2018-2019 Academic Year

# SIMULATION-BASED OPTIMIZATION FOR INVENTORY MANAGEMENT IN TEXTILE INDUSTRY

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## INTRODUCTION

In supply chain processes, effective order management has an important role. It is aimed to deliver the requested product to the customer in a fast and high-quality manner in this process. One of the most critical points in managing the process is to accurately identify customer demands and to determine appropriate inventory control policies in line with these demands. This study is carried out with ORTA ANADOLU TİC. ve SAN. İŞL. T.A.Ş. company which produces high-quality denim fabrics for its worldwide customers as the second biggest producer in Europe. In this study, the inventory management process of the fabric samples has been examined to simulate the current system. Then, a heuristic approach has been implemented to determine inventory levels of the samples that minimize inventory costs while satisfying the customer demands. The aim of this study is to control the high costs arising from excess inventory which is a result of management based on non-scientific methods. Moreover, some of the requested samples are to be prevented from being sent to customers late due to lack of inventory.

## CURRENT SYSTEM


**KAYSERİ FACTORY**

-There are two different samples;


-With different fabric type, washing type and color, there are 2026 sample types.
-Daily production capacity is 150 for garments.
-They send samples to warehouse everday.
-Inventory levels in warehouse is checked in every three weeks.
-If inventory level is decreased to a certain amount, they produce and send samples to warehouse.

**WAREHOUSE**

-There are 25 sales offices worldwide. They request samples from warehouse to send potential customers.
-According to sales offices' demand, warehouse requests samples from Kayseri factory.
-Samples are sent in one or two days if samples are requested from Turkey.
-If samples are requested from abroad, they are sent in five or six days.

## PROBLEM DEFINITION

The department determines production plan and inventory level to be kept in the warehouse mostly based on a non-scientific method. In addition, product variety is very large. Thus, it is very difficult to determine the inventory level in the most appropriate way in the department. Consequently, the department faces overstock or insufficient stock in İstanbul warehouse and these situations bring other problems along.

**OVERSTOCK**

**High total inventory cost**
**Warehouse management difficulty**

**OUT OF STOCK**

**10-15 days delay for the delivery of required sample**
Conflict in production plan

All samples are sent to customers free of charge, thus there is no profit gain. Overstock and insufficient stock situations affect potential sales adversely.

## METHODOLOGY


### DATA & PREPROCESSING

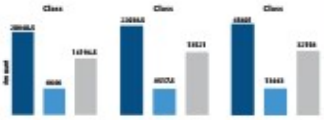
In this study, the order and production data from 2015 to 2018 are used. The production data consists of sample features produced in Kayseri, then sent to Beylikdüzü warehouse, and the order data includes sample features sent from Beylikdüzü warehouse to customers. These features are fabric types, sales volume of fabrics, delivery date of order, the number of samples sent to the customer and type of sample (garments/color charts of fabrics).

$$2026 \text{ different sample types} - \left( 171 \text{ samples with no production data} + 160 \text{ samples with negative inventory} \right) = 1695 \text{ sample remained to classify}$$

### CLASSIFICATION

1695 samples are put into five different pareto analyses. The parameters are defined as total amount of samples delivered to the customers, inventory levels, sales volume of fabric types, number of delivery, number of different customers. It is expected to have highest parameters' values for Class A samples which are the most critical samples.

- The samples that are in the first 80% of all pareto results are the ones that create the Class A.
- The samples that are in the first 95% of all pareto results and except Class A are the ones that create the Class B.
- The rest of the samples that are neither in the first 80% nor the 95% of all pareto results are the ones that create the Class C.


### SIMULATION

After classifying the samples as Class A, B and C, (Q, R) model for selecting a batch size Q and reorder point R in the continuous review inventory policy is implemented. Continuous review policy is performed, because there is a low stochastic demand, and replenishment can be ordered at any time. Within this policy, inventory levels are continuously checked and if the inventory level drops to R, a batch size of Q is ordered. Firstly, distributions of interarrival times and customer orders of samples are gathered as in Table 1. Then, simulation model for Class A samples is created.

Table 1. Statistical distributions of color chart and garment data

| Sample | Color Chart | | Garment | |
|---|---|---|---|---|
| | Interarrival Times (Day) | Order Amount | Interarrival Times (Day) | Order Amount |
| A1 | EXPO(4,65) | POIS(0,89) | EXPO(1,052) | POIS(0,7) |
| A2 | EXPO(2,152) | POIS(0,64) | EXPO(1,119) | POIS(0,615) |
| A3 | EXPO(2,157) | POIS(0,73) | EXPO(1,244) | POIS(0,615) |
| - | - | - | - | - |
| - | - | - | - | - |
| - | - | - | - | - |
| A66 | EXPO(15,5) | Constant (1) | EXPO(9,149) | POIS(0,333) |
| A67 | EXPO(7,167) | Constant (1) | EXPO(3,145) | POIS(0,375) |
| A68 | EXPO(5,833) | Constant (1) | EXPO(0,7) | POIS(0,333) |

After integration of these values to the model, current inventory system is simulated with the determination of R and Q values for each sample belongs to Class A.

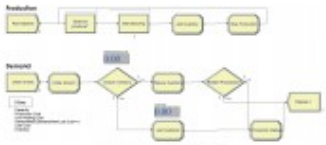


Figure 2. Arena simulation model

Table 2 shows the current inventories obtained from the company and inventory simulation results for Color Chart and Garment samples. In current situation, total inventory for color chart is 1622 samples while it is 1876 for garment. Considering the current inventory levels, current Q and R values are determined and inventory system is simulated with 4% deviation in inventory for each sample type.

Table 2. Simulation results of current Q, R values and inventory

| Sample | Color Chart | | | Garment | | |
|---|---|---|---|---|---|---|
| | Current Inventory | Current (Q, R) | Inventory (Simulation Results) | Current Inventory | Current (Q, R) | Inventory (Simulation Results) |
| A1 | 32 | (16, 16) | 16 | 43 | (16, 16) | 43 |
| A2 | 9 | (16, 8) | 9 | 17 | (16, 16) | 17 |
| A3 | 9 | (16, 8) | 9 | 16 | (32, 16) | 16 |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| A66 | 17 | (32, 16) | 16 | 46 | (32, 16) | 46 |
| A67 | 16 | (32, 16) | 32 | 46 | (32, 16) | 46 |
| A68 | 31 | (32, 16) | 27 | 47 | (32, 16) | 46 |
| | 1622 | | 1562 | 1876 | | 1802 |

### SIMULATION OPTIMIZATION

The aim is to optimize simulated system to obtain near-optimal values for new reorder point and batch size that minimize total inventory cost for each sample in Class A. Thus, OptQuest, a search algorithm that combines three metaheuristic methods which are Tabu Search, Neural Networks and Scatter Search is used. This combined algorithm moves around in the control space and try to find reliably optimal point. Decision variables of the model, which are reorder point and batch size, are bounded with (2,10) and (4,15) respectively by company responsibles.
In the model, only holding cost and total production cost of samples are considered.

Holding Cost = (Production cost) × Interest Rate
Total Inventory Cost = (Holding Cost + Production Cost) × (Inventory Level)

Constraints:
(1) Service Level >= 0.9
(2) Inventory Level <= Capacity
(3) Batch Size >= Reorder Point

In constraint (1), service level, which is the rate of demand that can be satisfied immediately from stock on hand, is indicated as should be greater than 90% by company.

Service Level = Demand Met / (Demand Met + Lost Customers + 1)

In the model, capacity constraint and (Q, R) policy constraint are defined as

## RESULTS

In Table 3, current system and simulation optimization results are shown for Color Chart and Garment samples. Total inventory is obtained as 472 and 426 samples respectively. New Q and R values are determined with minimum 90% service level.

Table 3. Comparison of current and proposed system

| Sample | Color Chart | | | | Garment | | | |
|---|---|---|---|---|---|---|---|---|
| | Current (Q, R) | Proposed (Q, R) | Proposed Reordering Point | Service Level | Current (Q, R) | Proposed (Q, R) | Proposed Reordering Point | Service Level |
| A1 | (16, 16) | (5, 5) | 5 | %90 | (16, 16) | (5, 5) | 5 | %90 |
| A2 | (16, 8) | (5, 5) | 5 | %90 | (16, 16) | (5, 5) | 5 | %90 |
| A3 | (16, 8) | (5, 5) | 5 | %90 | (16, 16) | (5, 5) | 5 | %90 |
| - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - |
| A66 | (16, 16) | (5, 5) | 5 | %90 | (16, 16) | (5, 5) | 5 | %90 |
| A67 | (16, 16) | (5, 5) | 5 | %90 | (16, 16) | (5, 5) | 5 | %90 |
| A68 | (16, 16) | (5, 5) | 5 | %90 | (16, 16) | (5, 5) | 5 | %90 |
| | | 472 | | | | 426 | | |

In Figure 3 and Figure 4, the difference in inventory levels between inventory simulation results and proposed system for Class A samples are shown.
According to simulation optimization results, inventory level which was 1562 samples in current system is decreased to 472 with proposed system for color chart samples. For garment samples, current inventory is decreased from 1802 to 426 samples.

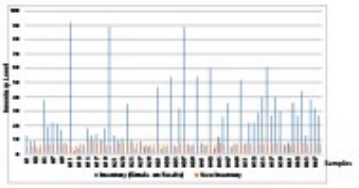



Figure 3. Change in inventory levels for color chart

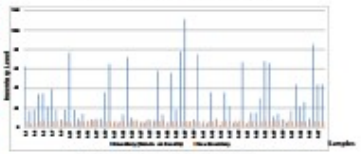



Figure 4. Change in inventory levels for garment

DECREASE IN TOTAL INVENTORY COST

**70%** for Color Chart

**76%** for Garment

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