FENS 402 ENGINEERING DESIGN PROJECT 2
DESIGN OF AN IN-SEASON INVENTORY ALLOCATION SYSTEM FOR APPAREL RETAILERS

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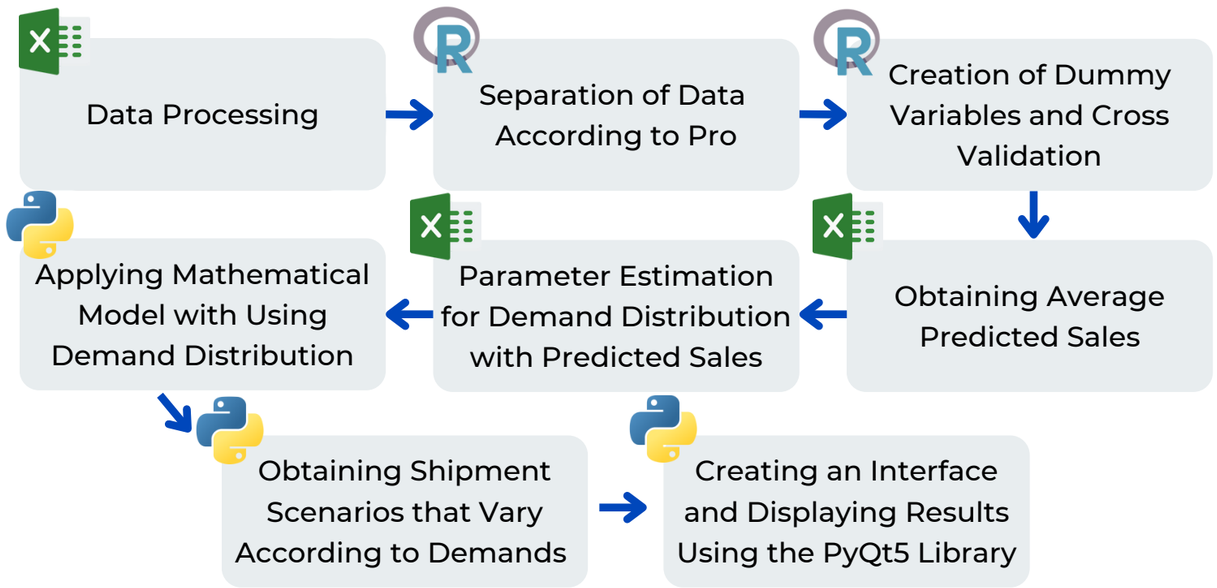
ABSTRACT

- ***Objective:*** To optimize inventory allocation by minimizing inventory allocation costs and determining product quantities needed for two distinct sales seasons.
- ***Methodology:***
  - Parameter Estimation: Employed 5-fold cross-validation and Negative Binomial Distribution to estimate random demand variables.
  - Determining second-period expected costs with optimum allocation sizes
  - Dynamic Programming: Calculation of expected costs for the first period with finding optimum allocation sizes

PROBLEM DEFINITION

- The uncertainty of demand for retailers in the ready-made clothing industry during shipment periods for new season products is a challenging problem for the company. In this project, a comprehensive optimization study was carried out to determine the optimal amount of product allocated to stores throughout the sales seasons.

PROJECT ROADMAP

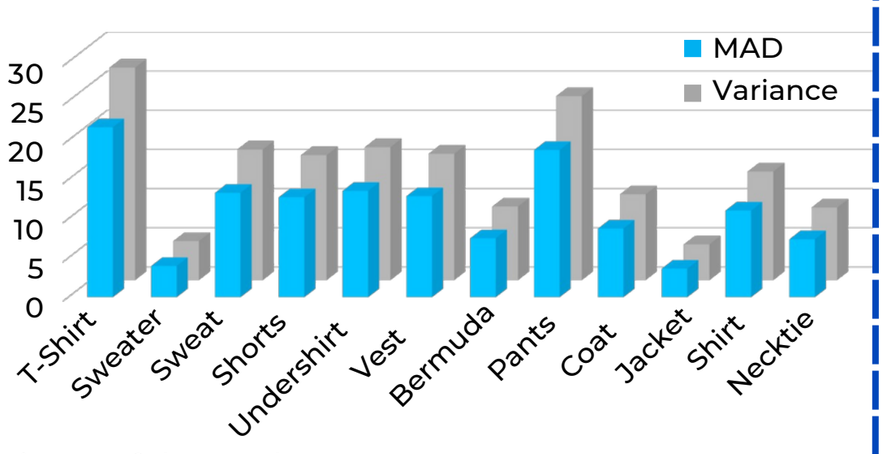


DEMAND PREDICTION STUDY

- Using 80% of the total sales in 12 different product groups, a dummy variable table was prepared for each product group's log-linear regression analysis.
- We made demand forecasts by evaluating the log-linear model we established with the K-Folds 5 Cross Validation method.

PARAMETER ESTIMATION

- The demand random variables we use in our model have Negative Binomial distribution.
- We calculated the p parameters for the demand in the two periods using the Demand Prediction Study results and the variance of the product groups.



- The *r* parameter was determined using the variance and *p* parameters.
  - *p : prob. of success, r : number of success*
  - *Variance = 1.25MAD*

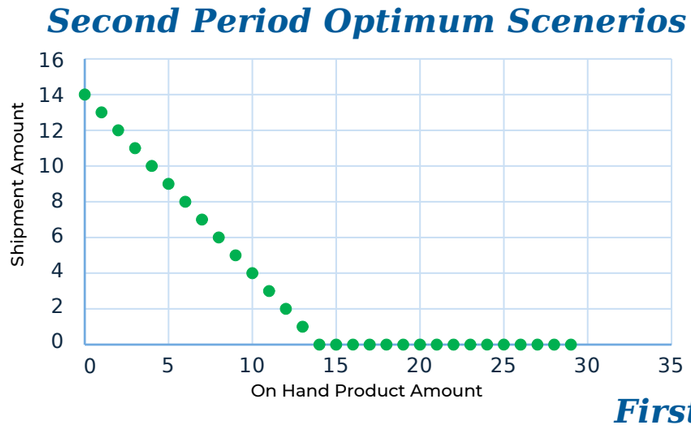
MATHEMATICAL MODEL

$$\text{Min } \mathrm{E}\left[c^1 \sum_{j=1}^{n} \left(\widehat{D}_{ij}^1 - q_{ij}^1 - v_{ij}^1\right)^+ + h^1 \sum_{j=1}^{n} \left(q_{ij}^1 + v_{ij}^1 - \widehat{D}_{ij}^1\right)^+ + V\left(v_{ij}^2, q_{ij}^2\right) \right] + a^1 q_{ij}^1$$

Description of Variables and Parameters

$\widehat{D}_{ij}^1$	Random demand at first period
$\widehat{D}_{ij}^2$	Random demand at second period
q_{ij}^1	Initial shipment to each store
q_{ij}^2	Second shipment to each store
v_{ij}^1	Units of inventory are carried in stores at the beginning of the first period
v_{ij}^2	Units of inventory are carried in stores at the end of the first period
h^1	Cost assessed per unit of unsold inventory remaining in the first period
h^2	Cost assessed per unit of unsold inventory remaining in the second period
c^1	Unit cost assessed per lost sale in the first period
c^2	Unit cost assessed per lost sale in the second period
a^1	Acquisition cost for first period shipment
a^2	Acquisition cost for second period shipment

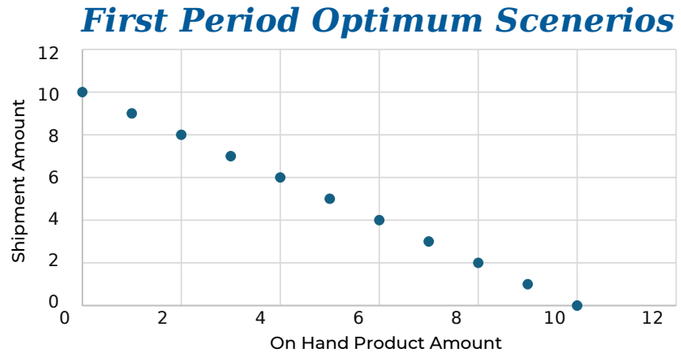
Second Period Optimum Scenerios



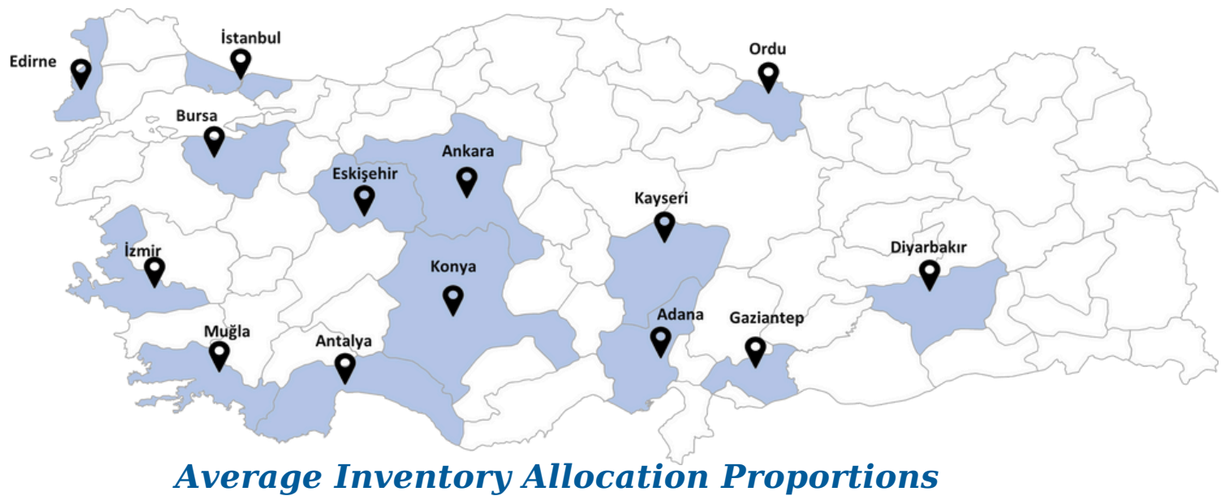
Value Iteration Algorithm with Dynamic Programming

$$v_{ij}^2 = \left(v_{ij}^1 + q_{ij}^1 - \widehat{D}_{ij}^1\right)^+$$

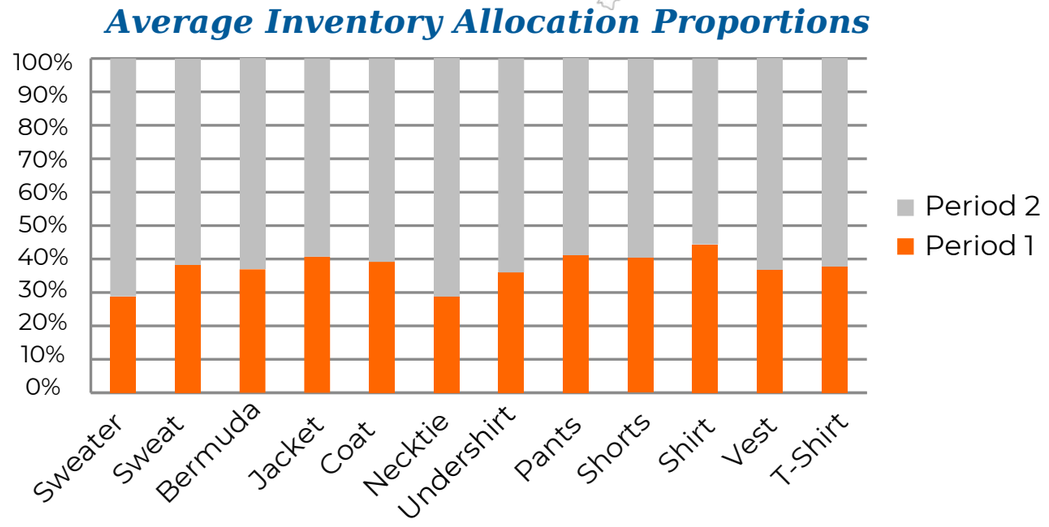
First Period Optimum Scenerios



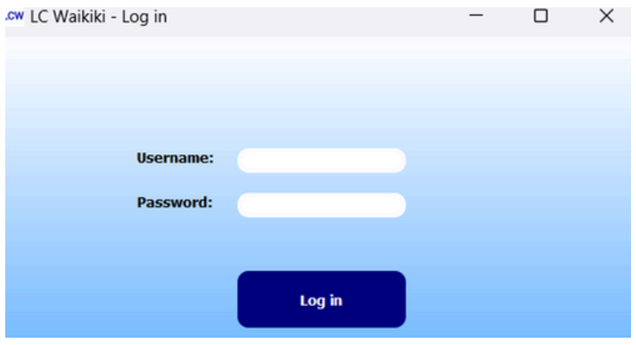
Average Percentages of Products Allocated From City Inventory to Stores in The 1st and 2nd Periods for All Product Groups



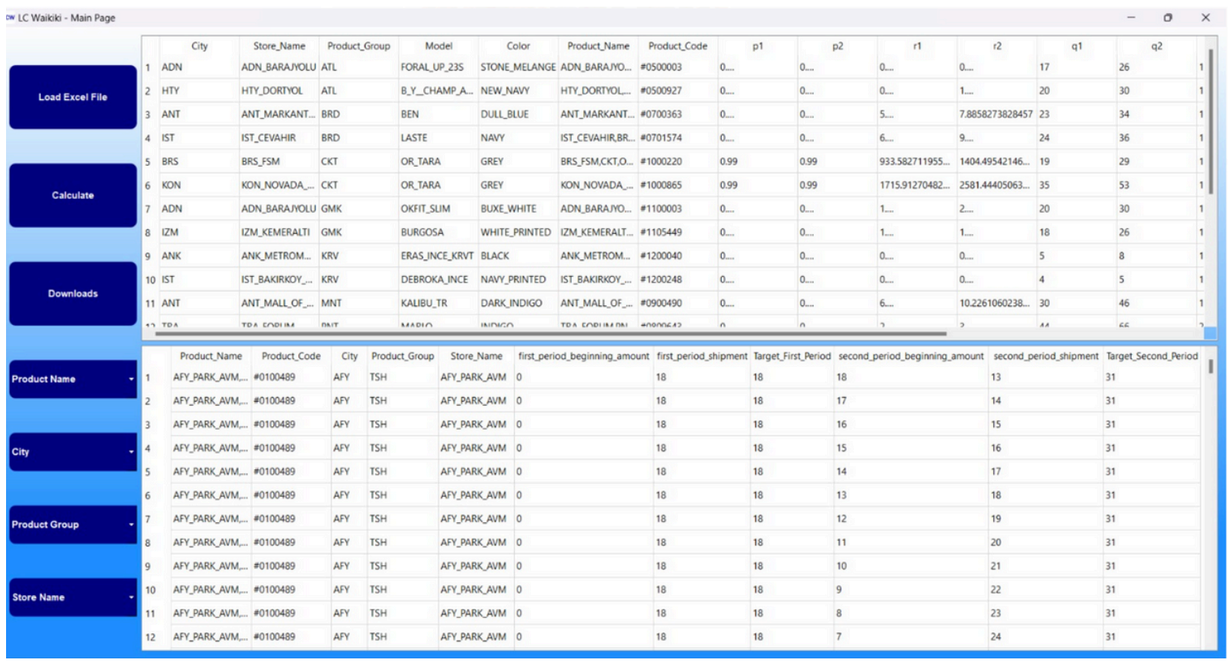
Average Inventory Allocation Proportions



IMPLEMENTATION



- **This is user-interface that we created to show the outputs of our work.**



CONCLUSION

- This thesis aims to how important inventory allocation system is for apparel retailers and minimizes the costs incurred due to inventory allocation decisions.
- Demands in 2 different sales periods have NBD. With these demands we found the optimum allocation amounts according to the number of products on hand in both periods.
- The product quantities that should be available in stores during the 1st and 2nd periods were determined.