Business Analytics | Retail | Network optimization | Mixed-Integer Optimization

An Optimization-Based Approach to Efficient Clearance Inventory Allocation

BUSINESS PROBLEM

Zara, a leading global fashion retailer, faces a recurring challenge during the clearance season: how to optimally distribute remaining inventory across stores to maximize revenue while minimizing overstocking and missed sales opportunities. During this period, product margins can become negative, yet it is still preferable to generate some revenue rather than none, given that production costs are already sunk. The business problem is to determine which articles and how many units to ship from secondary distribution centers to stores during the clearance period, ensuring decisions are made within a tractable timeframe.

DATA SOURCES

We queried and transformed internal tables to obtain inventory levels, store assignments, demand forecasts, shipment targets, and clearance group mappings. Additional data included dynamic price and margin info, e-commerce demand estimation, and historical sales to refine forecasts and ensure accurate, margin-aware distribution planning.

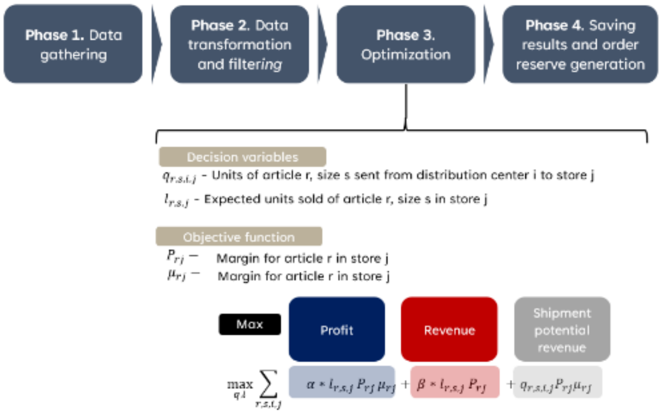
Data Types and Format

The data was primarily structured in tabular format, and all transformations were handled in Python using the Databricks environment.

Author: Karla Perez Muñoz

APPROACH

The challenge of optimizing the distribution of clearance inventory at Zara was solved by developing a data-driven optimization model. We formulated a mixed-integer linear programming model that incorporates business constraints such as product availability and expected demand. The model was implemented in Python and solved with Gurobi, using an optimized approach to ensure computional efficiency.



IMPACT

The implementation of the proposed optimization model to the secondary distribution centers demonstrated a clear improvement over the baseline distribution strategy. By leveraging store-level demand signals and incorporating margins, the model achieved a more balanced and targeted allocation of clearance inventory across the store network maximizing the potential profit. This led to better product availability in high-demand locations and a reduction in excess inventory in lower-performing stores. Quantitative results revealed a 4.5 percentage point absolute increase in margin for the optimized shipment compared to the single-item approach currently in place. This uplift highlights the financial potential of the model during the clearance season—a period typically associated with lower profitability. Beyond the numerical gains, the project also demonstrated the feasibility of building a tractable, scalable, and data-driven model that can support real-time decision-making during a commercially sensitive period. We successfully reduced computation times, enabling the model to be run multiple times per day using the most up-to-date information.

DRIVERS	In the retail-fashion industry, where product life cycles are short and new inventory constantly replaces old, clearing excess stock efficiently is crucial. This highlighted the need for a more data-driven, scalable, and responsive distribution strategy. The nature of the fashion industry was the catalyst for our solution, driven by the need to make allocation decisions rapidly—often multiple times a day—to respond to dynamic demand.
BARRIERS	The development of the optimization model faced several challenges, including fragmented data from multiple internal systems that required extensive cleaning and alignment. Weekly price fluctuations added complexity to margin calculations, requiring frequent input updates. Additionally, the model had to remain computationally efficient to support multiple daily runs with real-time data.
ENABLERS	Despite these challenges, several factors enabled the project's success. Centralized data architecture made it easier to access key information, and support from the Business Analytics team helped guide and validate the approach. Tools like Python and Gurobi allowed for fast, flexible implementation, while standardized exchange rates and definitions simplified data integration.
ACTIONS	Relevant data were cleaned and transformed to ensure accurate pricing, inventory, and demand inputs. A mixed-integer linear programming model was developed to optimize clearance product allocation from distribution centers to stores, incorporating constraints on stock, demand, and capacity. Implemented in Python and solved with Gurobi, the model enabled efficient daily runs and was benchmarked against existing heuristics.
INNOVATION	A key innovation was the integration of price and margin dynamics directly into the optimization model, allowing it to prioritize more profitable allocations. Another novel aspect was the refined treatment of e-commerce data, which was previously aggregated at the distribution center level. Finally, the code was optimized to efficiently handle large datasets and ensure fast execution.
IMPROVEMENT	The optimized solution yielded a substantial improvement in allocation performance. Specifically, the model demonstrated a 4.5 percentage point absolute increase in shipment margin compared to current heuristic approaches. Additionally, the model improved operational efficiency by enabling faster, more consistent decisions supported by real-time data inputs.
BEST PRACTICES	First, ensuring consistent and accurate data preprocessing is critical—especially when dealing with dynamic pricing and regional data variations. Second, building a scalable and tractable model that can run quickly is essential for integration into real-world decision-making cycles. Incorporating margin calculations and disaggregating e-commerce trends also added substantial value.
OTHER APPLICATIONS	While the model was designed for clearance inventory distribution, its framework is flexible and can be extended to other use cases. For example, it could support initial stock allocation for new product launches, replenishment planning, or real-time inventory balancing between e-commerce and brick-and-mortar stores. It can also be extended to other industries where there's a need to take decisions regarding shipments in short time.