Practical Example of Developing and Implementing an Optimization & Scenario Planning Tool

by

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B.S., Industrial Engineering
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Submitted to the MIT Sloan School of Management and the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degrees
of
Master of Business Administration and
Master of Science in Engineering Systems
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Massachusetts Institute of Technology

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ABSTRACT

There is significant complexity facing the Global Footwear Planning team when sourcing production, especially for sandals. The challenges include increasing manufacturing costs coupled with a changing tariff landscape and a high degree of complexity to produce the products. This thesis provides a practical example of the use of an optimization model for determining where to produce, and how much to produce, of each product, including the ability to perform strategic what-if scenarios. The model is based on minimizing the total landed cost for each product. This includes the manufacturing, transportation, holding, and tariff costs. The initial pilot model results suggested a 4-11% decrease in spending for a given year. This model provides the starting point for additional work to improve optimization in the sourcing group. The implementation of this model reinforces the notion of how much support is needed in an organization to change processes and implement new software models. Future work should include the addition of simulation, as the data are highly variable at the decision point.

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List of Abbreviations and Definitions

CMP Hot/Cold Press- Compression Molded Pre-form Hot/Cold Press, a methodology for producing footwear outsoles

Consolidator- location to group products together from multiple factories for shipment together

Deconsolidator- location to split up products based on destination after shipment to a port

FICO Inc.- A company with a suit of optimization software and solver engines

GFP- Global Footwear Planning, the planning organization within Nike for footwear

Mosel- A modeling and programming language

Sourcing Plan- A plan of how much to produce of each product in each factory for a given time period

Tableau- Data visualization software

Tooling- Equipment used to form the outsole of a sandal(or shoe), product specific and required in each factory where that sandal will be produced

1 INTRODUCTION

The purpose of this chapter is to introduce the rationale for the project, the initial hypothesis regarding the impact of an optimization model, and methodology for creating and implementing the optimization model. This chapter also introduces the partner company where the project takes place.

1.1 PROBLEM AND MOTIVATION

The current process for determining the sourcing and manufacturing plan for Nike Sandals is highly manual, strongly dependent on institutional knowledge, requires many interactions between teams and is not scalable or sustainable for the long term. Meanwhile, within the manufacturing footprint, labor rates, unpredictability in transportation costs, trade challenges and product complexities are increasing.

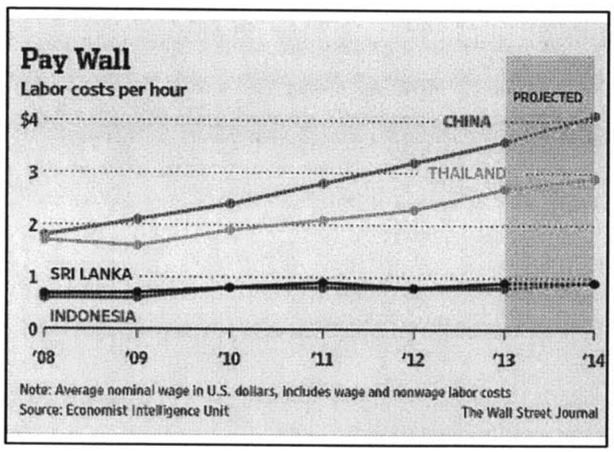


Figure 1- Labor Cost per Hour (Chu, 2013)

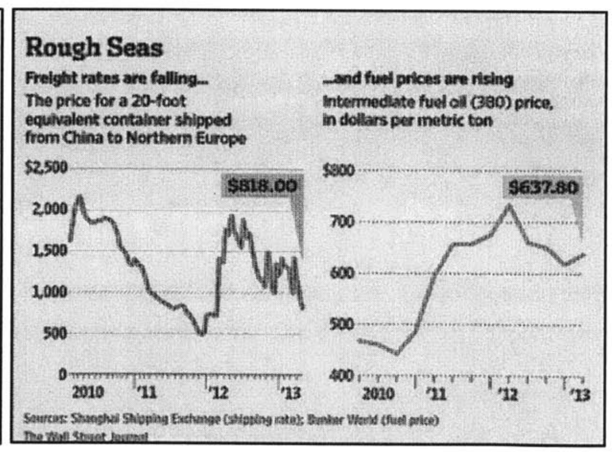


Figure 2- Freight and Fuel Rates by Year (Chu, 2013)

As shown in Figure 1, the labor costs are increasing in Asian countries that are central to footwear manufacturing. There is a significant sense of uncertainty in the tariff cost each year, as defined by government agreements. Companies are constantly lobbying to change these tariffs and planning against fluctuating tariffs is difficult. There is currently a proposed plan for a Trans Pacific Partnership that would greatly change the tariff landscape for footwear companies (Miller 2013). Nike is interested in being able to better understand and quantify how the Trans Pacific Partnership might impact their manufacturing strategy. As seen in Figure 2, the freight costs are difficult to forecast because fuel is increasing but freight rates are falling or difficult to predict due to the volatility in oil prices and the overall economic conditions of each destination country.

The idea for this project began after Nike saw success with previous research by Qunionez (2013) who developed a Risk Based Sourcing model. Quinonez suggested the use of a Risk Adjusted Total Landed Cost model. His model was developed for fleece apparel products and suggested a savings of $25M for a single demand season, better manufacturing index and lower country risk index. A similar total landed cost approach can be applied to footwear, specifically sandals in this case.

1.2 Hypothesis

Nike can improve its ability to react to changes in factors that affect the Total Landed Cost of a product and decrease the overall cost of its sandals supply chain through the implementation of an Optimization and Scenario Planning model. This model will help with making strategic sourcing decisions based on analytics. Implementing an optimization model to determine the factory allocations will help facilitate data-driven decision-making. The model will help optimize the sourcing plan based on the total landed cost, factory capacities, factory capabilities, product demand, and tariffs. Additionally, the model will give the team the ability to run "what-if" scenarios, help decrease the time it takes to react to last minute changes in demand and capacity, and better predict the impact of those changes.

1.3 Methodology

In order to properly test this hypothesis, the current state and process will be analyzed, a pilot program developed, and through iterations with the Global Footwear Planning (GFP) team, the model will be iterated upon and used as a test case for the rest of the footwear group. The model will be compared to the current state, as well as past data for validation.

1.4 Nike

"NIKE, Inc. is the world's leading innovator in athletic footwear, apparel, equipment and accessories"(Nike 2013 About Nike Inc.). Nike manufactures products under the Nike brand name, as well as Converse, Hurley, Jordan and Nike Golf. Nike employees over 44,000 employees globally with Global Headquarters in Beaverton, Oregon, European Headquarters in Hilversum, Netherlands as well as Chinese Headquarters in Shanghai and Japanese Headquarters in Tokyo. Much of Nike's recent growth and success can be attributed to its global reach and focus on expansion in emerging markets. "(Nike 2013 Locations)

In FY2013, Nike reported revenues from continuing operations of $25.3billion. Of this, $14.5billion can be attributed to Nike Brand footwear. (Nike 2013 Reports)

1.5 Confidentiality

In order to protect confidential information, the numbers in this report are representative of the actual data, but are fictitious. Additionally, terminology used by Nike and naming conventions have been changed.

1.6 Summary

The current process to determine the sourcing (manufacturing) plan for sandals is very manual, time consuming and the sourcing plans developed lack clear line of site to cost impacts. The motivation for this project is based on the benefits seen from Quinonez's fleece project. This project follows up on work completed by Carlo Quinonez on the use of a Risk Adjusted Total Landed Cost for apparel. Similar logic can be applied to footwear. The hypothesis is that by using a model to optimize for total landed cost within the sandals manufacturing network, there are cost savings opportunities, opportunities to streamline the process and the ability to perform what-if strategic scenarios.

2 Literature Review

This literature review is not intended to be exhaustive. This review briefly summarizes the research that has been conducted on the optimization techniques and models for Resource Allocation Optimization, the use of the Total Landed Cost in optimization and the use of scenarios from an optimization model. It also covers some of the research on data visualization, software selection and implementation and industry standards as the use and implementation is critical when building a model for a company in industry.

2.1 Resource Allocation Optimization

2.1.1 Optimization Techniques

A significant amount of research has been conducted around optimization methods and models for resource allocation, and production planning. Chai (2013) developed the use of a genetic algorithm to solve resource-constrained production scheduling problems due to the complexity of these problems. This model considers the practical need as well as theoretical. "The optimization of the resource-constrained project scheduling is an NP-hard problem. Complexity of the algorithm for solving this problem increases exponentially with the increase of resource constraints" Chai(2013).

Wu et al. (2012), propose the use of Bayesian theory to resource allocation. In this case, the previously used and widely selected resource assignments are an input to the model. This allows for a final solution with resource usage similar to the existing or initial plan.

The randomness in demand that is evident in practical problems is incorporated into a multi-period stochastic model by Yildirim et al. (2005) by using a rolling time-horizon and deterministic demand.

Leung et al. (2007) explore the "trade-off between solution robustness and model robustness", explaining the tradeoffs between the optimality of a solution and the feasibility to implement that solution. They do this using a weighting factor in the objective function to represent fulfillment.

"By analyzing penalty parameters, production management can obtain an optimal production plan with a workforces level in terms of lowest total costs within an acceptable range of under-fulfillment of market demand" Leung et al.(2007).

Simchi-Levi et al.(2013), express the need for data and model validation. They highlight these four questions as ones to answer during the validation process: "Does the model make sense? Are the data consistent? Can the model results be fully explained? Did you perform sensitivity analysis?" Generally a user should have a good feel of what the effects on the system the inputs might have, but data and model validation are crucial.

2.1.2 Total Landed Cost

Quinonez (2013), shows with modeling how important it is to consider the total landed cost and by including risk metrics, there can still be substantial cost benefits. Feller (2008) investigates the ability to combine a total landed cost optimization with a risk analysis assessment. This type of model allows the company to understand the tradeoffs between decisions, and compare multiple scenarios simultaneously.

2.2 Scenario Planning

Escudero et al.(1993) looked at the use of scenario planning and ways to build models around the need for varying assumptions. As typically the variables in the planning process will continue to change after the plan is developed. They note that, "it is a common business practice to develop several outlooks on the demand". They present several models for looking at scenario planning and they highlight the increased flexibility in multi-stage decision process.

Eppen et al.(1988), look at scenarios as a way to understand the tradeoffs around capacity decisions. As they acknowledge most capacity decisions are made before the exact demand is known. They also point out that there are many things that we can learn from these models outside of the initial scope, and these insights can be just as, or more, important than the goal of the model originally.

2.3 Software Selection & Implementation

Janson and Subramanian(1996) explore packaged software and benefits and risks with both packaged software and custom designs. The risks with packaged software can be mitigated by adapting that software to fit the business process. They have seen that the "quality of packaged software selection procedures, the expertise of the in-house information systems staff, and vendor support are critical to the success of the software implementation." One of their findings compares the degree of fit between a vendor and the organization adopting the software and the extent of the implementation success. This is seen below in Figure 3. They have also found that the working relationship with the software vendor itself can be important, especially in smaller organizations.

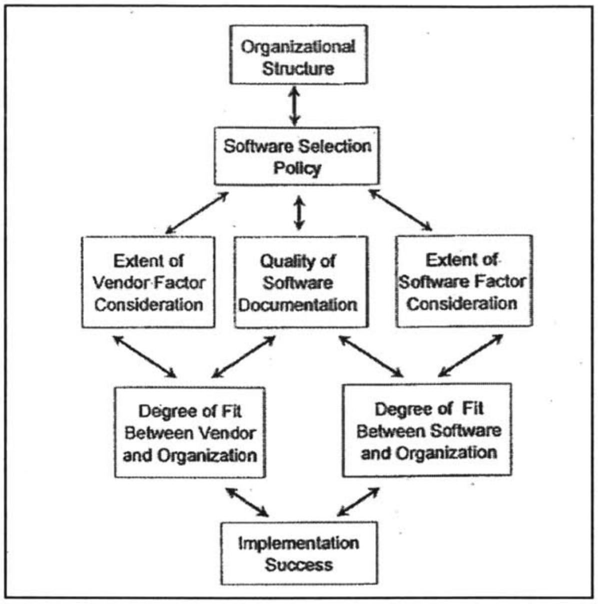


Figure 3- Links between Organizational Structure and Implementation Success (Janson and Subramanian,1996)

Geisler and Rubenstein(1987) focus on the managerial involvement with software implementation. They surveyed companies and found that the involvement of the user, number of interactions between the user and developer, and flexibility of the software is very important. They also found that the manager support and involvement is critical before, during and after the implementation.

2.4 BENCHMARKING

Albrecht (2010) points out that "frequently, ... planning tasks are supported by software tools in practice." He describes Master Planning as "mid-term operational decision-making carried out simultaneously for all functional areas participating in the order fulfillment process..."

Llamasoft (2013), highlights some success cases in various other industries. A tobacco company improved their production scheduling and service level. A global beverage producer is able to make changes to their plans "on the fly". A milk and dairy producer improved inventory stocking and has lower risk given lead -time variability. A hard drive manufacturer decreased the total landed cost of goods produced. A large food manufacturer saved over $50M through network flow improvements.

Ravidran and Warsing (2013) share successful modeling results at major global companies including Hewlett-Packard, BMW, AT&T and United Parcel Service.

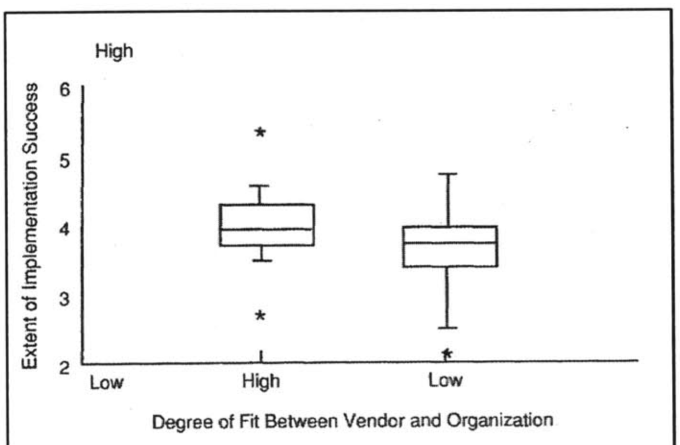


Figure 8: Association between Software Implementation and Vendor/Organizational Fit

Figure 4- Vendor and Organization fit vs. Implementation Success (Janson and Subramanian, 1996)

2.5 SUMMARY

There is extensive research in the area of optimization for production planning and resource allocation. Additionally, there is a significant amount of research in the area of the use of the total landed cost, as well as the implementation of these types of models- using off the shelf software versus completely custom software. However, the models have to be implemented with a strong understanding for the business and organization they will be used in and the data validation component is critical.

3 FOOTWEAR MANUFACTURING PLANNING

The purpose of this chapter is to introduce the department in which the master planning takes place. This chapter will explain the current planning process and manufacturing network to give context to where the model will fit into the organization.

3.1 GLOBAL FOOTWEAR PLANNING ORGANIZATION

The strategic planning functions and high-level production planning functions are located at the Global Headquarters. The Global Footwear Planning (GFP) team is responsible for demand planning, long-term capacity planning, near term factory assignments, and managing the production sourcing process, among other responsibilities. This team works intimately with the footwear development team to ensure products are produced in the most appropriate factories for the product. GFP also works hand in hand with each geography team to ensure that the products are delivered according to plan. Information about the organizational structure and Nike has been summarized by Giacomantonio(2013), and describes an organization that is a strong matrix, and one that requires a lot of cross-functional interaction.

3.2 FOOTWEAR MANUFACTURING NETWORK

Nike uses a contract-manufacturing network for the majority of its footwear production. On Nike's website, they report 1,034 factories, 14% of which are footwear factories. The publicly available data can be filtered to show Nike Brand, footwear factories. The manufacturing network consists of factory groups. Each factory group may have one or many factories producing Nike products. There are 107 factories in 12 countries for footwear. While the manufacturing spans most continents, the factories are predominantly located in China, India, Vietnam and Indonesia.

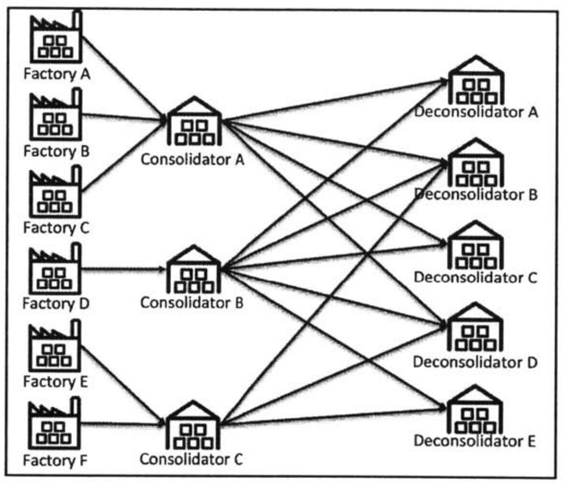


Figure 5- Simplified View of Nike Upstream Supply Chain

Nike handles distribution through a consolidator and de-consolidator model. As shown in Figure 5, products produced in these many factories are brought together at consolidators located near shipping hubs. The product is then allocated for certain destinations, and shipped to those destinations. Those destinations are typically de-consolidator warehouses, who then divert the product to Nike warehouses, or warehouses of customers.

This project will focus on ensuring that the sourcing plan developed is feasible, and the product is planned to be in the right place at the right time. This project will focus on getting product to the consolidator and in transit to the deconsolidator. The downstream processes are not included.

The factories are located for the most part in Asia. The factories ship product to the Consolidator at the shipping port. There are situations were many factories have products consolidated on containers to destination countries, and other consolidators that may serve only one sandals factory in that region. The deconsolidators are located in the destination countries. From the deconsolidators, product will go on to a customer warehouse or Nike warehouse depending on the end customer.

3.3 Sandals Manufacturing

Within the footwear-manufacturing network, sandals are produced in either dedicated factories or with dedicated capacity at factories. This is due to the difference in manufacturing equipment needed to make sneakers versus sandals. At these factories, the sandals capacity is determined by the machinery located at that facility and by the complexity of the mix of products being produced on the line. There are 13 of these locations with dedicated capacity for sandals.

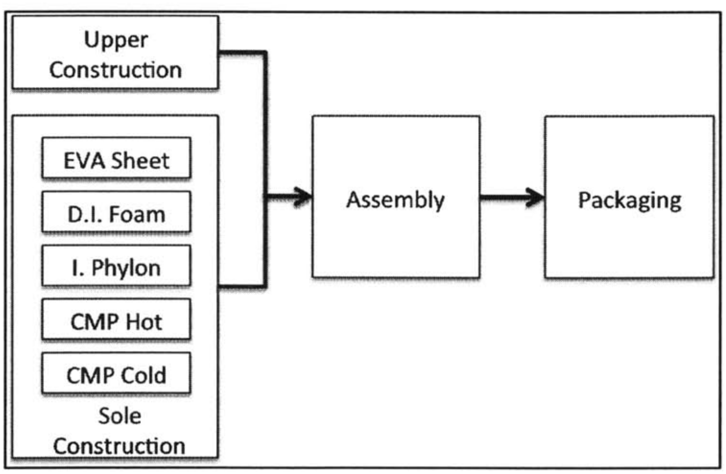


Figure 6 - Sandals Manufacturing Overview

The overall manufacturing process is shown above in Figure 6. The process begins with creating the upper, strap or toe thong, and creating the sole. The sole may be the combination of layers of different materials. This process may require injecting a material into a cavity to form the sole, or stamping a shape out of a foam material. The pieces are then assembled together manually, and packaged for shipment.

3.3.1 Construction Methods

The construction method refers to the method of production used in creating that sandal. There are 5 different methods that require distinct machinery: Injected Phylon, Dual Injection Foam, CMP Hot Press, CMP Cold Press, Eva Sheet. In addition to these processes, sandals also require manual labor that cannot be performed by machine.

3.3.2 Outsole Codes

The outsole code (O/S code) refers to the molding cavity needed to produce the sandal. Multiple sandals will share an O/S code.

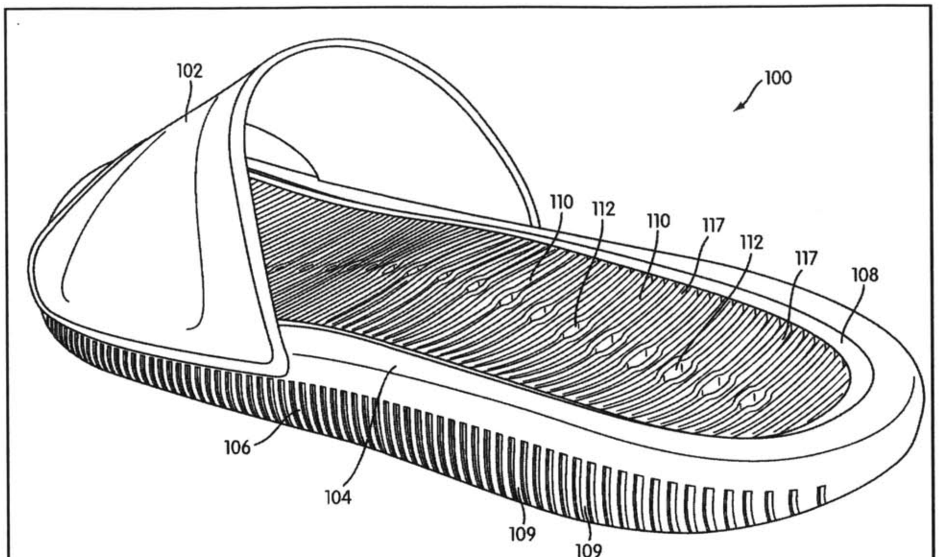


FIG. 1

Figure 7- Sandal Schematic (Sarantakos (2008))

In Figure 7, the basic components of a sandal are shown. 102 is the upper of the sandal. For flip-flop style sandals this may also be referred to as the toe thong. 104 is the sole of the sandal and 106 is the outsole of the sandal. In other variations there may be a layer between 106 and 104 that would be known as the midsole, or insole when appropriate. There may be different variations of sandals that use the same outsole, but have a different upper. Attaching one upper versus another is not a production constraint. The manufacturing constraint is on the outsole. Each outsole will have an associated construction method as discussed in 3.3.1. Nike aggregates the sandals into O/S code groups to make the problem more manageable. The molds specific to each outsole are also referred to as the tooling. The outsole material is injected into the mold cavity. The molds determine the whole shape of the outsole. The tooling comes in the standard footwear sizes for men, women and children.

Product Classification

For the purposes of this project, O/S Code will be synonymous with Product. The decision variables represented in the model are dependent on the O/S Code of the sandal, and therefore by the product. There are 71 different products to model.

3.3.3 FLEXIBLE MANUFACTURING

The current manufacturing network is already set up to be flexible, and the goal of this project is not to change that strategy. Most sandals are produced in more than one factory to hedge against demand changes or other risks. Additionally, not every factory can manufacture each construction method, but the machinery for each construction method exists in at least two factories. The current design has been developed over time through organic growth. Figure 6 below represents the flexibility within factories. On the left hand side is a sample of factories and on the right is a set of popular products. Flexible manufacturing, if achieved properly, according to Simchi-Levi (2010), allows the supply chain to react to changes quickly with no additional cost and little to no delay in delivering the product. Figure 8 represents the top sandals products and their factories. Here, the design is very close to the strategy outlined by Simchi-Levi, and the optimization model will only change these assignments if truly financially beneficial.

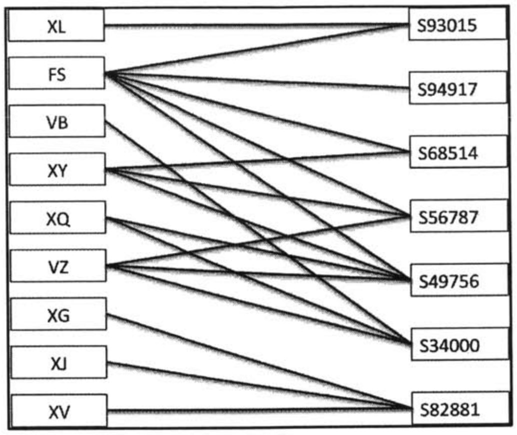


Figure 8- Existing Production Flexibility

3.4 Planning Process

3.4.1 Seasons

The planning process revolves around the fashion seasons: Spring, Summer, Fall, Holiday. For the sandals products, there are two seasons. Spring and Summer are considered collectively to be a season and Fall and Holiday are combined to make one season. This helps the team to manage what styles are being released when, and to manage the demand patterns. Sandals products are heavily seasonal. This strong seasonality is shown below in Figure 9. There is a large peak in demand in the late springtime and early summer, and less demand during the fall and winter months. The seasonality of demand is predictably consistent from year to year. Due to this seasonality, there is less capacity reserved at the manufacturing locations for the Fall-Holiday season. For the sandals products, the capacity, when graphed, typically has a bell curve shape to it for the year to mimic the seasonality and therefore available capacity from the factory. Nike achieves this flexibility in capacity and ability to mitigate the seasonality of demand by shutting down some factories in the off-season and moving the employees to other production lines, and by reducing the number of shifts that the factory works.

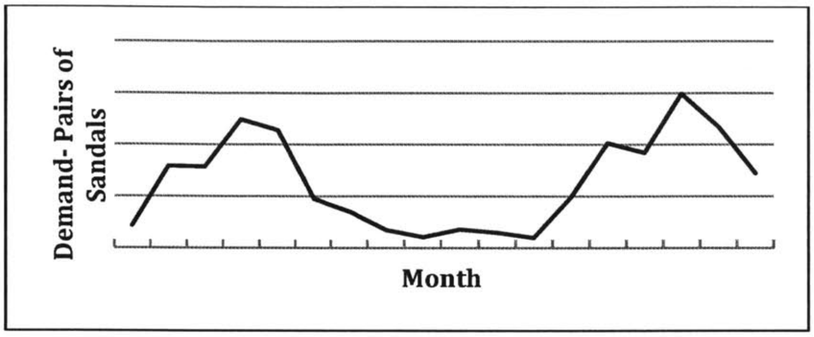


Figure 9- Seasonality of Product Demand by Time for all Sandals Combined, over 18months.

3.4.2 Planning Phases

The planning process for the manufacturing takes place over a multi-year time horizon. There are five phases to the process. The planning begins a few years out with a rolling look at the overall network capacity and as production for that season becomes closer, the planning becomes more granular. Each step of the planning process will be described below. The phases of the planning process can also be seen below in Figure 10. This project will focus on Phase 3 and 4 of the planning process.

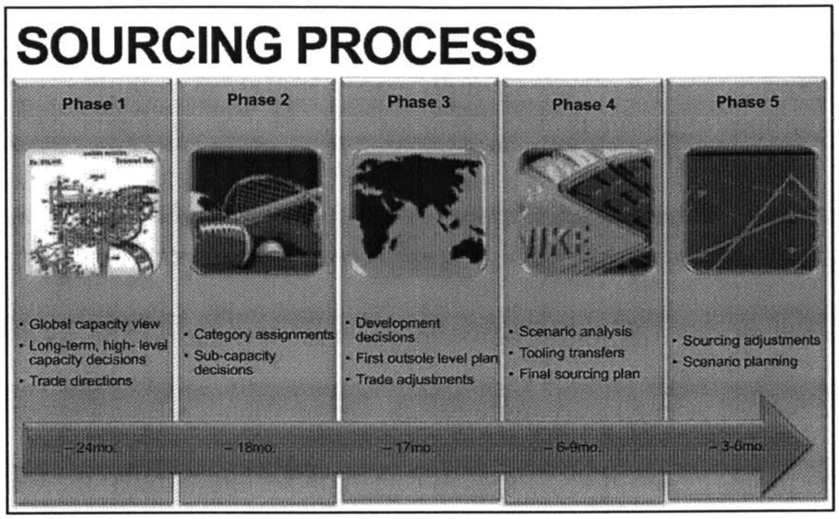


Figure 10- Master Planning Timeline

Phase 1

Key Decisions	New Information Available
• Capital investment in existing factories • Add new factories • Which countries to focus on	• Company strategy • Growth projections

Two or more years before production of a given season, the overall factory capacity is addressed. The inputs to this process are the overall factory capacities, the target growth of the company and forecasts at an aggregate level, which could be as general as all of sandals, or all of basketball shoes combined. At this point, production is too far away to have an accurate forecast for specific types of footwear since they haven't even been designed yet. During this phase, decisions to grow with certain factory partners are discussed, including any decisions due to trade agreements. The overall manufacturing and capacity strategy is analyzed by senior management.

Phase 2

Key Decisions	New Information Available
• Overall types of products a factory will be making • Investment in machinery by construction method	• Capacity projections based on Phase 1 • Category Forecast

As time moves forward, around 18 months before production of a season, the specific factories and product lines are looked at in slightly more detail. This is when GFP will make sure that there is enough of the proper types of capacities in certain factories, and that there are enough factories to make certain items. For example, some factories have made a lot of soccer cleats and are able to make them well, so the capacity of these factories and the soccer cleat demand will be addressed. At this time it is also important to start ensuring there are multiple sources for certain products as well. Using the soccer cleat example, it would be risky to have all soccer cleats come from one country or one factory, so it is important to ensure that there is flexibility and redundancies in the network.

Phase 3

Key Decisions	New Information Available
• Where new products will be manufactured • Needs for additional capacity • Production location for most existing products	• Forecast by outsole • Construction method capacity • New products being developed

During Phase 3, more of the products have been finalized for a season. This process occurs between 12 to 18 months before production. During Phase 3, the products start to be allocated to different factories. Rather than at the product group level (like in Phase 2), Phase 3 starts to look at the specific products. This is especially important for brand new products. A good portion of each season is new products that need to be developed. During Phase 3, the factory who will be developing the shoe is chosen. The factory that develops the shoe is also, ideally, the factory who will produce the shoe. These decisions include the cost of adding or moving tooling. At this point it is critical to make sure that the manufacturing plan is by product and by month for each factory. The forecast is still fairly rough, and placeholder volumes may be used, but assignments to factories are beginning, and the factories are involved in weekly communication at this point.

Phase 4

Key Decisions	**New Information Available**
• Manufacturing plan for all products	• Forecast by product number (including color and size)

During Phase 4, the manufacturing plan is set. The forecast from Phase 3 has now been refined, and the products have been determined. This planning phase occurs 6 to 9 months before product launch. It is a more detailed plan than in Phase 3 with fewer placeholder volumes being used, and the factories need to be balanced for capacity. The balancing of volumes between factories occurs through a series of meetings where planners determine as a group, which factories are over capacity and which factories are under capacity. They change the sourcing assignments, and re-calculate the capacity. Each week the planners are communicating with the factories to ensure the plan is feasible. This process continues until each factory is above the minimum required utilization but below the factory and construction method capacities.

Phase 5

Key Decisions	New Information Available
• Changes to the manufacturing plan • Contingency plans for products whose forecasts change	• Updated forecast information • Some sales data

When Phase 5 begins, production is just beginning or has begun. Communication with the factories is happening on a daily or weekly basis, now. At this point, if there are large changes to the forecast, the manufacturing plan will be adjusted as best as possible to account for those changes. This might mean having one factory produce more or less of an item, and therefore another factory also produces more or less of that item. It is mainly for fine tuning based on business decisions that have changed, or better forecast knowledge.

3.5 Summary

The footwear-manufacturing network is large, and the supply chain is long. Within the sandals category, the products are complex, require specific machinery, and the demand is highly seasonal. These reasons, coupled with the tools that exist today, make the planning process lengthy and challenging.

4 Planning Model

The goal of this pilot project is to figure out if an optimization model would make the current planning process easier and less costly. The process is working today, but it is cumbersome, difficult to scale for the future and highly manual. The future state should make the process quicker and more data driven. The goal is to put all of the data in one place and include all of the information Nike has in the model to determine the lowest total landed cost for delivering the product on time. Additionally, it will give Nike the ability to perform what-if scenario planning. This model will be a pilot, and will be adapted and expanded to other products based on feedback from use.

This chapter will cover the model that was built, including the mathematical formulation and the software used.

4.1 SOFTWARE

4.1.1 SELECTION

Nike has a relationship with Llamasoft, the company that has developed Supply Chain Guru. Supply Chain Guru is designed for modeling a supply chain and performing network flow optimization, as well as inventory optimization and greenfield analysis.

As part of this relationship, there are representatives from Llamasoft working full-time on site at Nike. There are many pieces of packaged software on the market for optimization and for network flow optimization, but with the co-location of the Llamasoft employees, the use of their software, and most importantly, the support of the software could be tightly integrated during the model build, implementation and post-implementation phases.

Tableau was selected for the outputs of the model. Tableau is a software gaining popularity at Nike, so the users of the model are becoming familiar with it. It is a software package that can interface with Supply Chain Guru, Excel and Access to easily visualize data, and have pre-set graphs which can be populated by the Supply Chain Guru model, and easily manipulated by the end user.

4.1.2 USE

The model is constructed using Llamasoft Supply Chain Guru. The software is an easy-to-use interface over a set of database tables. The software takes the tables and builds the optimization model and uses the FICO Inc. Mosel optimization solver to perform the calculations.

In addition to Supply Chain Guru, the model uses Llamasoft Data Guru to manage the inputs. This software allows some of the data to be updated automatically from the databases that exist within Nike already. This software also makes it possible for the end user to update the data through an excel interface which the user is more familiar with. Figure 11 shows a sample input screen. The user interfaces with Microsoft Excel tables to ensure the input data is correct, and modifies any data that needs to be updated.

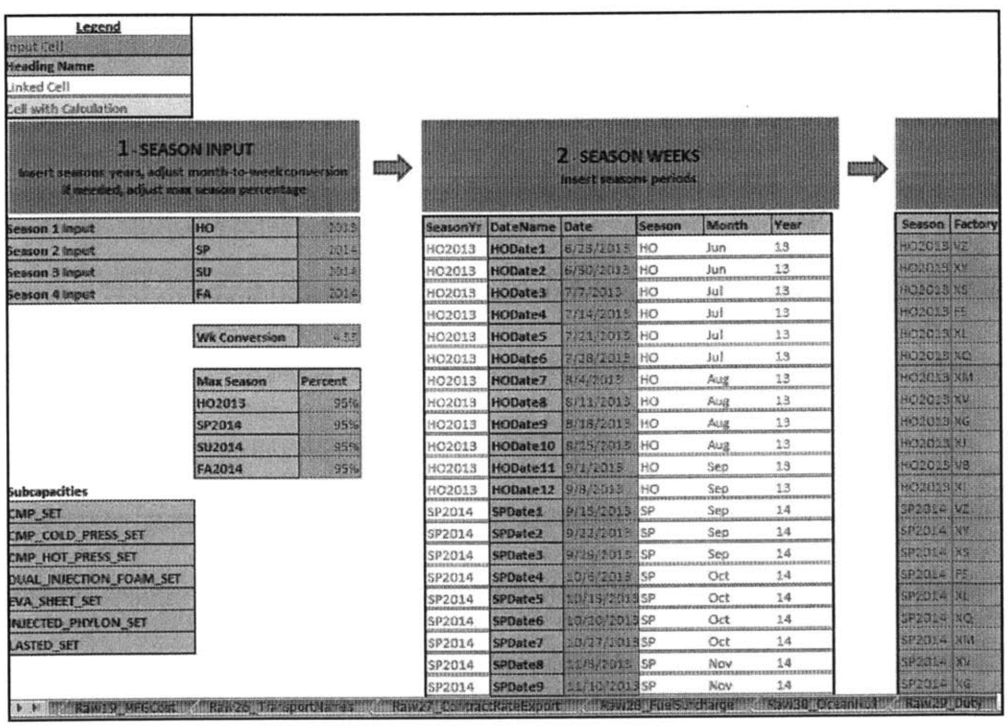


Figure 11- User Interface Screen

4.2 OBJECTIVE & DECISION VARIABLES

The objective of the model is to minimize the total landed cost for the entire horizon. The total landed cost in this case is the sum of the manufacturing cost, transportation cost, taxes and duties, holding cost and tooling cost.

4.2.1 DECISION VARIABLES

X_{ijklm}: Production of item i at factory j of construction method k during time l for country m

R_{ilm}: Inventory of item i during time l for country m

Y_{ij}: Binary variable, whether product i is being produced at factory j

4.2.2 OBJECTIVE FUNCTION

$$\text{Min} \underbrace{\sum_{i=1}^{I}\sum_{j=1}^{J}\left(M_{ij}\cdot\sum_{l=1}^{L}\sum_{k=1}^{K}\sum_{m=1}^{M}X_{ijklm}\right)}_{\text{Manufacturing Cost}} + \underbrace{\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{m=1}^{M}\left(T_{ijm}\cdot\sum_{k=1}^{K}\sum_{l=1}^{L}X_{ijklm}\right)}_{\text{Transportation Cost}}$$

$$+\underbrace{\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{m=1}^{M}\left(T_{ijm}\cdot\sum_{k=1}^{K}\sum_{l=1}^{L}X_{ijklm}\right)}_{\text{Taxes and Duties}} + \underbrace{\sum_{i=1}^{I}\left(F_{i}\sum_{l=1}^{L}H_{il}\sum_{m=1}^{M}R_{ilm}\right)}_{\text{Holding Cost}} + \underbrace{\sum_{i=1}^{I}\sum_{j=1}^{J}Y_{ij}C_{ij}}_{\text{Tooling Cost}}$$

4.2.3 TOTAL LANDED COST COMPONENTS

Manufacturing Cost

The manufacturing cost is calculated per unit by factory and product. These costs include labor, materials, and factory overhead by product and factory.

Transportation Cost

The transportation cost is calculated per unit by item, source factory and destination country. There is an average number of shoes that can fit into a shipping container, and the per unit cost is an average value based on the number of shoes that usually fit. The transportation for sandals will only happen via ocean freight as their value is too low to air freight them and the company does not allow it. The transportation lanes used to calculate the cost is the shipping port source to shipping port destination, the on the ground costs once the product reaches the destination are not included. This is because they vary to greatly based on if the product goes to a warehouse, or to the customer. The port to port decision is what Nike will know every time and can make a decision on. The ground costs will occur regardless of which factory originally shipped the product.

Taxes and Duties

The taxes and duties are by product and source and destination. They are either a flat rate per pair or a percentage of the value of the shoe. This cost per pair is represented by T_{ijm}. Depending on where the product is coming from and where it is going, there can be substantial trade implications.

Holding Cost

The holding cost is associated with any inventory that a factory or consolidator has. Here, it is a percentage of the value of the product per time period.

Tooling Cost

The tooling cost is the fixed cost associated with producing a particular product at a factory. It is a fixed cost multiplied by whether or not that product is being produced in that factory. There are cavities that form the outside of the sandal, this is known as the tooling. The tooling for a particular outsole needs to exist at the factory. If the tooling already exists in a factory today, the cost is zero.

4.3 PARAMETERS

I: number of products
J: number of factories
K: number of construction methods
L: number of time periods
M: number of destination countries

M_{ij}: manufacturing cost of product i in factory j
T_{ijm}: transportation cost of product i from factory j to country m
P_{ijm}: tax and duty cost of product i from factory j to country m
H_{il}: holding cost percentage for product i in time period l
F_i: value of product i
R_{ilm}: inventory of product i, in time period l in country m
C_{ij}: cost of tooling equipment for product i at factory j
D_{ilm}: demand for product i in time period l in country m
W_{jl}: capacity of factory j in time period l
U_{jkl}: capacity of construction method k at factory j in time period l
B_l: total inventory cap for time period l
A_i: minimum number of factories producing product i (optional)
E_i: maximum number of factories producing product i (optional)
N_{jl}: minimum percent utilization of factory j in time period l (optional)
V_{jl}: maximum percent utilization of factory j in time period l (optional)

4.4 CONSTRAINTS

There are a number of constraints applied for the solution to this model to be feasible.

Inventory Definition

$$\boldsymbol{R_{ilm} = R_{i,l-1,m} + \sum_{j=1}^{J}\sum_{k=1}^{K} X_{ijklm} - D_{ilm} \quad \forall\, i, l, m}$$

The inventory for a given period is equal to the inventory from the previous period, in addition to anything that was produced in the given period and the demand for the given period.

All Demand Must Be Met

$$R_{i,l-1,m} + \sum_{j=1}^{J}\sum_{k=1}^{K} X_{ijlkm} \geq D_{ilm} \quad \forall\, i, l, m$$

Demand can be fulfilled by product produced in the current, or a previous period.

Factory Capacity

$$\sum_{i=1}^{I}\sum_{k=1}^{K}\sum_{m=1}^{M} X_{ijklm} \leq W_{jl} \quad \forall j, l$$

The production for a given time period cannot exceed the factory capacity for that time period.

Construction Method Capacity

$$\sum_{i=1}^{I}\sum_{m=1}^{M} X_{ijklm} \leq U_{jkl} \quad \forall j, k, l$$

The production of a specific construction method cannot exceed the capacity at a factory for that specific construction method. Depending on the factory, the capacity of the machinery to make certain construction methods may exceed the overall factory capacity and it is important to constrain each separately to manage the product mix.

Inventory Cap

$$\sum_{i=1}^{I}\sum_{m=1}^{M} R_{ilm} \leq B_l \quad \forall l$$

Due to the seasonal nature of the business, there is only so much inventory that the company expects to have on hand from time period to time period. This cap is the total number of pairs of sandals set by the business but can be adjusted as needed. This constraint is meant to prevent too many pairs of shoes being produced in periods before they are demanded, where each sandal is treated equally.

Maximum and Minimum Number of Production Locations

$$\sum_{j=1}^{J} Y_{ij} \leq E_i \quad \forall i \qquad \sum_{j=1}^{J} Y_{ij} \geq A_i \quad \forall i$$

Many sandals are very important to the company and due to risk mitigation; those products need to be produced in at least a few locations. Additionally, to manage the product mix at certain factories, for some, more complicated sandals, there is a maximum to the number of factories that should be producing those sandals. This is also an optional constraint that the organization can use or not use depending on the product, and what they are using the model to investigate.

Factory Minimum and Maximum Utilization

$$\sum_{i=1}^{I}\sum_{k=1}^{K}\sum_{m=1}^{M} \boldsymbol{X_{ijklm}} \le \boldsymbol{V_{jl}} \cdot \boldsymbol{W_{jl}} \quad \forall \boldsymbol{j}, \boldsymbol{l}$$

$$\sum_{i=1}^{I}\sum_{k=1}^{K}\sum_{m=1}^{M} \boldsymbol{X_{ijklm}} \ge \boldsymbol{N_{jl}} \cdot \boldsymbol{W_{jl}} \quad \forall \boldsymbol{j}, \boldsymbol{l}$$

Even though each factory has a determined capacity, there are incentives to making sure that a factory is filled above a certain threshold. This is the minimum capacity and it is a percentage of the total factory capacity. For many factories, there are financial incentives to the company to fill the factory even though the per-pair cost might be greater than at another factory. Additionally, to help balance capacity utilization across the network, the factories are planned at a percentage of the total available capacity, and then this utilization percentage can be adjusted as needed. This is an optional constraint that the organization can use or not use depending on the factory, and what they are using the model to investigate.

Product Specific Production Capacity

$$\sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{m=1}^{M} X_{ij} \le Y_{ij} \cdot \sum_{l=1}^{L} W_j$$

When a specific product i is able to be produced in a factory, that quantity X_{ij} must be less than the factory capacity. When a product is not able to be produced in a factory, or that capability is turned off ($Y_{ij} = 0$), the total production quantity of that item in that factory must also be zero.

Binary
$Y_{ij} \in \{0,1\}$

The decision to produce a product at a factory is a binary decision.

Non-Negativity
$R_{ilm}, X_{ijklm} \geq 0$

The inventory and production quantities may not be negative.

4.5 Additional Comments

Demand

The demand is the quantity of each product needed at the consolidator during period l. The demand is divided by destination country to insure that the transportation cost and tariffs are accurately accounted for.

Time Horizon

The time horizon for this model is meant to be one season of production (Spring-Summer, or Fall-Holiday).

Time Increments

The time increments (l) in this model are meant to be one-week each.

Lead-time

One item that needs to be addressed is the production lead-time. For this model, the input demand is the demand at the consolidators. These consolidators are within a 2-day shipment from the factories. All of the transportation lead-time is already taken into consideration into the demand due date. For example, product that is needed in the United States for May 1st, needs to be at the consolidator by March 15th. In this case, March 15th is the date used in the model. These dates are set and already in use by Nike. This is possible because the only shipping method for sandals is ocean freight.

4.6 Model Validation

The validation for this model was done with the subject matter experts (SMEs). Many of the data used in this model had not been combined in any past projects, and therefore the total dollar figures and other high level results were new and could not be compared to past experience. The subject matter experts were used to validate the behavior of the model, the correctness of the data and the results in detail. The forum for the validation was in workshops with the appropriate subject matter experts, the end user, and other key stakeholders. Each session began with a review of how the process should be modeled. Then it was followed by a review of the constraints in the model, and the data in the model. Finally, the behavior that was being seen was reviewed and compared to what was expected to happen. If there were discrepancies, they were discussed one by one and either the model was fixed, or the behavior was explained.

4.6.1 *Concept Models & Input Data*

The validation process was ongoing. In the beginning, once the input data was gathered, it was reviewed with each team that provided the data to ensure that what was being used in the model was an appropriate interpretation of the data. This process occurred more than once throughout the model to ensure the inputs and any assumptions surrounding them were correct. Additionally, at the beginning of the process, a simple concept model was developed to start interpreting the constraints and information from the SMEs. This model began with only a few factories and a handful of products, but by using a small model, the SMEs were able to quickly see how certain constraints would impact the results, and what behavior they might drive. This aided in not only data validation, but the constraint validation. Since the existing process was happening without modeling, it was important for the SMEs to understand the impact of a constraint.

4.6.2 *Historical Data*

Once the full model was created, historical data was used to validate the behavior again. This data was used in a basic planning scenario. The model was validated to ensure that all constraints were adhered to, demand was met, and that the plan looked feasible. The feasibility of the plan, outside of any modeling constraints, was determined by the SMEs. Additionally, the behavior of the model pin pointed sandals that had been an issue. For example, a large volume of a specific sandal had been produced and delivered late during that season. The model was able to point out that capacity shortfall and determine how much additional capacity would have been required to have met demand on time.

4.6.3 *Current Model Behavior*

Using the data for the seasons that the planners were currently using for their existing process, they were able to compare in real-time, how the optimized plan from the model compared to what they were planning with their existing, manual process. For validation of this current season, the actual numbers are not available as the product is just being produced now. However, the SMEs were able to evaluate the plan from the model against their current plan, and for overall feasibility. The final model was updated each time a new demand forecast was received as the season approached. The model was updated three different times with a new demand forecast. Each time, the planners and SMEs went through the plan for each sandal and factory to ensure it was a feasible plan. Additionally, the model was evaluated to ensure each constraint was met, and the input data were correct. Throughout this process any differences between the optimized model solution and what the planners expected to see, were addressed. These differences were not feasibility issues; rather they were attributed to the model using objective cost data, and the planner using some subjectivity and basing plans on what had been done historically, which was not the lowest cost solution.

4.7 Summary

The model was developed using a comprehensive total landed cost approach and Llamasoft software. This model provides the ability to optimize the sourcing plan based on the given data. The model can also help with strategic what-if scenarios. The outputs are easily viewed in a Tableau workbook, in which charts can easily be updated, and modified to display and compare different information. The initial results from the model show significant opportunity for cost savings, and the outputs allow users to quickly determine where to do further investigations.

5 Model Use

The model itself is very simple to use. The Llamasoft software allows for the model to be directly linked to many existing data sources. There are two main categories of use for this model: Execution and Strategic. The execution uses are for tactical planning activities that happen during Phase 3 and Phase 4 of the normal planning process. The inputs for these uses are the best available data as the team knows or has access to. The strategic uses are variations on the data to do scenario planning, or other analysis on the impact of potential changes. The model is also used as reference for the planners because it contains all of the decision-making data in one place.

5.1 Integration & Data Update

It is important to keep the model up-to-date. The model is integrated with the existing GFP database, which contains the up-to-date forecast. Additionally, there is one Excel spreadsheet that contains the other parameter settings and constraints. Each time the end-user would like to run the model, they can import the new forecast from the database and double-check the parameters and constraints in the excel workbook. Through a documented process, they can update the Supply Chain Guru model. Once the optimization completes, the data from the model and decision variable results can be exported to a pre-set Tableau workbook where the end-user can analyze the results and compare different optimization runs or scenarios.

5.2 Execution

The normal planning activities using the model are considered execution based uses. The business is making decisions for manufacturing based on these results.

5.2.1 Factory Assignment

The main use of the model is to determine which factories should be producing which sandals. This is the factory assignment of the production. It also includes how much that factory should make of a certain sandal in a given time period to meet demand. The model would be used each time there is a new forecast, or a significant change to the input data.

One of the outputs of the model is a grid (Figure 12, below) that displays this information. This grid is known to the planners as the "What Moves Where" report, it can also compare different optimization solutions if for example, the planner wanted to see how much the plan changed from the last plan, the last forecast, or wanted to add additional constraints to the model.

Spring-Summer 2014		Factory							
Product	Scenario	C1	D1	D2	A10	A1	A2	A3	A4
S46787	Current Plan								
S46787	Optimized				5,938				
	Difference				(5,938)				
S61362	Current Plan						672,415		
S61362	Optimized				30,149		642,266		
	Difference				(30,149)		30,149		
S68514	Current Plan			619,007					
S68514	Optimized	69,915		549,092					
	Difference	(69,915)		69,915					
S94111	Current Plan						956,748		
S94111	Optimized				15,222		614,407		
	Difference				(15,222)				
S34000	Current Plan		1,505,832			51,339			
S34000	Optimized		1,250,624			306,548			
	Difference		255,208			(255,208)			
S49756	Current Plan			4,276,248					
S49756	Optimized	756,159		1,192,235				688,486	
	Difference	(756,159)		3,084,013				(688,486)	
S85088	Current Plan								
S85088	Optimized	2,843				480,719			
	Difference	(2,843)				(480,719)			
S68027	Current Plan	61,377							
S68027	Optimized	61,377							
	Difference								

Figure 12- What Moves Where Report

Using Figure 12, the planner would compare the previous solution to the model to the current solution of the model and determine what production assignment changes to make. For example, Product S49756 in the current plan shows 4,276,248 pairs of production for the season at factory D2. In the newly Optimized solution, product S49756 should be produced at factories C1 and A3 in addition to D2. While the total number of pairs of sandals is not changing, the change in volume at each factory represents the most optimal solution given the current inputs. This could be due to a change in forecast of another product that could only be produced at Factory D, or it could be due to a change in cost, or another parameter or piece of data that was changed.

In addition to the "What Moves Where" report, the Tableau workbook, which is populated with the optimization results, can show the factory utilization, construction method utilization, visual graphs of the sourcing plan, and a review of all of the inputs.

Each time the model is run, the planner will need to use their best judgment on which changes to accept. For example, if the model suggests a change in production that is inconsequential, or has other impacts that a person can interpret, they should not blindly follow what the model is telling them, but based on the cost and inputs that the model considers, it is the optimal solution.

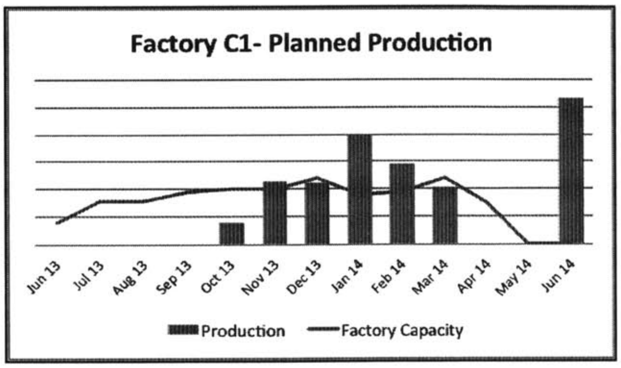
Factory Group Variant

The planner can also choose whether or not to constrain the model by the factory group. The factory group refers to who owns the factory. For example, Chang Shin has four different factory locations(Nike 2013 Manufacturing). Chang Shin would be the factory group, and each individual factory would have its own name within that group. It can be easier to re-allocate production volumes and products within one factory company, than to move that production to another company. For sandals, this would not typically be done, but reallocation could be considered as time gets closer to production.

5.2.2 Current Plan Analysis

The current plan refers to the sourcing plan as it stands before a new optimization solution is presented. This plan would be based on the previous optimization solution, but may include some decisions that were made in contrast to the model results based on business intuition, or data that changed after the model was solved.

The model can be used to analyze the current production plan and capacity in the network. The model can use the current production plan, which may be sub-optimal, and treat it as an output so that it can be compared to the optimized plan within the Tableau workbook. Then the current sourcing plan can compared to the capacity in the whole network, the factory utilization is calculated, and the costs are displayed. This will show the impact of the decisions that were made in disagreement to the optimization. Often decisions are made to change production quantities because the capacity has changed but that change has not yet been fed back into the optimization model.



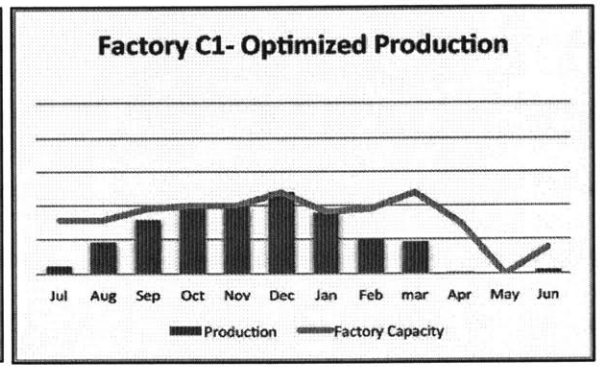


Figure 13- Planned Production at C1

Figure 14- Optimized Production at C1

The ability to look at the capacity compared to the sourcing plan quickly, and visually is helpful to the planners and allows them to target their analysis. Figures 13 and 14 show the Production(bars) and Capacity(line) for Factory C1. It is quickly visible that in Figure 13 that the planned production at C1 exceeds the available capacity and the plan needs to be changed, or capacity needs to be reassessed. Figure 14 shows the optimized solution with Factory C1 production less than capacity.

Factory	Subcapacity	Sep 13	Oct 13	Nov 13	Dec 13	Jan 14	Feb 14	Mar 14
C1	Supcapacity 1	0%	25%	49%	37%	49%	55%	33%
	Supcapacity 2	0%	11%	197%	138%	174%	133%	64%
	Supcapacity 3	0%	18%	62%	66%	206%	108%	71%
	Supcapacity 4	0%	53%	185%	124%	332%	253%	113%
C1 Overall		0%	39%	115%	94%	222%	153%	86%
D2	Supcapacity 1	0%	4%	12%	20%	8%	1%	3%
	Supcapacity 2	0%	0%	0%	0%	0%	0%	0%
	Supcapacity 3	0%	24%	73%	28%	45%	177%	41%
D2 Overall		0%	33%	106%	135%	70%	77%	35%
D1	Supcapacity 1	0%	13%	12%	169%	85%	162%	55%
	Supcapacity 2	0%						0%
D1 Overall		0%	12%	11%	160%	80%	153%	86%
A1	Supcapacity 1	0%	0%	0%	0%	0%	0%	0%
	Supcapacity 2	0%	0%	0%	0%	0%	0%	0%
	Supcapacity 3	0%	0%	0%	0%	0%	0%	0%
	Subcapacity 4				0%	0%	0%	0%
A1 Overall		0%	0%	0%	0%	0%	0%	0%

Figure 15- Utilization for Factory and Construction Method by Month

Similarly, in Figure 15, the planned utilization of a factory and each of the construction methods at the factory is easily visible as a result of the model. These charts help the planners save time. In the past, determining if a factory was over or under capacity was very time consuming due to the multiple construction methods and changing product mix. Ideally, this would not happen because the optimized plan would be used 100% of the time, but there is opportunity for factories to be under or over –loaded if the plat is not adhered to due to business events, and decisions made outside of the model, that are not then fed back into the model.

5.3 STRATEGIC

The model can be used to make strategic decisions that are outside of the day to day planning decisions. This can be done by varying the inputs and constraints in the model to mimic a scenario that the planners want to investigate.

5.3.1 DEMAND/ROBUSTNESS

A strategic use of the model, closely aligned to the execution uses would be robustness analysis, or demand scenarios. Under this analysis, the planner might change the input data to mimic an increase or decrease in demand to see how much the final production plan would change by. Ideally, a small change in demand would not change the production sourcing plan drastically. This can be very beneficial if the demand planners are unsure of how well received a new product might be, and this can be used to build contingency plans.

5.3.2 Additional Scenario Analysis

Other scenarios can be created by the user by varying the parameter values or constraints. Strategic investigations that would be beneficial to the users could be: deciding where to expand future production if labor rates change in certain countries, what the impact of a trade agreement is, what capacity type to be investing in with certain factory groups, evaluating the impact of a demand change in a specific country. This type of analysis can help give guidance to "What-if" questions that arise when planning. The table below outlines various scenarios developed for use throughout the construction, testing and implementation of the pilot model. The use case for each of these scenarios and the adjustments to the model to create the scenario are explained below. This table is not exhaustive of every scenario possible.

SCENARIO USE OVERVIEW

Scenario	**Use Case**	**Constraints & Parameters**
Overall Network	Determining if there is enough capacity in the production network regardless of where the capacity exists. Use as a quick capacity check before further analysis.	Relax the Construction Method Capacity, Inventory Cap, Max and Min No. of Production Locations, Factory Max and Min Utilization constraints
Overall Construction Method	Determining if there is enough machinery in the network for each construction method. Use as a quick capacity check before further analysis. Will pinpoint potential need for capital investment.	Relax the Inventory Cap, Max and Min No. of Production Locations, Factory Max and Min Utilization constraints
Product Demand Change	Determining if there is enough capacity in the network to handle additional sales for an item. Compare scenario result to base model solution.	Change the appropriate demand(D_{ilm}) parameter.
Seasonal Demand Change	Determining if the network can support more demand for a season, if the sourcing plan changes with more demand, and how the plan would change with less demand. Compare scenario result to base model solution.	Change the appropriate demand(D_{ilm}) parameters by a percentage.
Transportation Change	Representing the impact of airfreight or alternative shipment methods for certain products to determine if expediting is appropriate. Compare scenario result to base model solution.	Change the appropriate cost (T_{ijm}) parameters by a percentage, or change the value.
Tax & Duty Change	Representing what could happen to the sourcing plan if certain changes are made to the taxes and duties.	Change the appropriate cost (T_{ijm}) parameters by a percentage, or change the value.
Capacity Change	Determining where to expand production in the future, or where to decrease production.	Change capacity parameters at individual factories, or factories by country (W_{jl}).
Production Delay	Representing the impact of a production delay or capacity change in certain factories.	Change the capacity of the appropriate factory (W_{jl}) and construction method capacities(U_{jkl}).

5.4 Reference

The ability to have all of information contained in one place for the construction of this model has been beneficial on its own. The model is used as reference for data that the team previously had to source from many people across the organization. Now, the data are easily accessible to all of the decision-makers. It saves on time, and reinforces the need for accurate and up-to-date data.

5.5 Summary

The model is integrated with existing systems to make the process of updating the information easy so that the model is kept up-to-date. From an execution point of view, the model is used to help determine factory assignments during planning phases 3 and 4. The model can also be used to evaluate the feasibility of a current production plan. From a strategic point of view, the model can be used for scenario planning and to help analyze the impact of potential changes in any of the variables.

6 Pilot Implementation & Knowledge Transfer

The implementation of the model requires training for and support from the end user and management. In order for the implementation to be successful, it is important for the end user and management to be involved throughout the process

6.1 Involvement

It is important to make people who will be impacted or involved in the process aware of the project and keep people involved throughout the project.

6.1.1 *Make it Visible*

A model like this will frequently involve many groups. It requires transportation data from the logistics group, manufacturing costing data from the costing team, etc. It is important to keep everyone involved in the process, or depending on the person, at least aware of the project. It is helpful to have a larger meeting with those who will be involved to kick-off the project. This way they are not caught off guard when they are asked for a piece of information. Throughout the project, the stakeholders might change, and it would have been better to be proactive in meeting with them individually and presenting the same materials from the initial kick-off meeting as well as the current status.

Having time on the agenda of a larger group meeting can also help. For example, if the department is having a quarterly meeting, a presentation during that meeting serves two purposes: ensuring that people in the department know what and why the project is happening, and showing the senior leader's support for the project by allowing it on the agenda.

It also helps to make it visible by giving the project a name. The optimization model in this project is named SPOT (Sourcing and Production Optimization Tool). In an organization where everything has a name, this helps give credibility to the project and makes it easy to adopt as part of the company culture.

6.1.2 *End User Involvement*

The end user of the model, in this case the planner, was involved throughout the development of the model. As decisions were made the end-user, as a key stakeholder and as a subject matter expert, was able to give much needed advice and feel like their opinions were being considered.

This gives ownership to the end-user throughout the process making them more likely to adopt the process once the pilot and testing phases are complete.

6.1.3 Getting Data

For this project the data was critical. It needed to be aggregated from many sources, and different teams. The involvement of the gatekeepers of data is one of the most important pieces to a successful project. There is often a disconnect between what senior management believes is available for data, and how that data is actually stored. There is typically someone in each group who owns their data. That person feels responsible for whatever model, or presentation that data are used in. It is important to involve the data gatekeepers from the beginning of the project to understand how available certain data are, and to make sure that you understand what the data mean and represent, and most importantly for the gatekeeper to trust that you will not abuse the data. These gatekeepers should be involved in the validation and should understand what the model is being built to achieve. They might have insight into pieces of information that were not in the initial scope of the project but that could be useful.

6.2 Support

Support by stakeholders, and support for those changing their process and going through training is critical.

6.2.1 Management Support

This cannot happen without the support of management. There is a significant amount of time needed from the end-user for the development of this model, for them to sit in training, and change their process at the end, to using the new model. The management needs to be involved throughout the project. They can be a supporter, and also a gate-keeper to help keep the project on track. Adoption of any new business process needs support of the highest levels.

6.2.2 Training

The initial pilot training was conducted through one on one sessions with the end user, through a mixed medium of power points, allowing the end user to play with the model on their own, and working sessions to practice using the model.

6.2.3 Ongoing Support

A model like this cannot be implemented and left alone. It needs to have someone with intimate knowledge available to the end-user if something goes wrong, or a parameter needs to be changed. Additionally, there needs to be support in updating the model. This might come from outside groups supporting the model by emailing a critical data file in time to be used in a new optimization solution.

6.3 Transfer of Modeling Information

In addition to making sure the end users were trained on the model and the model was going to be implemented, there needed to be a transfer of all of the information gained in creating the model. This process occurred through a series of meetings with the modeling successor. Additionally, there were data analysts involved in the project throughout the process, with the plan for them to stay involved as the pilot was expanded.

A guidebook was created to document each step of the process, and track where information came from and who the key contacts are. This document also tracked assumptions made, and the rational for each constraint. The guidebook, along with all of the supporting data and documents are stored on a shared drive for easy access for future modelers. The set-up of the documents within the shared drive is standard for each person who uses that drive to ensure ease of use and understanding.

6.4 Summary

There are a number of action steps that can be taken to ensure a successful implementation. Most important is to keep people involved throughout the process. The level of involvement depends on the person's relationship to the project. Management adoption, end user involvement and ongoing training and support are critical.

7 Initial Results

7.1 Execution

The model played a role in the Spring and Summer 2014 seasons for Nike. The anecdotal evidence has been favorable, as the model assisted with decision-making for production and suggested plans that would have been difficult for an individual to develop on their own. The planners refer to "daisy chain" plans as the most difficult to figure out. This model is able to facilitate this type of plan. A simple example of a "daisy chain" would be moving 20,000pairs from factory B to C of one sandal, and then 20,000 pairs from C to D for another sandal, so that a new sandal can go into factory B. After the Spring/Summer 2014 season, the actual production data, cost data, and any capacity issues can be reviewed and compared to the model to see how well the model performed. During and after the Spring/Summer 2014 season, the planners should review and compare how the planning and execution differed from previous seasons to help in determining how useful the model was, and to determine what changes should be made to the model and process for the next season.

7.2 STRATEGIC

The initial strategic results were solely used for exploratory evaluation while developing the model to show what the results could be. Any analysis using the model for strategic decision-making is company confidential.

7.2.1 LABOR RATES

One of the issues the company is facing is increasing labor rates in some countries, and changing or unpredictable labor rates in other countries. In this analysis the labor rates for the factories in Country B were increased by 30% to begin to understand how that change would impact the manufacturing footprint.

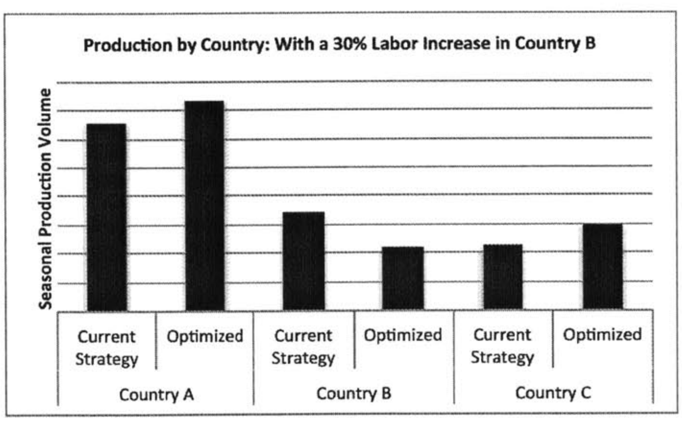


Figure 16- Country B Labor Rate Increase

In Figure 16, the quantity of production in Country B would decrease as a result of the labor increases and the production in Countries A and C would increase. This type of thought process, and use of the model can be used when thinking of where to expand production as the company grows.

7.2.2 TARIFFS

Tariffs, taxes, duties are a substantial cost for Nike and are widely varied depending on the producing country and receiving country. A well known example of this is the cost to ship product from China into Brazil. Tariffs change frequently based on different government partnerships and regulatory legislation. The benefits to having tariffs in this model are two fold. First, they were not directly analyzed in the past when determining the production sourcing- they were something that planners considered but they were not factored into the initial cost. Second, by being able to change the tariffs in the model and see the impacts on certain trade decisions, it can help Nike plan future production more strategically, and understand the impacts both positive and negative to certain trade legislation across the globe.

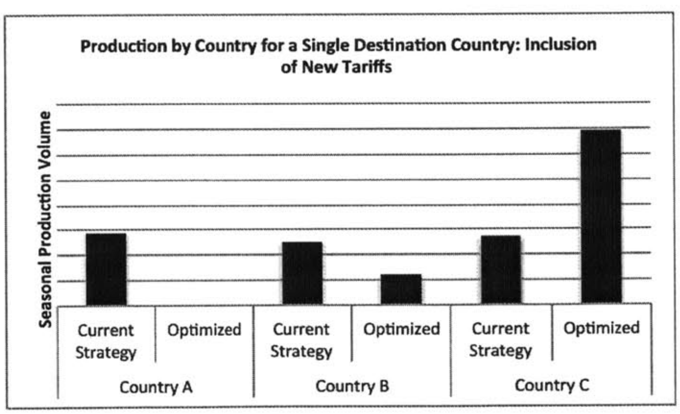


Figure 17- Impact to Production by Country from

Inclusion of new Tariffs at a destination country

In Figure 17, it becomes clear that when new tariffs for a country are included in the model, the source of the production for that country shifts completely out of Country A, and into Countries B and C. This type of analysis is important because it helps to understand where certain types of products should be made or imported, especially since some types of sandals are more/less popular in different countries.

7.3 Cost Savings

There are significant forecasted cost savings based on the optimization model. Looking forward to 2014, the plan that was generated with optimization, (compared to the plan without optimization) shows a savings of 3.8% to 10.4% of the total spend. The former is if the model is constrained to only allow production to be transferred from one factory to another if those factories are in the same factory group. The latter is more common for sandals. It would allow any product to be produced in any factory regardless of the factory group it belongs to. The majority of the savings is attributed to having the ability to now optimize based on the lowest total cost, and maximize the use of the lowest cost factories. These savings are represented below in Figure 18.

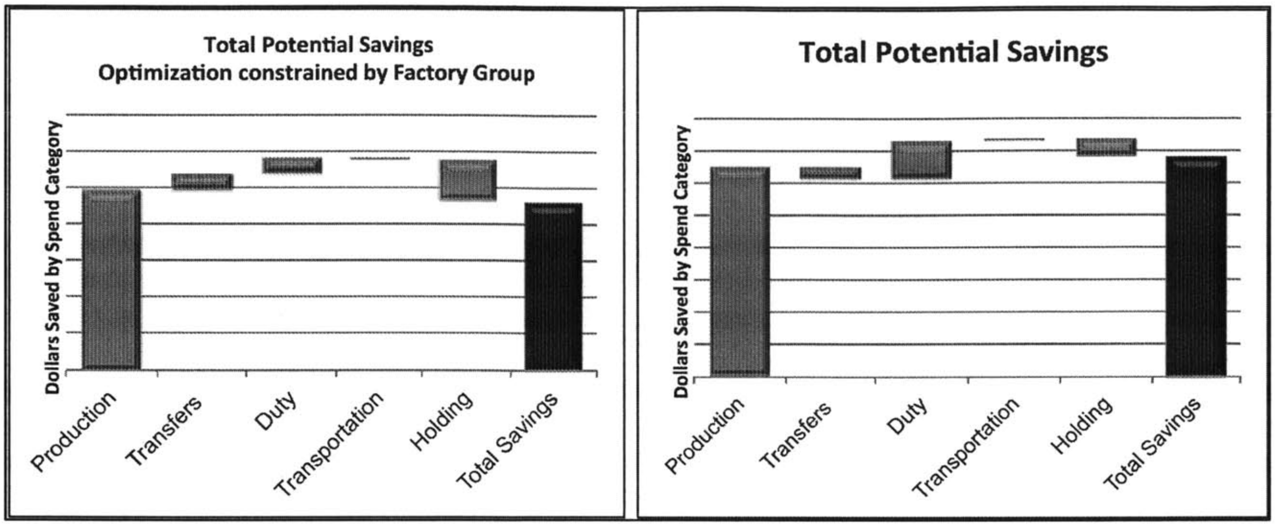


Figure 18- Potential Savings by Category

7.4 Information Sharing

The framework of this model, the data collection that went into creating the model, and process to update that data has helped the GFP group in communication among its own employees and through information sharing across groups. The ability to have all of their decision-making data in one place has made conversations with GFP and other groups more streamlined, and actionable because everyone has all of the data in front of them.

7.5 Pilot Expansion

Based on the initial results, the expansion of this pilot is now underway. Other product groups using this modeling framework, are having similar success.

7.6 Summary

There have been positive initial results with the use of the model. The model has already helped with the planning of the next Spring and Summer sandals season. Based on the plans created without the optimization model using Nike's previous process, the optimized plan has the potential for 3-10% savings. Strategically, the model has been shown to be able to perform analysis of interest to the footwear leadership. The layout of the model also allows the GFP team to access all of their data in one location.

8 CONCLUSIONS & RECOMMENDATIONS

8.1 PROJECT CONCLUSIONS

The outputs from the model show that there are significant savings opportunities from this type of modeling and its worth the investment needed to create the model. The model may not speed up the entire planning process but it will give tangible data to the team to use for decision-making. It allows for fact-based comparisons between scenarios and strategic investigations. Through this fact-based approach, the model can prove or disprove gut feelings. This type of model can be continuously improved and adapted to improve the quality and accuracy of the output. In a few months, after tracking what production decisions were made with and without the model, Nike will have more concrete data to support or disprove the financial savings from this model. They will be able to compare the cost to produce product for the Spring/Summer 2014 season, as well as the ability to deliver product on time to previous seasons. However, the anecdotal evidence is favorable and the pilot expansion has begun.

A model implementation like this needs complete buy-in and support from key stakeholders. Management needs to be supportive, and key stakeholders need to be involved throughout the whole process. The support of the end user, and the ongoing training and support are key to long-term success.

8.2 Recommendations for other areas of research

There are a number of areas for continuing work on the model, and doing research in similar areas. As in Quinonez(2013), this model could be adjusted to include the risk adjusted cost. It could also include the Manufacturing Risk index or Country Risk index as a constraint, or objective function.

Outside of the model, within the planning process, a process map can be developed now that this optimization model exists. The map could explore why things are done the way they are, and can reassess the way to go about planning. The profiling process would also be something worth exploring.

Additionally, the upstream planning process should be investigated by including the profiling process, and capacity planning. There could be considerable value in looking into optimization or modeling techniques for these processes.

Finally, and most importantly, the addition of a simulation or way to assess variability should be added to this model and considered in context with the entire planning process. One example for this would be adding Monte Carlo simulation around the demand and certain costs. There is significant variability at the time capacity and production is planned, and simulation would help address this variability.

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