# Local Inventory Deployment Optimization

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## Overview

| Background | Problem statement |
|---|---|
| • Holdback policy - minimize store inventory by aggregating inventory in centers<br>• Manhattan Local market strategy: Trade off backroom for specialized customer services | Current approach: Stock Merchandising & Restocking Tool (SMRT)<br>Triggers transfers based on target stock levels<br>Labor-intensive<br>Reactive<br>Non-generalizable |

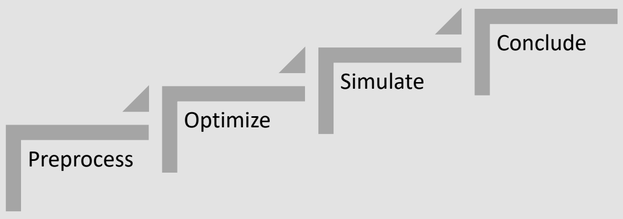
**Goal**

- Build a system that returns optimal transfer quantities based on input data
- Compare proposed inventory management system against SMRT

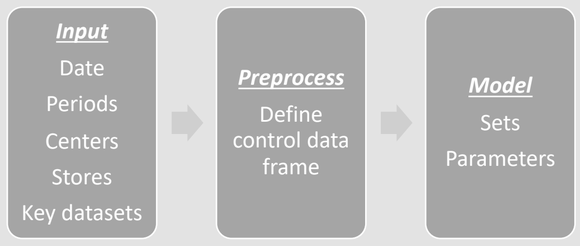
| Data | Components |
|---|---|
| Inventory | Snapshot of product quantities in-store |
| Demand forecasts* | Forecasted sales |
| Sales | Past store product sales |
| Merchandise hierarchy | Product specification |
| Transfer schedule | Past contractual delivery schedules for NY (Transportation dept) |
| Product pricing | Product cost, retail price |
| Allocation/Replenishment polices | Past user-set target inventory levels (Inventory Deployment dept) |
| Transportation | Delivery capacities, transportation cost estimates (Transportation dept) |
| Product specifications | SKU volumes, Product lifecycle (Product dept) |

## Methodology

*Workflow*




*Preprocessing*




*Model assumptions*

| Parameter | Explanation |
|---|---|
| Demand | Actual sales +/- 20% (Estimated forecast accuracy)<br>Intraday Allocation: Historical sales % |
| Cost | Holding cost = Cost of good / (3 * Product Lifecycle) |
| Fixture capacities | **Max** stock-on-hand during previous month at Store/Div/Subdiv/Dept/Class level |
| Min. Presentation Targets (**MPT**) | **Min** stock-on-hand during previous month at Store/Div/Subdiv/Dept/Class level |

*Optimization – Local Inventory Deployment Optimization (LIDO)*

$$\min \sum_{c\in C}\sum_{s\in S}\sum_{t\in T}(P_c\alpha_{c,s,t} + Q_c/L_c\ *\beta_{c,s,t}) + \sum_{f\in F}(R_f* \sum_{t\in T}\delta_{f,t})$$

*where*

- $P_c$: Profit per unit of deptclass c sold
- $Q_c$: Holding cost for deptclass c
- $L_c$: Product lifecycle for deptclass c
- $\alpha_{c,s,t}$: No. of class c units short in store s at (beginning of) time t
- $\beta_{c,s,t}$: No. of deptclass c units short in store s at (beginning of) time t
- $R_f$: Cost of truck delivery for forward deployment center f
- $\delta_{f,t}$: No. of shipments from center f during period t

*Constraints*

- Network: Transportation schedule, truck capacity
- Store: Fixture capacity, minimum presentation targets

*Simulation*

*Parameters*

- Duration: 2-29 February 2020
- Centers: NJ Stock Staging Area (209)
- Stores: NYC Flagship (210) & Men's Only (212)

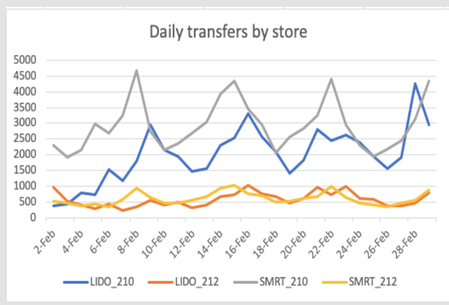
Subroutine

| LIDO | SMRT |
|---|---|
| If **SOH** < Sales: lost sales | If **target level** < Sales: lost sales |
| If **SOH** > Sales: holding cost | If **actual SOH** > Sales: holding cost |
| **Simulated end-of-day SOH** for 2 Feb = **Simulated start-of-day SOH** 3 Feb | **Actual SOH** |

## Results

Running both LIDO and SMRT, we obtained the optimal transfers from SSA to each store (Flagship & Men's) for each delivery and summarized the key results.

*Transfers*




- Weekly seasonality
- Sales & Transfer volume: Flagship ~5x Men's store

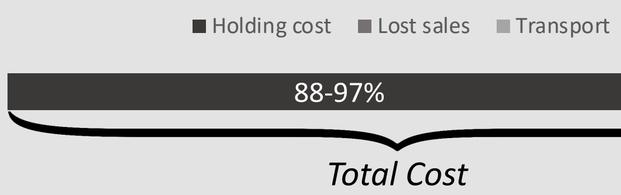
**Simulation starts**

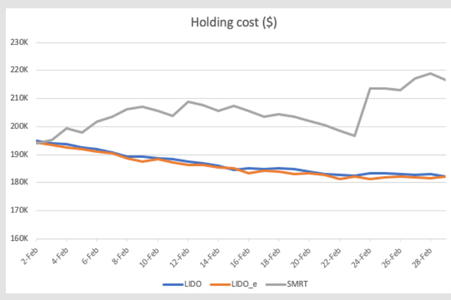
- LIDO transfers less than SMRT.
- Current inventory levels are higher than optimal level

**Simulation ends**

- Gap between SMRT and LIDO transfers is closed
- Current inventory approach ideal
- Transfers reflect actual sales

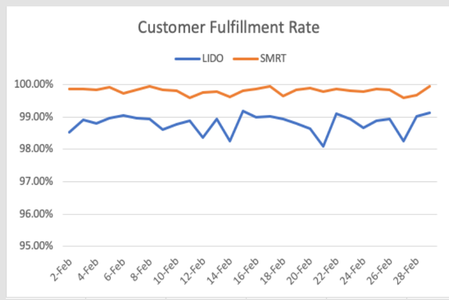
*Cost*




| | |
|---|---|
| **Actual vs Expected LIDO** | Actual cost (LIDO) using sales / Expected cost (LIDO_e) using forecasted demand<br>Expected closely tracks actual cost |
| **LIDO vs SMRT** | LIDO plateaus at $182k, SMRT at $215k<br>**11.2%** cost reduction in median value |

*Customer Fulfillment Rate (CFR)*



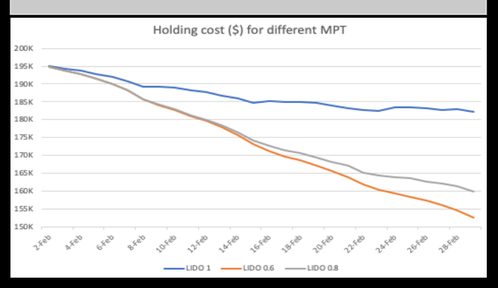

| | |
|---|---|
| **Customer Fulfillment Rate** | Percentage of customer demand met by immediate stock availability<br>Absence of stockout/lost sales |
| **Comparison** | SMRT 99.7%<br>LIDO 99.0% |
| **Trade-off** | Vast reduction of inventory levels generates minimal increase in stockouts. |

## Sensitivity Analysis

Varying cost parameters (e.g. average cost, product lifecycle) would have a profound impact on the daily cost due to the outsized proportion of holding cost.
However, focus is on the effect of parameters whose data was entirely unavailable as there is greater uncertainty about their true values.

**Minimum presentation targets (MPT)**

- Initial MPT is an upper bound on the actual value.
- We repeated the simulation with 60% and 80% of the estimated targets.
- The lower the minimum presentation target, the lower holding cost decreases to before it plateaus. without affecting CFR.




**Forecast accuracy**

- We ran simulation using Mean Absolute Percentage Error of 10% and 40%.
- The results were robust with <3% variation in transfers and cost.
- Small variations as a result of ceiling the weighted NY demand using store and period sales percentages.

**Profit**

- Nordstrom associates a Customer Lifetime Value and profit is a lower bound on penalty of a stockout.
- We repeated the simulation with 2x profit.
- Results were robust to these perturbations, with <3% variation in transfers, cost and CFR.

## Conclusion

| | SMRT | LIDO |
|---|---|---|
| **Cost** | $205k;<br>Dependent on user-defined targets | $182k;<br>Model-recommended optimal transfers |
| **Customer Fulfillment Rate** | 99.7% | 99.0% |
| **Framework integration** | Independent; Reactive | Integrative; Proactive |
| **Workload** | Manual | Automated |
| **Generalizable** | No | Yes |

## Acknowledgements

We would like to thank MIT and Nordstrom for their support throughout the project. We would like to especially thank James Pestrak (Principal Data Scientist at Nordstrom) for his constant support and guidance, as well as Dr. Georgia Perakis for her invaluable expertise on inventory deployment.
We would also like to thank Brian Trinen, Michelle Li, Carine Simon, Divya Singhvi, Ioannis Spantidakis and Cherryleen Montemayor for their assistance and encouragement.