Supply chain planning and inventory management | Retail | Predictive forecasting | Regression analysis

Dynamic Algorithm for Target Inventory and the Impact on Replenishment Strategy

INDITEX

BUSINESS PROBLEM

To maintain the desired service level while minimizing inventory, Zara uses a heuristic-based algorithm to come up with the optimal shipment quantity. They use an adjusted version of the base stock model where cycle stock and safety stock are combined into a single figure called "days of coverage", which is one of the main inputs to calculate the required shipment for each item for each store. The goal of this project is to build a machine learning model that incorporates additional features to improve the forecast accuracy for days of coverage and therefore reduce overall inventory while minimizing stock-outs.

APPROACH

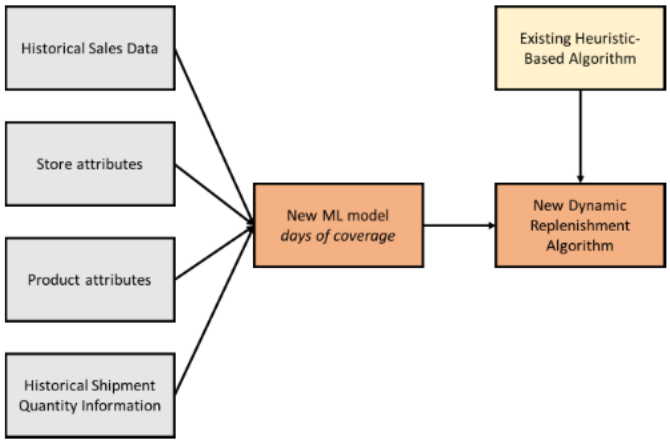
To improve the accuracy of the shipment quantity, I will design a new dynamic algorithm that calculates the required days of coverage for each item-store combination. A list of features that have the potential to be strong predictors of future demand were identified through several meetings with the business teams. These features will be incorporated into an explainable machine learning model.

DATA SOURCES

The data is available in Inditex's central data warehouse and can be accessed using SQL queries. It consists of: a) Daily store-level data on shipment quantities, inventory levels, sales, and product availability b) Static data on store and product attributes c) Existing demand forecasts on target inventory levels

Data Types and Format

Time-series data (e.g. daily data), Static classifiers (e.g. store type, product family), Boolean (e.g. item in stock)



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IMPACT

The proposed algorithm allows Zara to better balance the conflicting priorities of reducing overall inventory while minimizing stock-outs to ensure high customer satisfaction. This solution develops the full-scale optimization problem that can be used in the future to further improve supply chain performance through optimal replenishment strategy. The new dynamic replenishment algorithm designed builds on Zara's non-traditional model to calculate shipment quantities more optimally. The straightforward design of the algorithm, which leverages Zara's existing calculation for days of coverage and then makes positive or negative tweaks to it based on the value of various features added to the model, means that it combines effectiveness and explainability. An indirect benefit of attempting to incorporate new features in the calculation of optimal days of coverage is insight generation. The features that ended up being significant drivers of performance when combined into a model helped distinguish which drivers are truly significant in Zara's context. Lastly, this work proved that Zara's pioneering approach to calculating optimal inventory is effective. Although the value of traditional models such as the base stock model is undeniable, this work helped reaffirm that novel approaches also have merit if designed well.

DRIVERS

The proliferation of advanced analytics in many industries and especially retail meant that business stakeholders at Zara were open to new approaches and viewed analytics through a positive lens. Additionally, the impact of COVID-19 on all businesses and the unpredictability it brought necessitated the use of analytics to improve existing processes and capture the underlying uncertainty.

BARRIERS

The first barrier was the problem itself and its inherent complexity. The dual objective of minimizing inventory and minimizing stock-outs (two opposing goals) meant that finding the optimal tradeoff was a difficult question. Another challenge was the amount of data that Zara has and over which the algorithm needs to be optimized. Running the optimization script and waiting for it to solve made iterating on the algorithm very time-consuming.

ENABLERS

A large number of business stakeholders were very open to spending time with me and sharing their knowledge and expertise. Their help in identifying candidate features was critical. Additionally, my two close mentors within Zara were always available to provide feedback and guidance which is appreciated. Lastly, Zara's granular and well-structured data made it very easy for me to get a head start and begin working on my algorithm immediately.

ACTIONS

I conducted interviews with business stakeholders to source potential features. I wrote code to combine all the necessary data and build the features that were fed to the model. I formulated the optimization problem and developed a simplified heuristic that runs in a shorter amount of time. I designed an algorithm that calculates optimal inventory leveraging the new features and runs a simulation to measure the theoretical impact on our two KPIs.

INNOVATION

This thesis develops the full-scale optimization problem that can be used in the future to further optimize replenishment strategy. It also develops a dynamic replenishment algorithm that builds on Zara's non-traditional model to calculate shipment quantities more optimally. The solution offers a unique way of capturing uncertainty in the days of coverage metric instead of the demand forecast, which is an approach not found in common literature.

IMPROVEMENT

The heuristic algorithm reduced the total inventory by 2.11% as compared to the baseline approach used by Zara, and this improvement came at a minimal impact to the percentage of stockouts (+0.05%)

BEST PRACTICES

Engaging business stakeholders early was critical to the success of the project. Their knowledge and expertise was instrumental in understanding the dynamics of inventory management and the unique elements of Zara's supply chain. Automating data collection and feature engineering was also very helpful since it allowed us to iterate through multiple versions of the algorithm in a short amount of time without a lot of manual effort.

OTHER APPLICATIONS

The contributions of this thesis may be leveraged by other retailers looking to enhance their replenishment strategy by optimizing their inventory levels, and may also be used as a starting point for academic researchers attempting to develop novel algorithms dealing with the uncertainty surrounding demand forecasting and safety stock calculations.