Also, competitors of NIKE sell their products to customers using the replenishment model, thus the Always Available business model

is a key competitive move to ensure NIKE stays forefront on the shelves of its customers. The Always Available business represents approximately 8-10% of NIKE's total revenue[3].[3]

2.3 NIKE's Supply Chain

NIKE's supply chain is generally trifurcated along the three different product engines (footwear, apparel, and equipment) but a single model can illustrate the generalities of all three different supply chains. Figure 1 provides a general overview of NIKE's supply chain and who owns the process and inventory for both NIKE and its retail customers.[3]

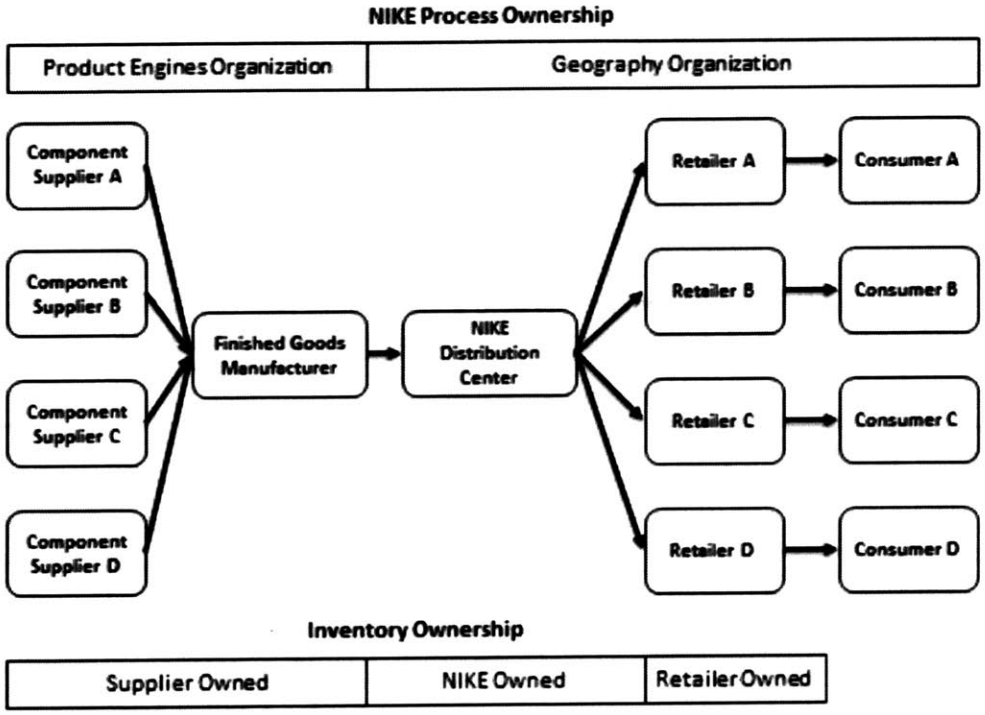

Figure 1: NIKE Supply Chain Structure [3]

There are five layers in the supply chain: supplier, contract manufacturer, distribution center, retailer, and end consumer. Some NIKE products skip the DC or retailer, but most of NIKE's products follow this structure. In the Futures business, four to six months from PO to delivery is standard for this entire process.

Two different organizations are responsible for the bulk of the supply chain operations. The first is the product engines which are responsible for sourcing raw materials and handing them over to contract manufacturers to manufacture finished goods. Once a CM has created a finished good, the CM generally ensures it is delivered to a 3rd party freight consolidator in the CM origin country for shipping. Once delivered to the consolidator the supply chain organization within the geography takes on the ownership of the product through delivery to the end retailer.

[3] From Section 2.1.2 of the MIT LGO thesis by Benjamin Polak, *Multi-Echelon Inventory Strategies for a Retail Replenishment Business Model*, 2014

NIKE takes financial ownership of products once finished goods inventory are manufactured and sent to the consolidator. NIKE takes on ownership of raw materials and work in progress (WIP) if these materials are not used up within a contract specified amount of time. This may happen if demand drops off and NIKE reduces or cancels orders with the CM. This is important because even though RM and WIP inventory does not appear on NIKE's financial books immediately, it will eventually if NIKE over forecasts and cancels orders with CMs.

2.4 Always Available Supply Chain

From Section 2.2, NIKE developed the Always Available business model to ensure core products are available to end consumers in their size, style, and color whenever they shop. To ensure products are available, NIKE replenishes retailers from an on-hand inventory position in a DC. Retailers can place orders throughout the selling season and NIKE targets a one week replenishment lead time to retailers.

The Always Available business uses the same physical supply chain as the rest of the NIKE business. The key difference is shown in Figure 2, namely that inventory is planned to be held in the supply chain. Component material (raw materials) is staged at the finished goods factory (see red triangle). The finished goods inventory position is held at the factory (see first blue triangle). The last inventory node is the finished goods held at DCs (see second blue triangle). [3]

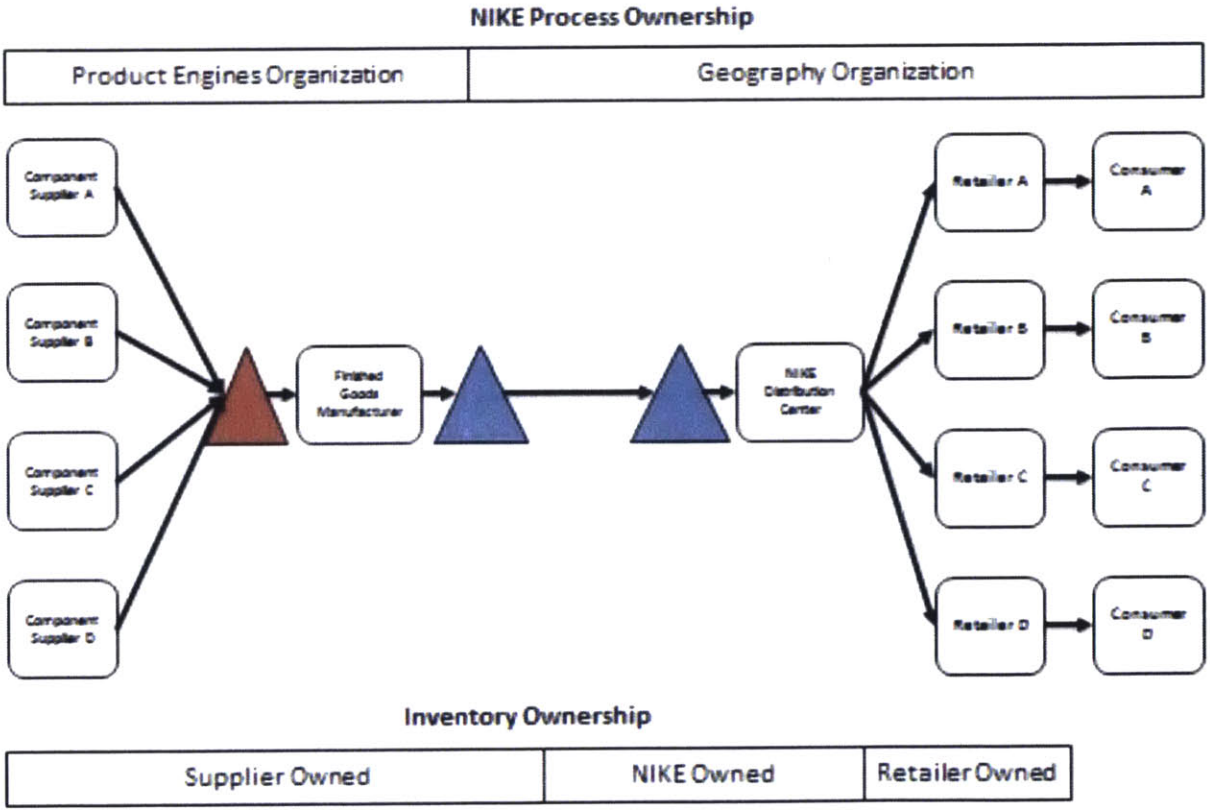

Figure 2: NIKE Always Available Supply Chain Macro-level Structure [3]

2.5 Seasonal Products on Always Available

NIKE places seasonal products on the Always Available line to help their customers, by bearing the risk of excess finished goods inventory, and to ensure that their products are on shelves (and not stocked out in either colors or sizes) versus their competitors. Seasonal products do not conform to the typical product characteristics of Always Available products (essential product that needs to always be available) because of their seasonality. These items are generally hard to forecast due to the seasonality of sales, long lead times, and churn of new products.

2.6 How Always Available Products are planned

Always Available products are planned by Demand Planners (DPs) at NIKE using commercial off the shelf (COTS) software. DPs use their own judgment to match new products to style-colors (SKUs) which are similar to the new products. These matches enable the DPs to start planning from a baseline which enables them to understand how the new product will behave in the market. The COTS software, called Logility Voyager, uses a modified Holt-Winters formula [4] to forecast demand using level, trend, and seasonality factors in its algorithms. In addition, Logility generally targets a safety stock quantity corresponding with a 95% Item Fill Rate (IFR) using the forecast error of the product.

The output of the DPs work is a forecast which inventory and supply planners use to negotiate capacity at contract manufacturers (CMs) and to build up inventory of finished goods at their distribution centers (DCs). Occasionally, planners may need to pre-build finished goods due to capacity concerns which ensure that product is available for NIKE's customers when ordered.

3 Literature Review

3.1 Introduction

This project dealt primarily with inventory policies and models to increase the profitability of NIKE's seasonal products. The purpose of this literature review is to outline the various inventory topics that are pertinent to increasing the profitability of NIKE's seasonal products that are on replenishment (on NIKE's Always Available business). The three methods of improving the inventory profitability of made to stock forecast driven products are modifying safety stock levels, dual-sourcing, and reducing lead times (not mutually exclusive). This literature review will also cover how style goods are managed and how forecasts are generated and used.

3.2 Modifying Safety Stock levels

The author relied heavily on Silver, Pike, and Peterson's definitive textbook on Inventory Management, *Inventory Management and Production Planning and Scheduling,* to understand how to analyze safety stock for NIKE's replenishment business.[5] Always Available hedges against demand actualizing higher than forecast by carrying safety stock. This is due to the long lead times that NIKE faces in replenishing the North America DC (in Memphis) versus the one week lead time that NIKE promises to its customers. Safety stock is generally calculated via the below equation:

$$Safety\ Stock = k * \sigma_L$$

Equation 1: Safety Stock

k is the safety factor and σ_L is the standard deviation of demand during the lead time. If we assume normality in forecast error, then k can be set for a given IFR using the unit normal loss function *G[k]*

$$G[k] = \frac{E[D_{LeadTime}]}{\sigma_L} * (1 - IFR)$$

Equation 2: Normal loss function

$E[D_{LeadTime}]$ is the forecasted demand during the lead time and *IFR* is the target item fill rate. The item fill rate generally means that if an order for 100 shoes is placed then there will be at least 95 shoes in stock at that time. Generally in Always Available most products are targeted to a 95% IFR. The standard deviation of demand over lead time is (assuming demand and lead time are independent random variables)[5]

$$\sigma_L = \sqrt{E(L)(\sigma_D)^2 + (E(D_{LeadTime}))^2 {\sigma_{LeadTime}}^2}$$

Equation 3: Standard Deviation of demand over lead time

E(L) is the mean lead time

σ_D is the root mean square error (RMSE) of the forecasted demand over expected lead time

$E(D_{LeadTime})$ is the expected demand during lead time

$\sigma_{LeadTime}$ is the standard deviation of lead time

The required inputs for safety stock are the demand forecast, RMSE of the demand forecast, lead time, standard deviation of lead time, and target item fill rate.

3.3 Style Goods inventory management

To think through how to manage style goods, which most of NIKE's products are, the author turned again to *Inventory Management and Production Planning and Scheduling.*[5] The text recommends using the framework of the Newsvendor formula to think through Always Available products because they are style goods which means that there is considerable uncertainty about demand. In the simplest case inventory cannot be carried over after one season[5]. This simplification is helpful to keep in mind when applied to Always Available where NIKE can order goods every week, thus making this a multi-period problem. The style goods problem has a few features[5]:

1. Short selling season (less than four months) with a defined beginning and end.
2. The buyer (which is NIKE in this case) must commit to how much of each SKU to stock prior to the selling season.
3. There may be one or more opportunities for replenishment after the initial order is placed.
4. Forecasts prior to the season include considerable uncertainty.
5. When total demand in a season exceeds the stock, there are associated underage costs.
6. When total demand in a season turns out to be less than the stock, there are associated overage costs. The salvage value of leftover inventory is generally quite low.

7. Style goods products are often substitutable.
8. Sales of style goods are usually influenced by promotional activities and space allocation in the store.

To determine the appropriate order quantity you should use the below formula to balance the cost of too much (overage) and too little (underage) stock[5]

$$p_{x<}(Q^*) = \frac{c_u}{c_u + c_o}$$

Equation 4: Critical Ratio

$p_{x<}(Q^*)$ is the probability that the total demand x is less than the value Q*

c_u is the underage cost, associated with demand that cannot be met. Generally Wholesale Price – Landed Cost.

c_o is the overage cost, associated with each unit not sold. Generally Landed Cost – Salvage Price. Salvage price is the price you can receive for excess products you do not sell through normal channels.

This analysis of underage and overage costs helps provide a framework for deciding how much inventory to stock for seasonal products on AA because these are style goods. To further analyze AA seasonal products we assume normally distributed demand. If we assume normality we can use the two equations below to calculate the order up to level, including safety stock, for a single period model

$$Q = \hat{x} + k * \sigma_L$$

Equation 5: Order up to level including forecast and safety stock

Q is the quantity to stock or purchase

$\hat{x}$ is the mean of the normally distributed demand (generally the forecast for that period)

$\sigma_L$is the standard deviation of demand over the period

k is determined using the $p_{x<}(Q^*)$ and the normal distribution table

3.4 Forecasting

In this paper we assume demand is stochastic, independent, identically distributed, and drawn from a normal distribution. Demand then takes on a mean demand and a standard deviation of demand. This stochastic demand leads companies, like NIKE, to forecast using various methods to mitigate for the uncertainty in demand. This thesis uses the results of forecasts and their respective accuracies to improve the inventory performance of NIKE's seasonal replenishment products. One paper assesses the advantages and disadvantages of using various forecast accuracy measurements and recommends using mean absolute scaled error as the standard measure for comparing forecast accuracy across multiple time series [6]. Another recent paper highlights the popularity and importance of the mean absolute percent error (MAPE) metric of forecast accuracy.[7] MAPE is scale independent so you can compare forecast accuracies against

each other. NIKE generally uses MAPE to compare forecast accuracies amongst different products and different time periods.

Due to the limited or nonexistent history of demand for these products, an empirical relationship between standard deviation and the demand level had to be made. The relationship used was

$$\sigma = c_1 * a^{c_2}$$

Equation 6: Empirical relationship between standard deviation and the demand level

$c_1$and $c_2$are regression coefficients typically with $0.5 < c_2 < 1$ and a was the demand level[5]. Both constant coefficients, $c_1$and c_2, were developed using historical data from past history (where it existed) of the same products and from like products where history did not exist. Using this method the standard deviation of forecast error could be estimated for different demand levels for different products. NIKE generally forecasts monthly demand for replenishment products and then further breaks down this monthly forecast into weekly forecasts using an algorithm by product (for instance some products have demand evenly staggered each week of the month). The look-ahead for the forecasts is the lead-time for each product from PO to a CM to receiving the product in NIKE's DC. Also, the standard deviation needed to be adjusted for different lead times. To do this an approximation for the standard deviation over lead time was used

$$\sigma_L = \sqrt{L} * \sigma$$

Equation 7: Approximation of standard deviation over lead time

σ_L is the standard deviation of forecast error over lead time of duration L basic forecast updated periods. L is the lead time (in forecast update periods).[5]

3.5 Dual Sourcing

Dual sourcing is generally a strategy of sourcing from two different suppliers for various different reasons from cost, quality, risk, and lead-time. For this analysis dual-sourcing is used to mitigate the overall safety stock carried due to long lead times. In this case, dual sourcing was used as a strategy of sourcing from traditional low-cost countries with long lead times (from purchase order from NIKE to a supplier to delivery to NIKE's North American warehouse in Memphis) along with sourcing from a higher-cost shorter lead time source. This hybrid sourcing strategy allows decision-makers to order a base amount of inventory from a low-cost long lead time source and source the reactive component of demand at a later period when forecasts are more accurate. One recent paper by Oberlaender, "Dual sourcing of a newsvendor with exponential utility of profit," shows that hybrid sourcing is always advantageous over pure offshoring as long as the markup cost on the shorter lead time source is not more than the cost of underage (price sold minus cost of producing at the long lead time source). This means that as long as the short lead time source costs are smaller than the selling price. [8]

Dual-sourcing modifies the order up to level from Section 3.3 by adding a second order up to level. Veeraraghavan and Scheller-Wolf in, "Now or Later: A Simple Policy for Effective Dual Sourcing in Capacitated Systems," helps to explain some of the complications of a second source. A non-expedited order from periods prior may push the expedited inventory position (the expedited is the higher cost shorter lead time source) above the order up to level causing an

overshoot, thus leading to situations where expedited ordering is skipped for certain time periods.[9] These results were invaluable in helping the author model potential new supply chain structures for NIKE.

3.6 Reducing Lead Times

Chandra and Grabis in, "Inventory management with variable lead-time dependent procurement cost," show that reducing lead times from suppliers can lead to situations with more accurate demand information in making inventory replenishment decisions. This helps to reduce safety stock requirements and improves customer service[10]. This can be balanced against the higher costs of purchasing from shorter lead time suppliers. This higher cost can be from premium transportation or greater factor costs for shorter lead time suppliers. In a recent paper, it was found that reducing lead time is justified when increase in procurement cost is slow, the external demand is highly uncertain, and the product has large added value.[10] In NIKE's case the three factors mentioned before all are met by NIKE's seasonal products. Improvement in customer service level can be quantified as an increase in profit by higher customer service levels assuming that customers do not back-order for NIKE's replenishment business (most products on this business are highly substitutable with competitor products thus this is a generally accurate assumption).

4 Methodology

4.1 Introduction

The research in this paper focused on NIKE's North America Always Available business because it is the largest market for Always Available and due to the ease of acquiring data (the North America business was co-located with corporate headquarters where the author worked). Even though the models described in this thesis are developed for North America, the results can be scaled and applied to other geographies by changing the input data.

The earlier chapters describe NIKE and the Always Available business. In addition, in the literature review the author has covered various different methods retailers use to manage retail products by managing their safety stock levels, dual-sourcing finished goods inventory, and reducing lead times. With this information, some hypotheses can be made.

From Section 1.3 we know that the primary goal of the project is to increase profitability of highly seasonal products in NIKE's replenishment business. From this goal, three hypotheses were explored:

1. Rather than managing highly seasonal products to the Always Available 95% item fill rate method, greater profit could be realized by changing the item fill rate based on product characteristics and where the product is in its lifecycle.
2. There is a profit opportunity to dual-source highly seasonal products with greater per product cost in Always Available.
3. There is a significant profit opportunity for NIKE by decreasing lead times for these products.

4.2 Data Collection and Analysis

To better understand the characteristics of products sold by North America in the Always Available business, the author collected and analyzed two years of data for 21 different products. The author selected these 21 different products by determining the most representative seasonal products in the Always Available business via interacting with demand planners in the business and studying the demand patterns of these products. Nine different products were chosen from the apparel product engine and nine others were chosen from the equipment product engine. Seven was decided upon as a reasonable number due to the difficulty in finding data for more products than this. Also, the author studied only three different products in the footwear product engine because there were only a few sandals (representative seasonal products in the footwear category) that fit the criteria in North America of being a North American Always Available product within the past two years that experienced seasonal demand.

Demand data was assumed to be normally distributed for the purposes of this research. Also, NIKE generated monthly demand forecasts, but ordered finished goods inventory from suppliers once a week. This fixed the review period (R) for NIKE at a weekly level.

4.2.1 Process fulfillment characteristics

Data was captured at the product level aggregating for size but not for color differences (each product was a unique style of product and color or otherwise known at NIKE as a style-color or a SKU). Forecasts were captured the month of demand, one month out, two months out, three months out, four months out, five months out, and six months out. The lead times for the 21 different products studied ranged from two months to five months, meaning the time it takes from NIKE generating a purchase order to the product arriving in NIKE's North American distribution center in Memphis. These lead times assume ocean transport from Asia (where the bulk of these products were manufactured) to North America, which is generally a reasonable assumption regarding these products. NIKE only transported via air for very high value to weight products like the NIKE Fuel-Band (a consumer electronics product) or in emergency situations.

NIKE does not own any manufacturing (except for acting as a supplier to their own suppliers providing the NIKE Air plastic inserts), but purchases products from their contract manufacturers. The cost of the product varies by the materials and labor required for each product. Once NIKE orders a product it is transported overland in Asia to a port, via ocean to North America, and then via truck or rail to NIKE's North American DC in Memphis. Air freight is about a factor of five or six higher than ocean for typical NIKE SKUs. NIKE typically uses an inventory holding cost of approximately 20% per year incorporating the cost of capital and warehousing.

4.2.2 Price and Cost Data

NIKE keeps pricing and cost data at a seasonal basis in a centralized merchandising database. The price used for this analysis was the wholesale price that NIKE sold their products to their customers. Customers generally marked up the product they purchased from NIKE by 100% and sold to end consumers. The salvage price for Nike was assumed to be 50% of this wholesale price at the end of life for a product. This assumption for salvage price was verified by NIKE sale's employees as a reasonable assumption. The cost used in this analysis was the landed cost which factored in not only the cost to purchase a product from their contract manufacturer, but also the cost of shipping and paying taxes/duties to import it into North America. For the

purposes of this research it was assumed that the price and cost data from the first season that the product was offered was generally the same price and cost offered throughout a year of a product's life. Prices and costs vary small amounts throughout the course of a product's life, but for the purposes of this project these variations would not impact the overall recommendations or conclusions of this project.

4.2.3 Forecast and Demand Data

Forecasts in the Always Available replenishment business were generated by demand planners at NIKE using the *Logility Voyager* statistically generated software package.[4] This software package used a modified Holt-Winters algorithm[5] of either the same product in a previous season or a similar product from a previous season and generated a statistically generated forecast at 6, 5, 4, 3, 2, 1, 0 months out from actual demand. Demand planners made modifications to statistically generated forecasts to incorporate specific non-forecastable events, like large sporting events (like the world cup for soccer equipment), and other information that the system would not be able to handle.

4.3 Inventory Simulation Model

The author developed an inventory simulation tool in conjunction with NIKE's Supply Chain design group. The group had been modeling a different problem, procuring shirts, but the base of the model was used to develop an inventory simulation tool that could be used to simulate various replenishment inventory policies and how they compare to each other in terms of potential profitability. The model analyzed each product (of the 21 studied) individually.

4.3.1 Underlying Assumptions

This tool was modeled in Microsoft Excel and simulated an inventory policy with the base time period of a week. NIKE procures weekly so this model replicated that aspect of its supply chain. A listing of the major assumptions used in this analysis is listed below in Table 1.

Assumptions	Reasoning
Excess inventory is classified as inventory that remains after the product has reached end of life. Generally products on Always Available are sold through replenishment for two years before reaching end of life.	Products with an end of life shorter than two years are not good candidates for Always Available because products on AA should be essential products that do not change that often.
Excess inventory beyond 5% of a year's forecast is discarded with little to no financial value.	NIKE inventory sales confirmed that their organization cannot sell too much inventory beyond 5% of a year's forecast after a product's end of life.
Of the excess inventory, some portion is sold through NIKE Factory Stores and the other portion is sold through value channel partners like TJ Maxx and Burlington.	NIKE Factory Stores serve as a means to sell NIKE products after end of life at a discount directly to consumers.
Calendar year 2013 forecast data is used during simulations.	Many of the products studied did not have historical data prior to 2013 (they

[4] See Logility Voyager's website for more information: http://www.logility.com/inventory-optimization-software
[5] See Logility Voyager's website for more information: http://www.logility.com/library/white-papers/demand-planning-papers/media/7-methods-that-improve-forecasting-accuracy

	were new products with no history).
To simulate a two year life on AA, the Calendar year 2013 forecast data was replicated for another year for the purposes of this simulation. This means that inventory held over from the first year of a simulation could be used in the second year. After the second year any remaining inventory was considered excess.	Most products on AA had a two year life, but the products chosen for study only had a one year history (calendar year 2013). To simulate two years of life, the first year's forecast data was used as the second year's forecast data.
Excess inventory was sold through NIKE Factory Stores (NFS) at 90% of the wholesale price. Excess inventory was sold through Value Channel partners at 50% of the wholesale price.	NFS sold directly to consumers so NIKE as a whole kept most of the margin. NIKE had to sell excess inventory to value channel partners at a large discount because it was sold during the non-peak selling season and because it was considered an end of life product.
Soccer shin-guards sold 10% of excess inventory to NFS and 90% to value channel partners. Sandals sold 90% of excess inventory to NFS and 10% to value channel partners. Fleece clothing items sold 20% of excess inventory to NFS and 80% to value channel partners.	These different products had a different percentage of products sold through NFS because NFS had differing rates of accepting end of life products depending on type of product.
The lead-times used in this inventory modeling was the lead-time from NIKE sending a purchase order (PO) to a supplier and receiving it in their fulfillment center.	This simulation did not consider lead-time variability as that data was not readily available. Depending on the variability of the lead-times the results could be impacted.
Forecast standard deviation was used as a proxy for standard deviation of forecast errors when simulating the various inventory policies. Historical data was not available for most of these products so standard deviation of the forecast was used.	Depending on the actual forecast errors the results could be impacted.
The model assumed that forecast accuracy improves 2% per month as lead-time is reduced. That is, we reduce the forecast standard deviation per period by 2% when the lead-time is reduced by one month. This number was used to simulate the impact of reducing lead-time.	This assumption was not verified but came from an inventory expert in AA.
The model assumed a holding cost of 20% per year of a product's cost (landed cost).	This number was used throughout NIKE for modeling purposes but was not verified.

Table 1: Inventory modeling assumptions

4.3.2 Inputs

The inputs that were fed into the model consisted of inputs that were specific to each product and one that was specific to family of products (sandals, soccer shin guards, and fleece apparel). The one input that was specific to a family of products was the percentage of excess inventory of a product that was sold through NFS vs. value channel partners. For sandals 90% of excess

inventory was sold through NFS and 10% through value channel partners. For fleece apparel 20% of excess inventory was sold through NFS and 80% through value channel partners. Lastly, for soccer shin guards 10% of excess inventory was sold through NFS and 90% through value channel partners. These numbers were obtained through discussions with NIKE inventory sales personnel who sold excess inventory after a product reached end of life. The inputs that were specific to each product are listed in Table 2.

Inputs	Reasoning
Lead time in weeks.	Obtained directly from NIKE's product characteristics database.
Cost to NIKE which encompasses purchasing from a supplier, shipping and duties, and receiving in NIKE's North America distribution center in US dollars.	Obtained directly as the Landed Cost from NIKE's product characteristics database.
Wholesale price at which NIKE sells products to its customers in US dollars.	Obtained directly from NIKE's product characteristics database.
Forecast per month taken at a product's lead time in quantity of units sold in that particular month. For instance, if lead time is 3 months then the model used the forecast 3 months out from actual demand. These monthly forecasts were broken out into weekly forecasts by dividing by four and using that value as a week's forecast within a particular month.	NIKE's demand planners forecast the demand in quantities the month of demand, 1 month out, 2 months out, all the way to approximately 6 months out. It made the most sense to use the forecast at lead time for analysis.

Table 2: Inventory Modeling Inputs

4.3.3 Outputs

The most important output of this model was the mean profitability which is the average profit of all of the trials simulated for a particular product's inventory policy. This average profit was computed by subtracting the cost of a product by the revenue of a product in a two year trial. The revenue was by adding the revenue of wholesale sales to customers (wholesale price multiplied by number of units sold) and by adding the revenue of excess inventory sales to NFS (90% of the wholesale price multiplied by inventory sold to NFS) and value channel partners (50% of the wholesale price multiplied by inventory sold to value channel partners). The cost was computed by adding the cost of products (landed cost multiplied by inventory of product purchased) and the holding cost of products (20% of the cost of a product as the holding cost per month). The higher the average profits the better for a particular inventory policy. So the criterion for comparing different inventory policies is average profitability.

4.3.4 Settings for the Simulation tool

This model was simulated by using Frontline's *Analytic Solver* software add-on to Excel.[6] This software performed Monte Carlo simulations modifying, with each trial, the simulated demand placed on a particular product's inventory policy. This demand varied every trial with the standard deviation of the forecast error.

The author used 100 trials per simulation for a product's inventory policy. The author considered using 1000 trials per simulation, but the time to complete a simulation took too long to make it

[6] See Frontline Analytic Solver's website for more information http://www.solver.com/monte-carlo-simulation-overview#What_is_Monte_Carlo_Simulation

feasible (using 100 trials took place over a period of two days running on an average corporate laptop in 2014). The author modeled every product (21 products) via a static and dynamic service level approach (2 policies). In addition, the author modeled single sourcing vs. dual sourcing (used an escalating cost of 5% to 100% increase in landed cost of the second shorter lead-time source in 5% increments which meant 20 different landed costs). Also, the author modeled this using a second source with a one week to eight week, in one week increments, lead times (so 8 different lead times for a second source). Lastly, the author modeled the impact of decreasing the single source lead time by one week all the way to a ten week decrease in lead time in one week increments (so 10 different lead times). Due to the large number of simulations, 100 trials per simulation were chosen to trade-off accuracy vs. speed.

4.3.5 Model validation

The author validated that the model accurately represented the inventory system that AA used by comparing the targeted item fill rate to the actual item fill rate that the simulation computed. To do this, the author compared the resulting average actual item fill rate (IFR) from 100 trials of the simulation vs. the targeted IFR, which was always 95%. As you can see in Figure 3,for most products the actual achieved IFR from the 100 trials of a simulation run was very close to the target of 95%. The average IFR achieved from the simulation weighted by number of products forecast to be sold in a year (so the products with higher volumes like the Sandals had a higher weight) was 94%, which is very close to the target of 95%. These results validated that the model accurately modeled the inventory system by demonstrating that the model could achieve IFRs that were very close to the targeted IFRs, which is a key indicator that the model accurately represents the inventory system.

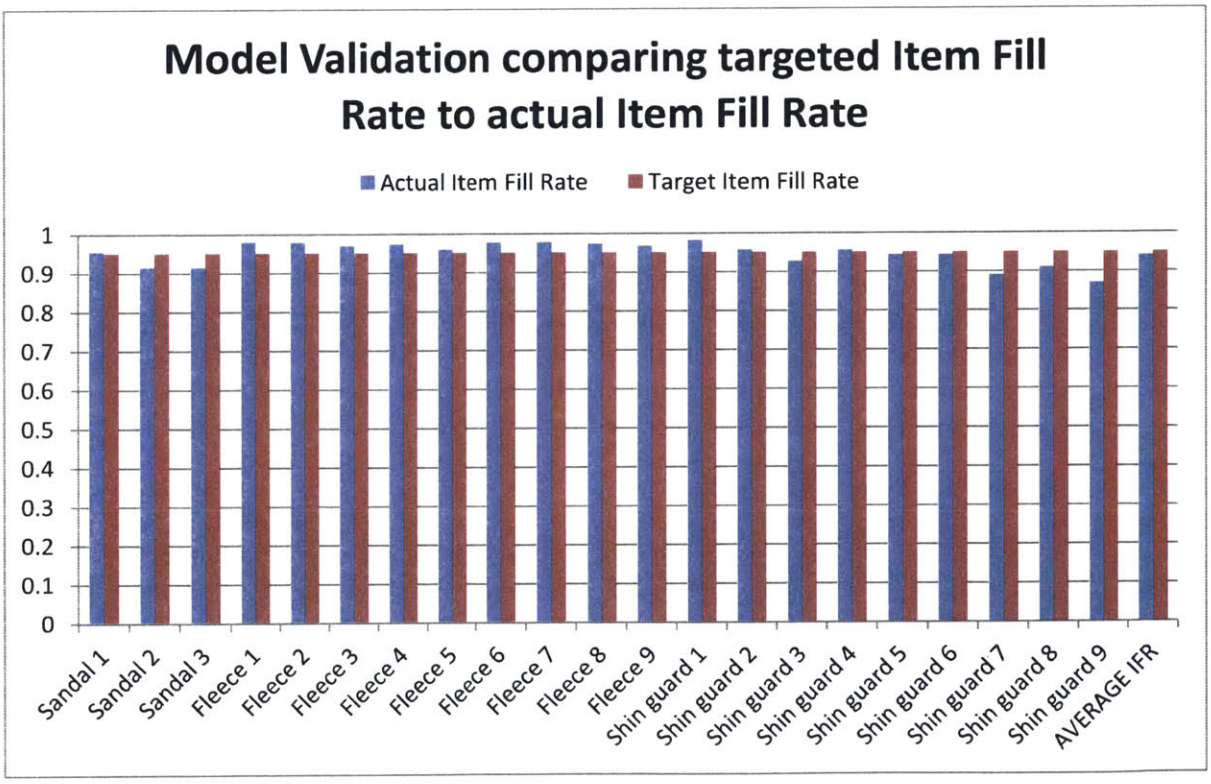

Figure 3: Model Validation comparing targeted Item Fill Rate to actual Item Fill Rate

5 Inventory Modeling

5.1 Current State

In the current state model the author modeled NIKE's current method of planning safety stock for Always Available products. Always Available aims to achieve a 95% item fill rate (IFR) for all products on replenishment. This target can lead to situations where the safety stock required for a given month may go up dramatically due to a large demand increase from the previous month. Suppliers generally are not able to change capacity dramatically from month to month, thus NIKE generally buys ahead of peak seasons to mitigate capacity constraints. This can lead to situations where safety stock levels go up higher than the recommended 95% IFR. Also, demand planners often override the recommended safety stock targets (from a 95% IFR) to input their own values for various reasons. These two reasons (supplier capacity and demand planners) lead to situations where NIKE does not achieve the 95% IFR that they are targeting from month to month.

NIKE experiences three primary difficulties in managing seasonal products as seen in Figure 4. Two reasons are interrelated, demand variability and the constant refreshing of their product line (new products), which leads to products that are difficult to plan. The third reason, long lead times, greatly magnifies the difficulty of planning for variable demand because the selling seasons are often shorter than the replenishment lead time. This leads to situations where NIKE essentially takes one bet for a season because it is unable to replenish during a season (a classic newsvendor situation). You can see from Table 3that for many products the peak selling season is a little more or the same length as the lead-time. This makes it very difficult to replenish during the peak selling season as the replenishment product would not arrive in time to meet customer demand during the peak selling season.

Representative seasonal replenishment product (data is masked)	Lead-time (from PO to receipt)	Peak selling season length
Footwear	4 months	5 months
Apparel	6 months	6 months
Equipment	5 months	6 months

Table 3: Lead-time and peak selling season length for representative seasonal products

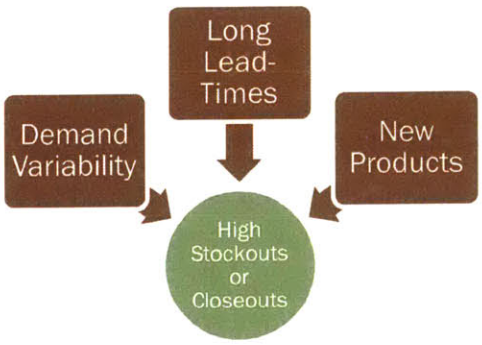

Figure 4: 3 reasons why High Seasonality products are difficult to plan

As seen in Figure 5 you can see that most North America Always Available seasonal products experience either high stock outs or excess at the end of the selling season. This is a problem for the Always Available business because with high stock outs they are losing opportunities to sell more products, and with excess inventory NIKE is forced to clear out obsolescent product at low or negative margins. This excess inventory is cleared out with generally a small positive margin to NIKE Factory Stores and at a negative margin to value channel partners like TJ Maxx, Ross, Burlington, etc... Stock outs and/or excess products are very detrimental to the Always Available business and are the reason for the work that the author conducted at NIKE. As seen in Figure 5 the author studied 21 different products. Of those different products, the Soccer Shin Guards experienced Closeouts/Excess/Carry-Over that was greater than the target rate of 3%. This 3% means that of a year's forecast if a product has 3% or more of that product in inventory at the end of the lifecycle for that product then the product had excess closeouts. With stock outs Always Available estimates stock outs by estimating the average number of products sold per day prior to running to zero in inventory for a certain item. When NIKE no longer takes replenishment orders for a product because inventory is zero, it counts the average number of products sold per day for the prior period as the stock out rate until inventory comes above zero and NIKE starts accepting orders. The Target of 5% for stock outs was determined arbitrarily from the target item fill rate of 95%. The Average Always Available Closeout rate of 3% was measured across all AA products and was taken from previous year's closeout rates.

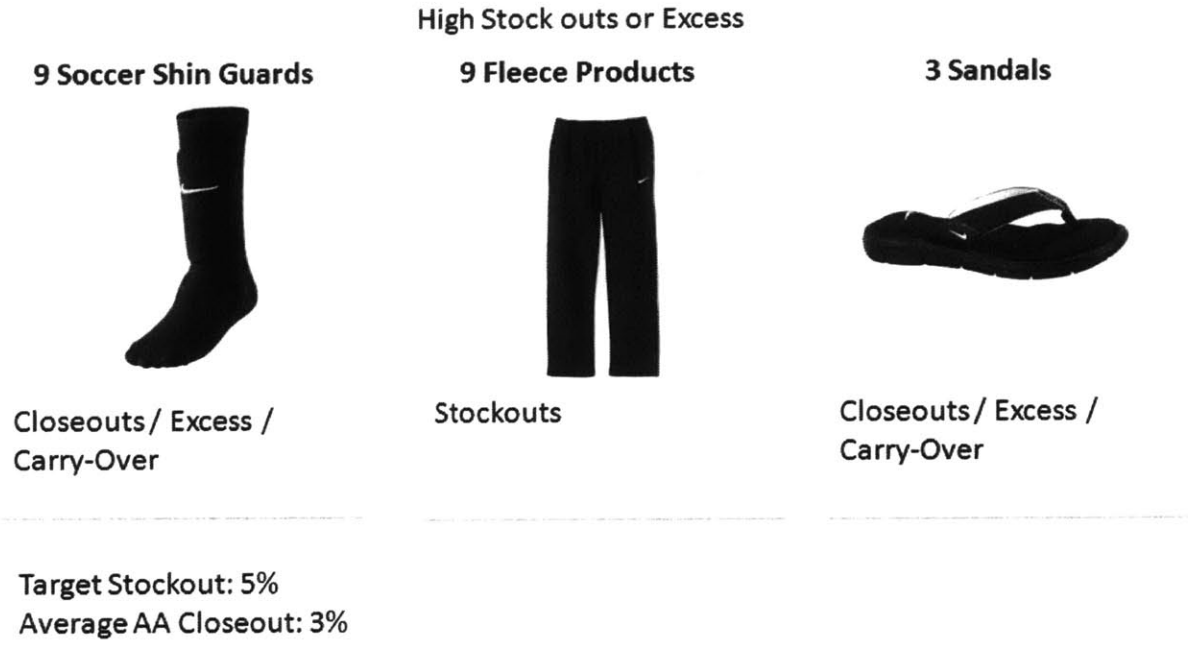

Figure 5: Example performance of North America Always Available products in 2013

5.2 Static Service Level Method targeting a 95% Item Fill Rate (idealized current state)

In order to compare different inventory strategies to improve profitability, a static service level method targeting a 95% IFR was used. The author did not compare only against the historic performance because it would not have been that useful due to the myriad of factors that changed

due to subjective (demand planner intuition) and objective reasons (capacity constraints). To compare different inventory strategies on apples to apples basis the author reconstructed what NIKE would have done without capacity constraints and demand planner overrides. Capacity constraints lead NIKE to front-load the purchase of inventory so the holding cost may go up, but not significantly. Primarily, this was done to reduce the effects of demand planner overrides on the safety stock quantities for these products. Also, this was done so as to use a Monte Carlo simulation to compare the performance of different inventory strategies on profitability. The Monte Carlo simulation modified the standard deviation over demand variability as opposed to forecast error. This assumption was used because many of these products did not possess forecast vs. demand history. Also, NIKE used this same assumption when calculating safety stock for some of their products with an excel tool they used alongside Logility Voyager.

5.3 Dynamic Service Level Method

The easiest method of improving the inventory performance of NIKE's seasonal Always Available products was to vary the static 95% IFR target used to manage their products safety stock. The overage and underage costs of inventory vary over the season so operating with a constant service level may not be optimal. As costs vary over the season, so we should consider a dynamic service level which changes as costs change.

To determine how to vary service levels the author modeled the performance of the 21 style-colors (SKUs) using Monte Carlo simulations (100 trials for each simulation) varying the actual demand using the standard deviation over demand variability and forecasted demand week to week. The author conducted these simulations using various methods of varying the item fill rate and found that the most robust model used a variant of the critical ratio Equation 4: Critical Ratio.

To accurately model the changes in critical ratio by month and product characteristics, the salvage value had to be modified. The author varied the salvage price dynamically throughout the life of a product. The cost of overage early on in the life of a product was just the cost to hold the product for an extra week. Near the end of the life of a product (as the *YearWeek* incremented higher) the salvage price dropped because the cost of overage increased due to the risk of excess inventory at the end of life of a product. The products that responded most favorably, in regards to higher profitability, to varying service levels were products that had high seasonality (over 60% of sales within 3 months for a year's forecast), correlating with difficulty in forecasting demand, and long lead times (over 17 weeks).

The way the author managed the critical ratio dynamically by product and where in its lifecycle it was by the below equation modifying the salvage price:

$$Salvage\ Price = \left(WholesalePrice - CloseoutDiscount * WholesalePrice * \left(\frac{YearWeek}{52} \right) \right) * \left(\frac{EndInventoryClearance}{StdDev} \right)$$

WholesalePrice is the price retailer customers of NIKE purchased products from NIKE. *CloseoutDiscount* is the discount to the wholesale price when sold to value channel partners after a product's end of life, generally 50%.

YearWeek is the week of the year the product was in based on its lifecycle. So, assuming the product's last major selling season of the year was December, week 52 would be reached by the product in the last week of December.

EndInventoryClearance is the amount of inventory that can be sold after the end of life of a product through value channel partners. This was generally 5% of a year's forecast of a product could be liquidated through value channel partners. The remainder over the 5% excess would have to be written off.

StdDev is the standard deviation of the forecast over lead time and review period (review period was 1 week for all products).

The Salvage Price was scaled by the ratio of the Ending Inventory that can be cleared divided by the standard deviation of the forecast as a means to scale the Salvage Price by how much of a product can be sold after a product's end of life. For instance, in a highly volatile product like soccer shin guards the ending inventory that can be cleared could be 10,000 units while the standard deviation of the forecast could be 20,000. The Salvage Price would be scaled down by half accordingly due to its higher volatility of forecast vs. actual demand. For a more stable product like a sandal, the ending inventory could be 25,000 units while the standard deviation of the forecast could be 25,000. Then the Salvage Price would not be scaled because of the low volatility of sales vs. forecast for this product.

If the salvage price for a particular product was higher than the *WholesalePrice* early on in a product's lifecycle then the author used the *WholesalePrice.*

Due to the difficulties of implementing a new model in NIKE's planning process the author conducted further analysis into the possibility of developing some insights that would apply to highly seasonal products on replenishment. The author found that products with high seasonality (over 60% of sales within 3 months for a year's forecast) and long lead times (over 17 weeks) had the greatest uplift in profitability by managing with a dynamic service level method. These characteristics corresponded with the Apparel product engine products analyzed as seen in Figure 6 from Tableau (data visualization software). These figures shows the large profitability potential for managing the finished goods inventory of products with high seasonality and long lead times via a dynamic service level method. On the x-axis is the profit of products in a product engine and the y-axis shows the different product engines and how to manage the inventory (95% item fill rate method or dynamic service level method).

The author found two possible rules (heuristics) to increase profitability over the static 95% item fill rate method:

1. Prior to the very last season (3 month selling season) of a product's life: Hold the service level at 95% item fill rate.
2. During the very last selling season of a product's life: Drop the service level to 85% item fill rate.

The author found that running new simulations using these two simple rules for highly seasonal and long lead time products, versus running the dynamic service level method, produced results that did not degrade profitability results much, but greatly aided the potential adoption of this method by NIKE. 95% item fill rate was an upper-bound as greater item fill rate did reduce the risk of stock outs but greatly increased the potential for holding excess inventory. 85% item fill rate was a lower-bound as the sales team thought that any lower service level would not be palatable to their customers. Using these two simple rules increased the overall inventory profitability of these 21 products by over 20% on average in the last year of life of a product (some of these products had lifecycles of one year, 18 months, or greater than 18 months). Further analysis would need to be conducted to determine whether or not these results will apply broadly to highly seasonal long lead time replenishment products outside of the ones studied by the author.

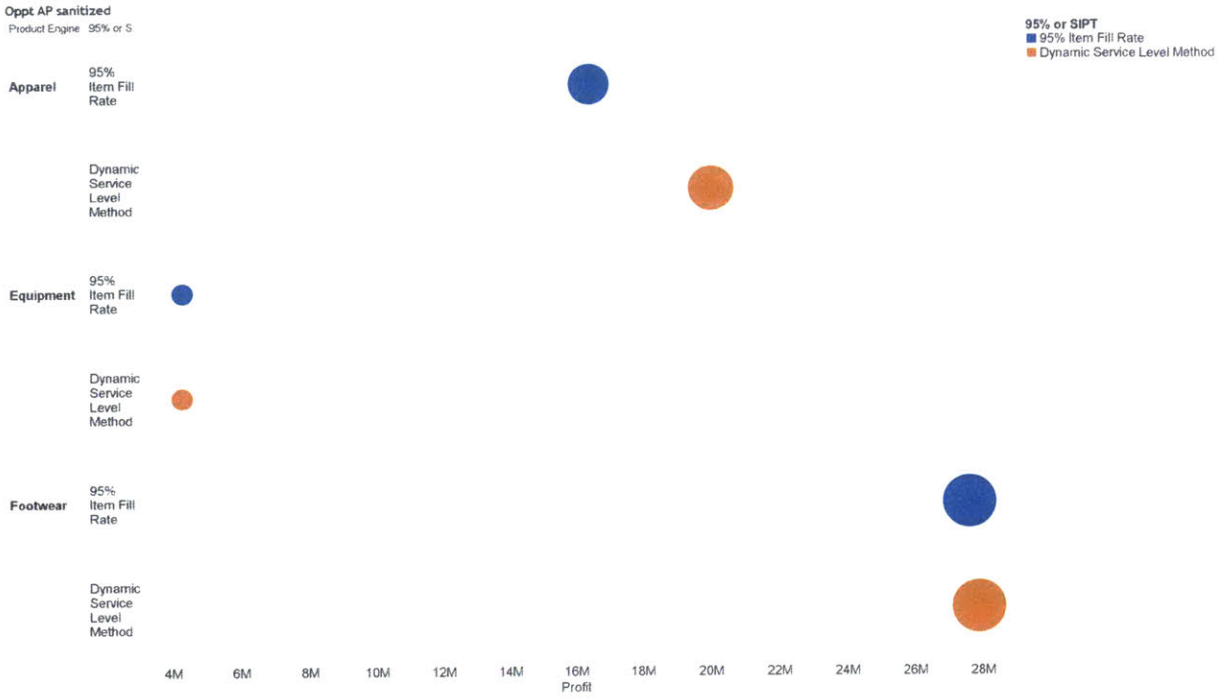

Figure 6: Sum of profit for each 95% IFR or Dynamic Service Level Method broken down by product engine. Blue is 95% IFR and Orange is the Dynamic Service Level Method. Size shows sum of profit.

5.4 Dual Sourcing

The second method of increasing the profitability of NIKE's seasonal Always Available products, dual-sourcing, would be harder to implement for NIKE but could potentially yield large increases in profitability.

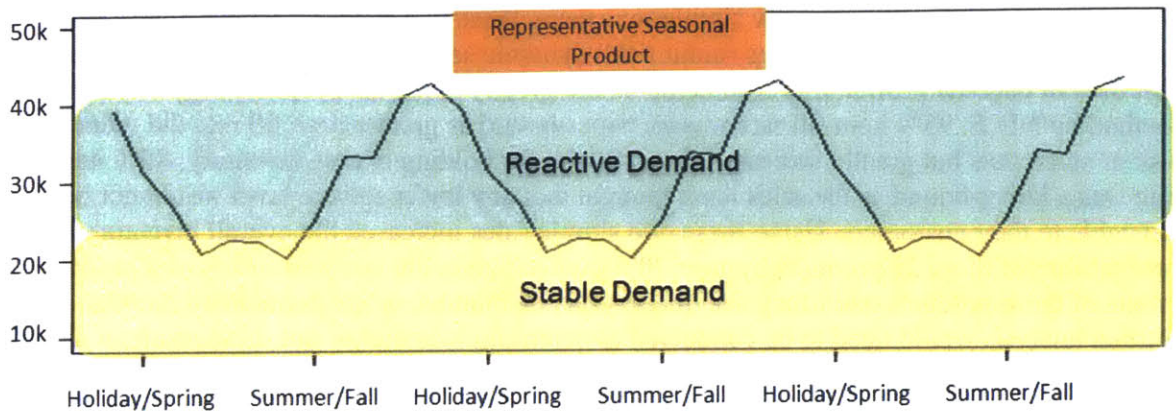

Figure 7: Buy stable demand on long lead times and reactive demand at short lead times

The concept behind dual-sourcing was to source the predictable portion of demand (stable demand) using the same long lead time sources NIKE currently uses as seen in Figure 7. The reactive demand would be sourced using a hypothetical source with a short lead time but greater landed cost. This hypothetical source was modeled at 1 to 8 weeks of lead time with increase in landed costs ranging from 5% to 50% using a similar modeling approach as for the Dynamic Service Level method (week to week Monte Carlo inventory simulation model).

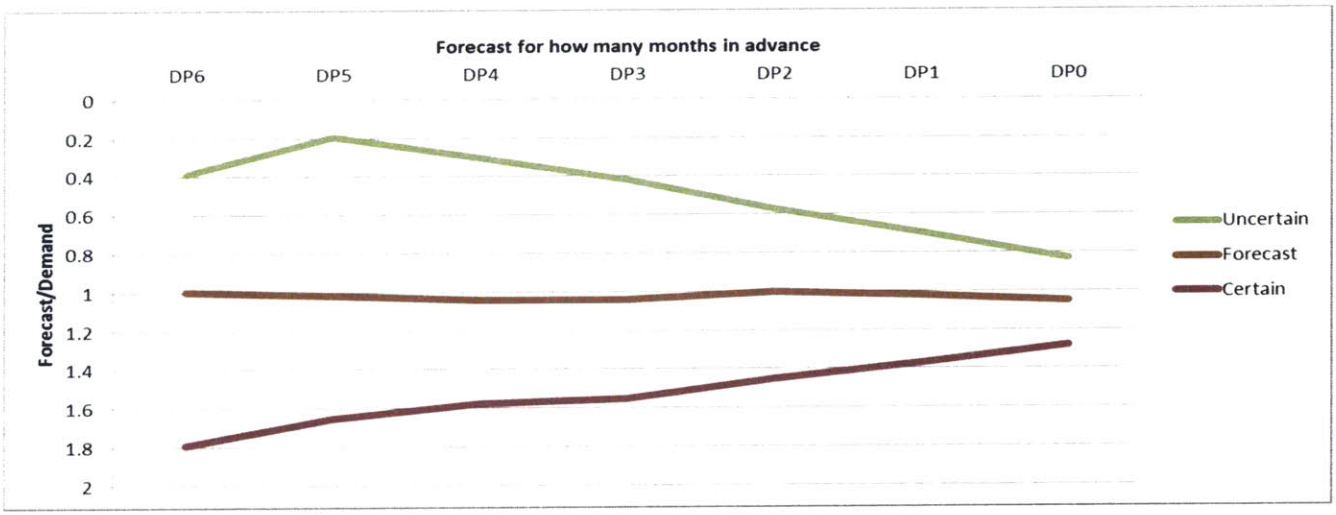

Figure 8: Graph of certain vs. uncertain demand

The author conducted an analysis on the forecastability of demand by visualizing the forecast/demand for seasonal products on Always Available. This was accomplished by studying all 21 products and analyzing the forecasts at various months out from actual demand (from six months out to the forecast the month of demand) in month increments. The forecasts for one year of a product's life is compared at various forecasts (six months out to the forecast of the month in one month increments) to the sum of demand by adding the entire forecast for a year at a given lead time and dividing by the sum of actual demand for a year. All 21 products were studied in this manner and the ones with historical data (forecast vs. actual demand prior to 2013) were

included as well. The results are shown in Figure 8. The x-axis is the forecast at various months out from demand (so DP6 is the forecast 6 months out, DP5 is the forecast 5 months out, etc..) and the y-axis is the forecast/demand as a measure of inaccurate the forecast can be.

The line termed uncertain is the 1 percentile result of forecast divided by actual demand. This means that only 1% of the time forecast/demand would be lower than this amount. This was labeled uncertain because this represents instances where the forecast is too low compared to the actual demand. So a value of 0.4 (as seen in DP6 on the uncertain line on Figure 8) means that forecast was 0.4 times the demand, which means that the actual demand was 2.5 (1/0.4) times the forecast. So, if NIKE wanted to cover 99% of a year's forecast variability vs. demand, then their supplier capacity for a year should be about 2.5 times a year's forecast.

The line termed certain is the 99 percentile result of forecast divided by actual demand. This means that 99% of the time the forecast/demand would be lower than this amount. This was labeled certain because this represents instances where the forecast is too high compared to the actual demand. So a value of 1.8 (as seen in DP6 on the certain line on Figure 8) means that forecast was 1.8 times the demand, which means that the actual demand was 0.56 (1/1.8) times the forecast. So, if NIKE wanted to pre-build inventory that 99% of the time would be sold within a year, NIKE could build up to about 50% of a year's forecast with little risk (1%) of that inventory not selling within a year.

So, in the dual-sourcing model the long lead time source satisfied half of the forecast's demand and the remainder was satisfied at a shorter lead time higher cost source with a more accurate forecast (due to the ability to order closer to demand actualization). This 50% number was chosen as a conservative estimate to reduce the risk of excess inventory.

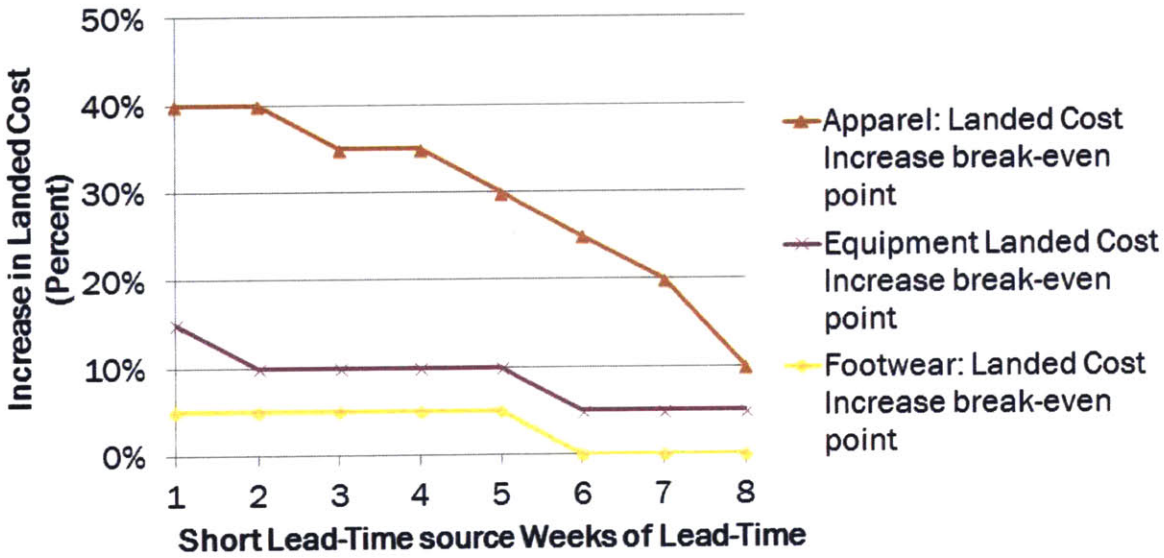

Figure 9: Break-even points for the lower bound of increase in landed cost for various lead times

Figure 9 is a summary of the dual sourcing inventory modeling. For example, if lead time is 4 weeks for a second source, then for dual sourcing it is profitable for apparel as long as the landed cost increase is no more than 35%. For Equipment the break-even point is lower, so for 4 weeks

lead time on a second source, dual sourcing is profitable up to a 10% increase in landed cost. What it shows is that at various lead times (x-axis) and various landed cost increases (y-axis) there is a profitability horizon of where profit is equal to the single source method. This means that if NIKE could identify and develop a second source for those products below the line for the respective product (Apparel, Equipment, and Footwear); it would have more profitability than if only sourcing from its existing suppliers. In Figure 9 the y-axis represents the lower-bound of a profitability break-even point (so for the 7 Apparel style-colors the lowest increase in landed cost that was break-even with a simple single source with just the long lead time source). As you can see in Figure 9 the greatest profit opportunity is in the Apparel subset of products. This was primarily because of the long lead times in these products (approximately 5 months or more for these products). With a second source at 4 weeks of lead time and 10% increase in landed cost the profit opportunity is greater than 28%. The author confirmed with the sourcing team that 4 weeks of lead time and an increase in landed cost of 10% was achievable with some Latin American factories they had identified. To actually implement a dual-source NIKE would have to evaluate the cost increase to their products by either air-freighting materials or developing second sources closer to North America.

5.5 Reducing Lead times

The last method to improve the inventory profitability of seasonal products in NIKE's Always Available business was to reduce the overall lead times from PO to delivery to their DCs. This analysis was conducted to determine the potential to increase the profit of these products by reducing the lead times. Anecdotally many of NIKE's employees acknowledge that long lead times hurt NIKE's profitability, but this potential profit had not been quantified. The author used a similar model to the one used for Dual-Sourcing, but instead of adding a second source I reduced the lead time for the primary source, 1 week at a time, all the way to 10 weeks in reduction. The result was that in Apparel there was a profit opportunity of approximately 2% of increase in profitability for the first week of lead time reduction and a subsequent linear increase of profit of about 2% of the total profit with each week reduced in lead time as seen in Figure 10. The x-axis is the decrease in lead time from 1 to 10 weeks and the y axis is the profit increase. For Equipment the profit opportunity was approximately 1.5% of increase in profitability for the first week of lead time reduction and a subsequent linear increase of profit of about 1.5% of the total profit with each week reduced. The author did not investigate the costs of reducing lead times, but some of the methods identified to reduce lead times would be to use material staging (pre-purchase raw materials for NIKE's suppliers), lean events at factories, finished goods inventory staging at the factory, and by reducing the transit time.

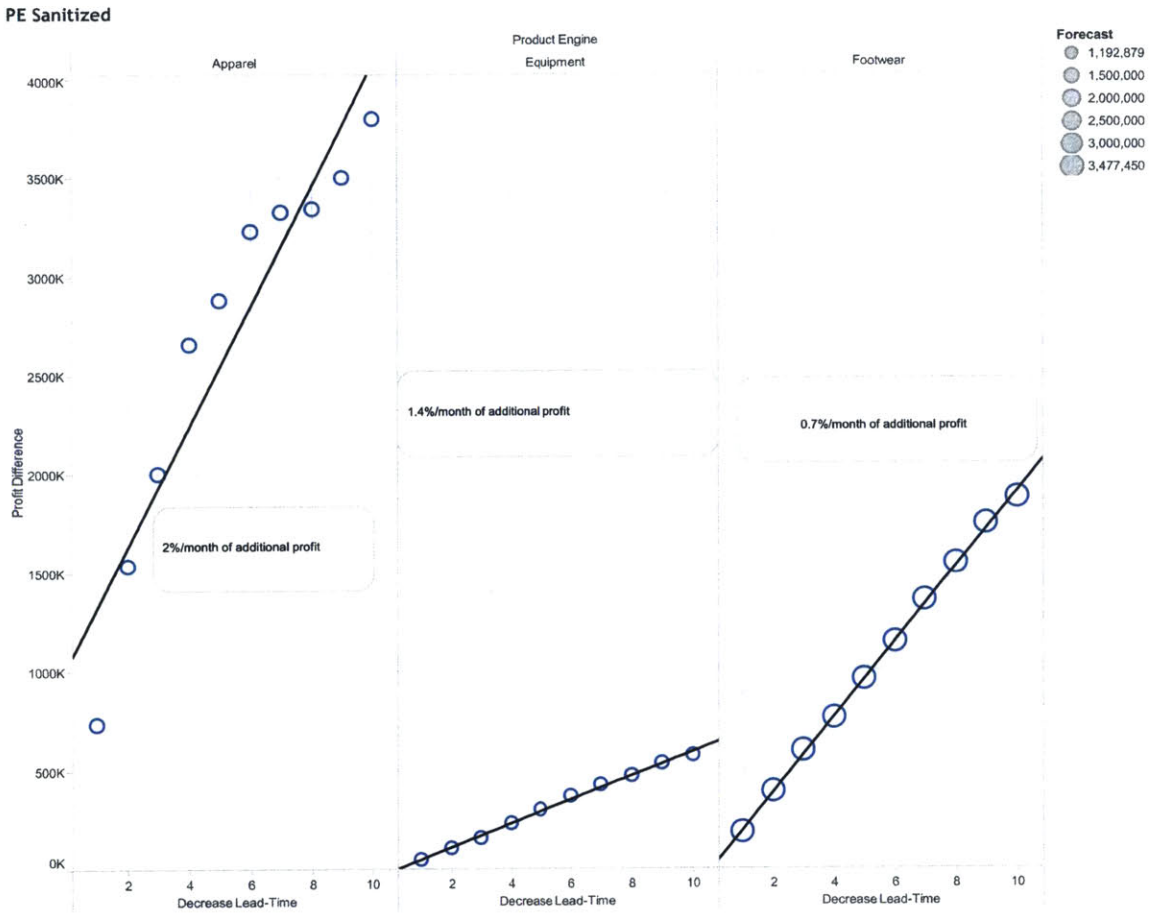

Figure 10: Increase in profitability by reducing lead times by 1 week all the way to 10 weeks

6 Implementation Strategy

The results listed in Chapter 5 on Inventory Modeling illustrated some of the findings from the hypotheses from Chapter 4.1. This chapter will highlight some strategies for implementing the findings in the Always Available organization and in the broader organization.

6.1 Dynamic Service Level Method

As illustrated in Chapter 5.3 the Dynamic Service Level Method heuristic consists of maintaining the 95% IFR for all major selling seasons for a seasonal product on Always Available except for in its last major selling season. In a particular seasonal product's last major selling season, the safety stock quantities should be reduced to correspond with 85% IFR to reduce the risk of overage. This heuristic applied for all 21 representative seasonal products on Always Available. This heuristic should be applied in the segmentation strategy that the Safety Stock Center of Excellence (COE) is developing to manage Always Available products. This would entail salesforce training to ensure Always Available customers understand the implications of the reduction in item fill rate for these products. For instance, the author learned

through NIKE sales that AA customers often ordered extra products in the product's last major selling season for end of season sales. This reduction in item fill rate would impact the quantity of product these customers could order for these end of season sales.

6.2 Dual Sourcing

As identified in Chapter 5.4 there is a large profit opportunity specifically in the seasonal Apparel products in the Always Available business. To implement the strategy of dual sourcing for these products the Always Available business would need to engage with the Sourcing and Finance team to align the incentives of all groups. The Sourcing team at NIKE may not be incentivized to find local or near-local sources of supply for products with short lead times. With engagement from Always Available and the Finance team the Sourcing Team could be incentivized to identify, develop, and source from higher cost short lead time sources. Also, the Information Technology (IT) group would have to identify whether or not dual sourcing could be planned and sourced with the existing NIKE IT systems. If not, a long term effort could be undertaken to enable this functionality in NIKE's planning systems.

6.3 Reducing Lead times

In Chapter 5.5 the author identified the opportunity to increase profit by reducing lead times from PO to delivery at NIKE's DC for seasonal products on Always Available. This would require a clear understanding of the costs of reducing lead time and the potential magnitude of impact of various projects to reduce lead time. The Always Available team would need to facilitate various projects with different groups from the Lean Manufacturing team (to reduce manufacturing lead time), Transportation Team (to reduce transportation lead time), and Supply Planning team (to reduce the raw material order to receipt time). The costs of these projects need to be balanced against the potential profitability increase by reducing inventory and improving forecast accuracy when NIKE orders seasonal products on the Always Available product line.

7 Recommendations and further work

7.1 Recommendations

Even though the static service level approach for NIKE's Always Available business is easy to manage, NIKE should adopt a policy that varies service level by product lifecycle. Managing products at end of life effectively is very important to reducing the incidence of excess inventory that must be cleared out at slim to negative profit margins to value channel partners. This will impact NIKE's customers, due to the lower availability of product in a product's last major selling season, but could be mitigated through sales force training and customer education.

To increase fill rates with customers while keeping or reducing inventory levels NIKE should consider dual-sourcing and/or reducing lead-times for their seasonal products on replenishment. NIKE's highly seasonal products are sourced from factories with very long lead times which drive up uncertainty regarding actual demand and increases safety stock requirements. By dual-sourcing a portion of their demand at shorter lead-times they could mitigate some of this uncertainty and high safety stock levels. Also, by reducing lead times NIKE can stock less safety stock and fill their customer orders more effectively by being able to place orders closer to demand with more accurate forecasts.

7.2 Opportunities for further work

This project focused on NIKE's North American replenishment business, but opportunities for follow on work exist in other geographies and in other business units. This work can be applied with some modifications to the European geography and other geographies as NIKE's replenishment business (Always Available) is expanded to other geographies. Further work could be undertaken to consider the ramifications of these findings as the lead times and costs differ from geography to geography. In addition, further work could be conducted to study the relevancy of these results for NIKE's Futures business. Even though NIKE shifts much of the inventory risk to their customers in the futures business by requiring six month lead times to deliver products (in the futures model), customers have the option of modifying orders in this business. Thinking through safety stock and lead-times for seasonal products in the futures business could yield to higher customer fill rates.

Other opportunities exist at NIKE to improve the forecasting of seasonal products and in reducing lead-times for seasonal products. Demand planners forecast demand using the Logility tool. This tool's outputs are only as good as its inputs. More work could be conducted in tuning the various input variables and to train demand planners on how to use like style-colors to forecast new seasonal products. These forecasts could be greatly improved if NIKE used point-of-sale (POS) data from their customers. A recent MIT student recently conducted a project with a company similar to NIKE wherein the author analyzed the impact of using POS data on the retailer. POS data could help increase the profitability of seasonal products on replenishment by increasing forecast accuracy.[11] Reducing lead-times for finished goods is feasible at the raw material, manufacturer, or transportation stage of the supply chain. Projects could be undertaken in either of these stages to reduce the lead times for seasonal products.

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8 Appendix A - Screenshots of the model

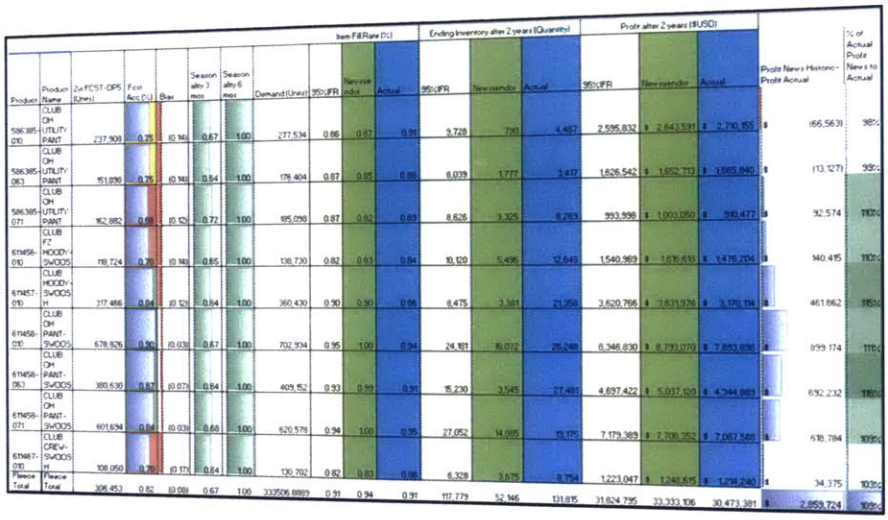

Figure 11: Model output screenshot

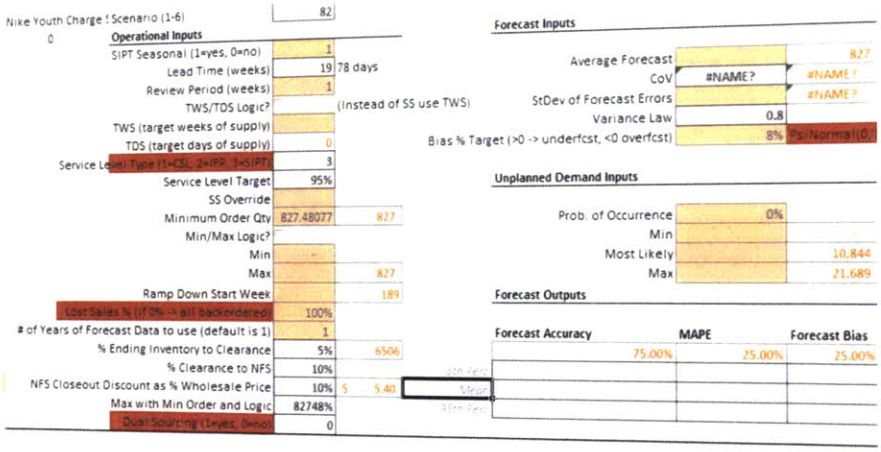

Figure 12: Model input screenshot