



“Power of Analytics: An Application in Apparel Retail

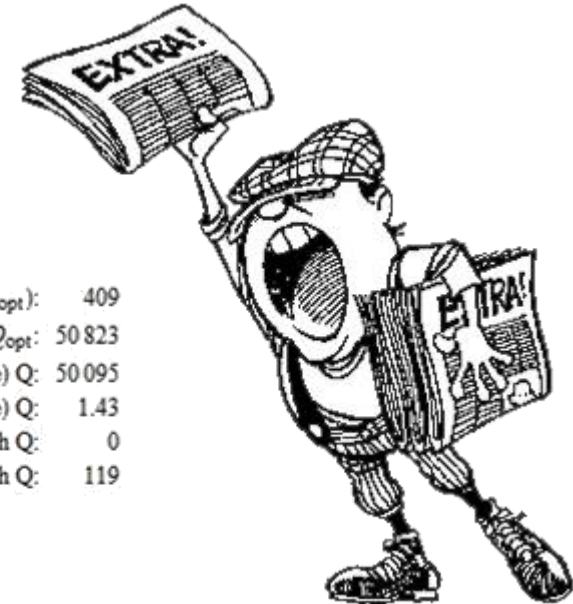
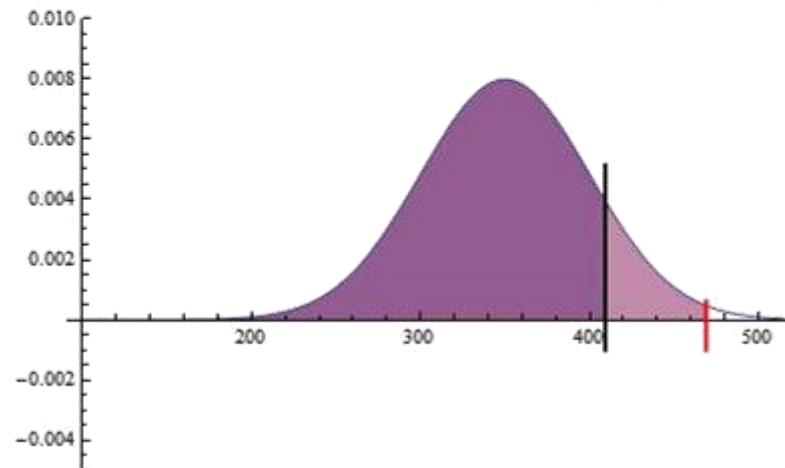
Mustafa Gökçe Baydoğan

Annual Workshop on Business Analytics, October 2017

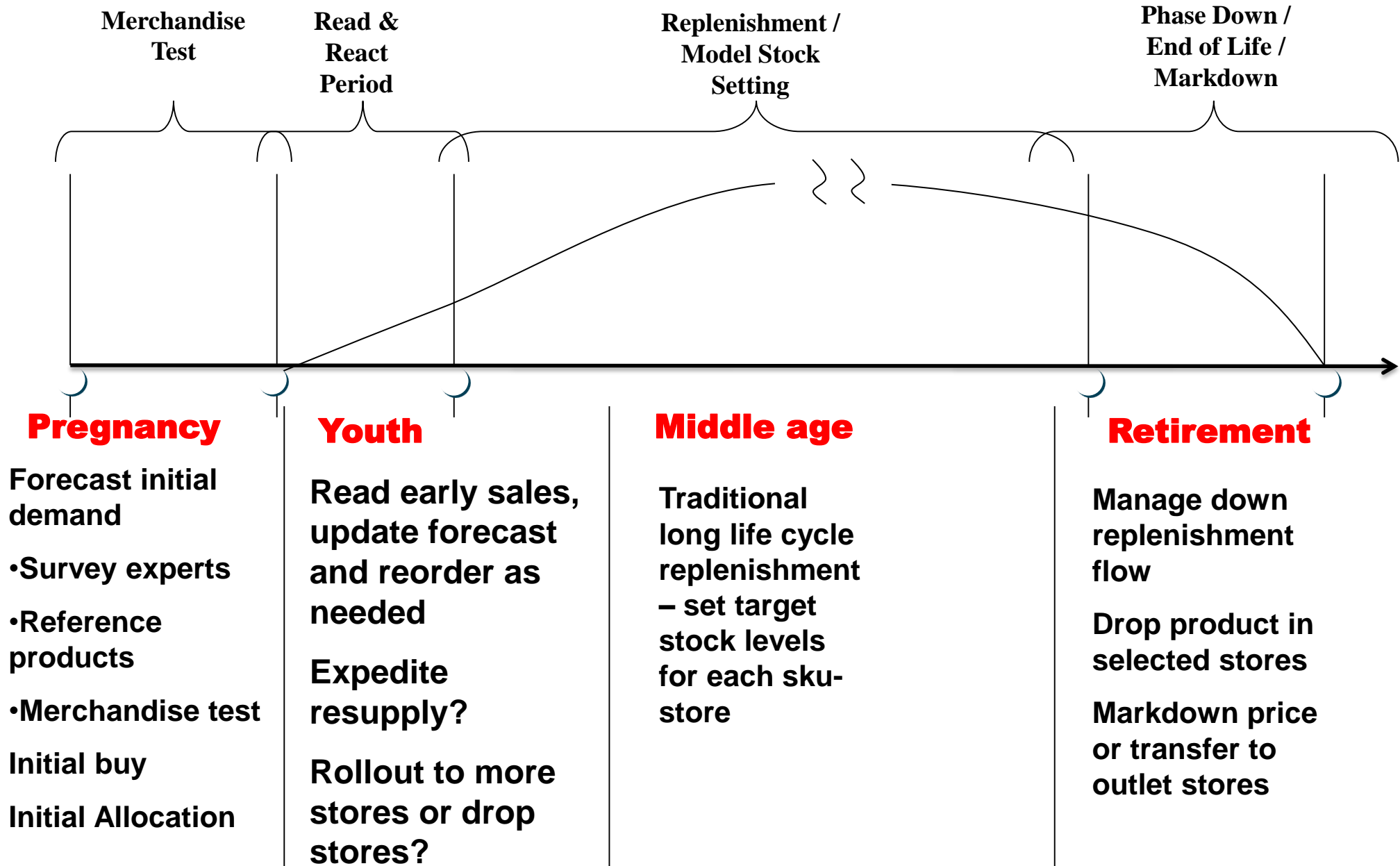
Newsvendor problem

- Continuous demand
- Homogeneous distribution
- Single period
- No constraints
- Objective: Minimize cost
 - Inventory (salvage)
 - Cost of sales lost

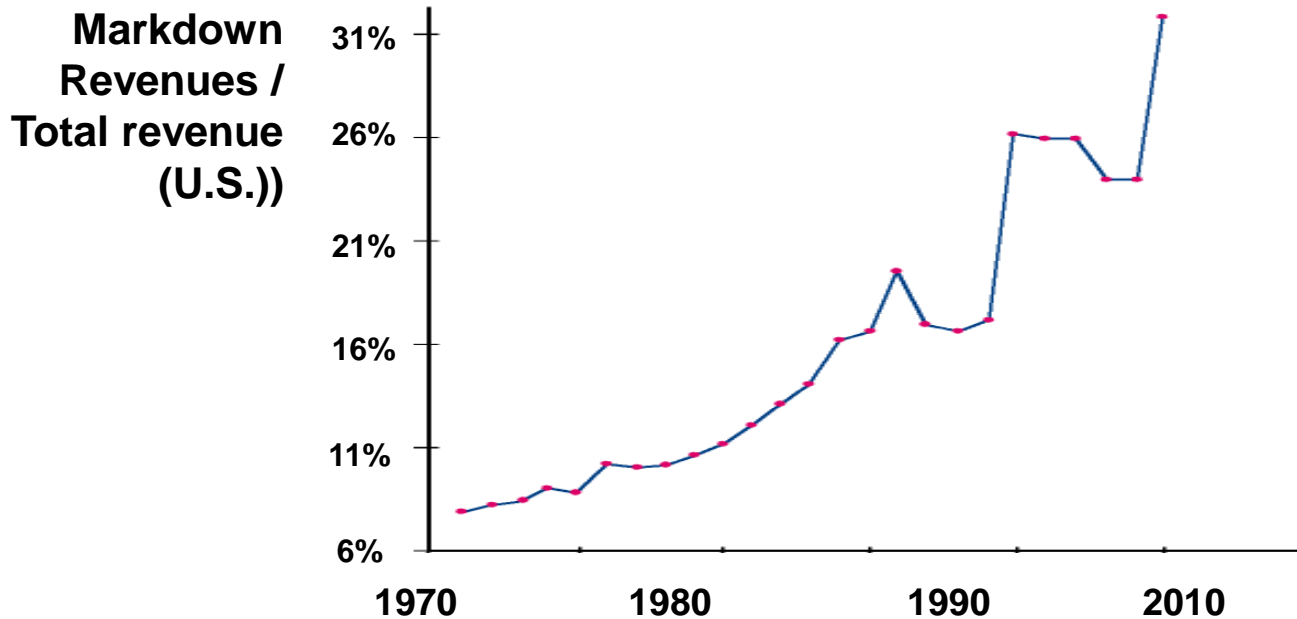
optimal order quantity (Q_{opt}): 409
expected profit with Q_{opt} : 50 823
expected profit with (naive) Q : 50 095
percent profit decline due to (naive) Q : 1.43
expected end-of-season understocking with Q : 0
expected end-of-season overstocking with Q : 119



Product Life Cycle Planning



Retail Industry Overview



Too much inventory of the “wrong” products

“One third of the customers leave the stores without finding the product they were looking for.

(Kurt Salmon Associates, 1995)



Too little inventory of the “right” products

Root Causes of the Inefficiencies

Long lead times



Purchase and production decisions are taken months in advance

Inaccurate forecasting



Chain-level product forecast error rate is in the order of 50-100%

Inaccurate allocation/distribution of products



“Wrong” product at the “wrong” store: Transfers between stores within season makes 20% of total movement



Big Data and Analytics

**Day-store-customer
sales and inventory
data**



**“We are awash with data but
starving for information”**

**External and social
data**

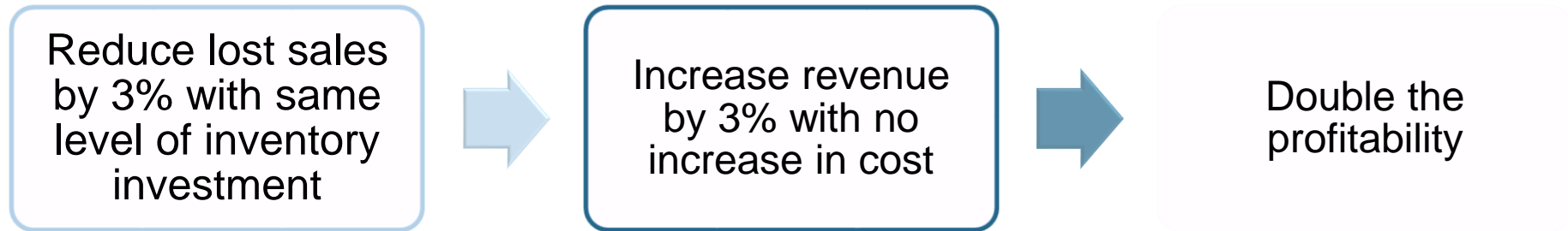
**Analytics can help
retailers double
their profitability**



Data-driven Analytics

- **Lower lost sales**
- **Lower markdown sales**
- **Less inventory**
- **%5-10 revenue/profit improvement**

A Simple Plan



RETAILER	GROSS MARGIN	NET PROFIT
Jewelry	52.4 %	2.7 %
Electronics	33.1 %	2.3 %
Apparel/Fashion	36.1 %	4.0 %
Department Stores	32.2 %	2.5 %

Mavi Jeans Inventory Allocation



- Seasonal products
 - Lifecycle < 26 weeks
 - Single seasonal buy
- Non-seasonal product (Denim Models)
 - Repeated buys

Product entry

Initial Allocation

Replenishment

Objective: Maximize gross margin

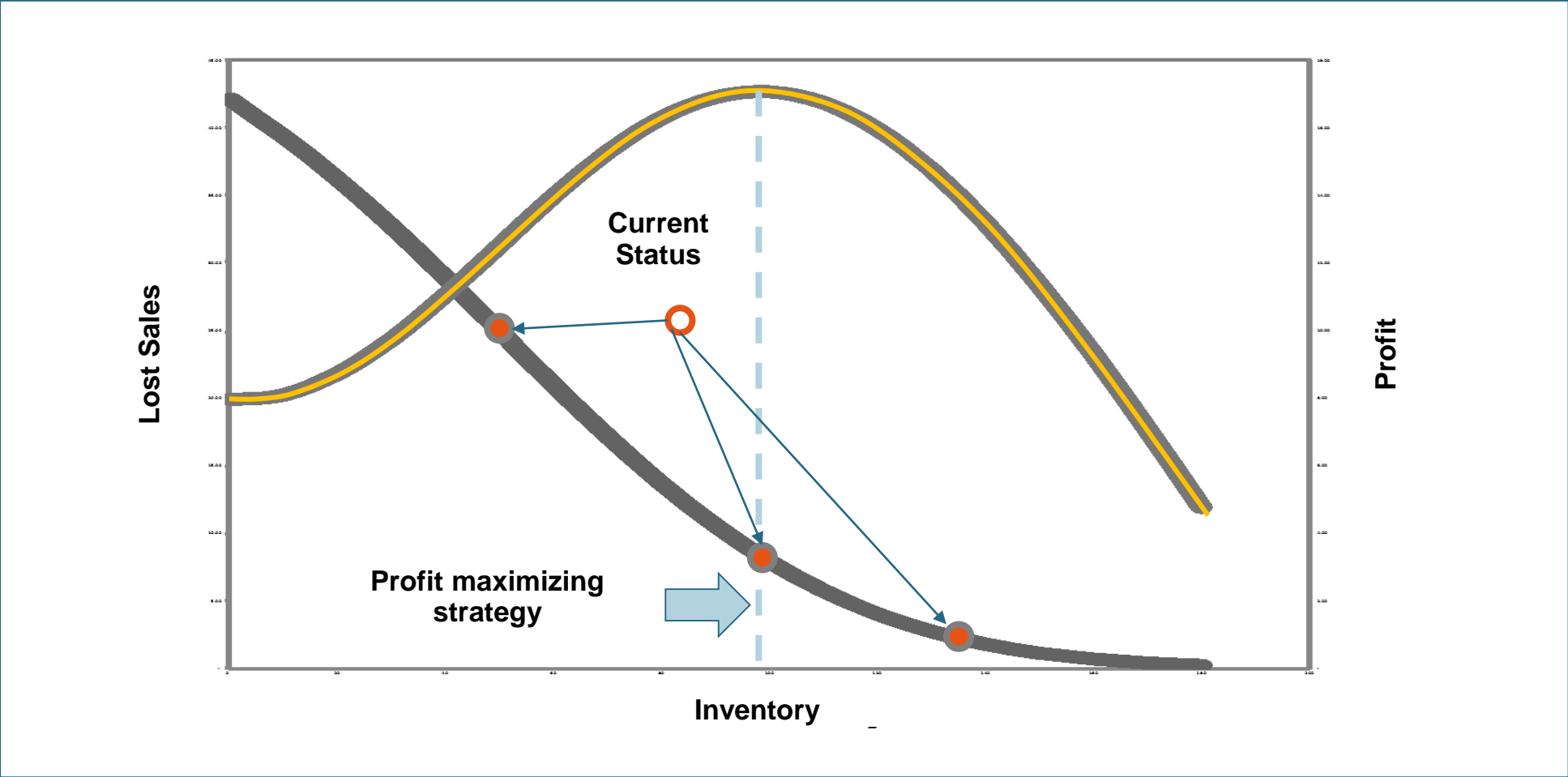
Constraints:

- Size constraints
- Store display constraints
- Warehouse-store delivery frequency

Challenges:

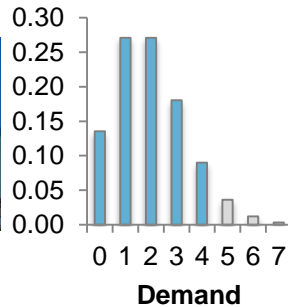
- Store-SKU forecasts
- Highly variable demand
- Slow moving products

Inventory replenishment to maximize profits

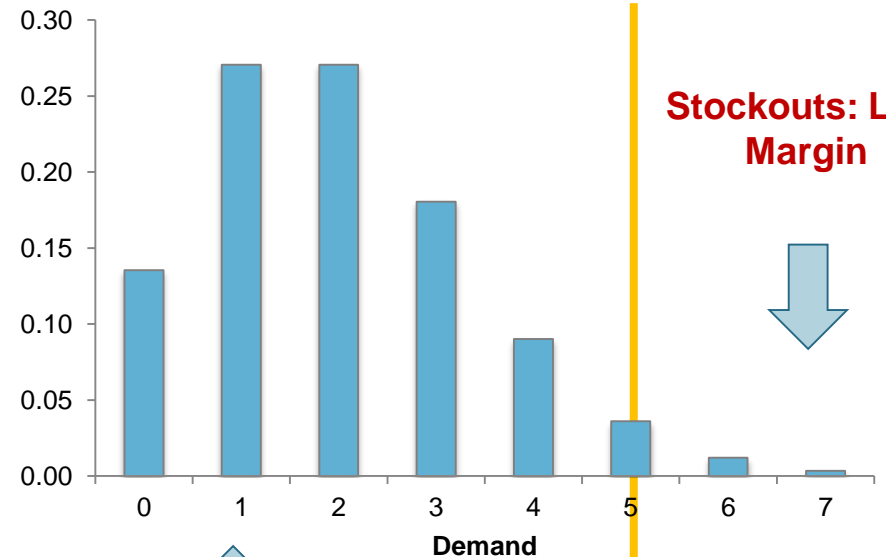


Modeling the demand distribution is of fundamental importance

Istanbul Cevahir Mall Store

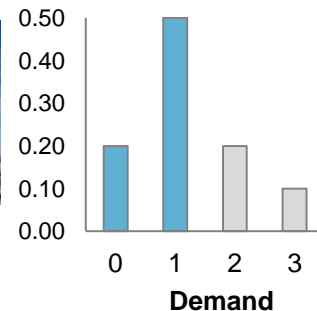


Probability of Demand Realizations



Stockouts: Lost Margin

Insufficient Inventory ?

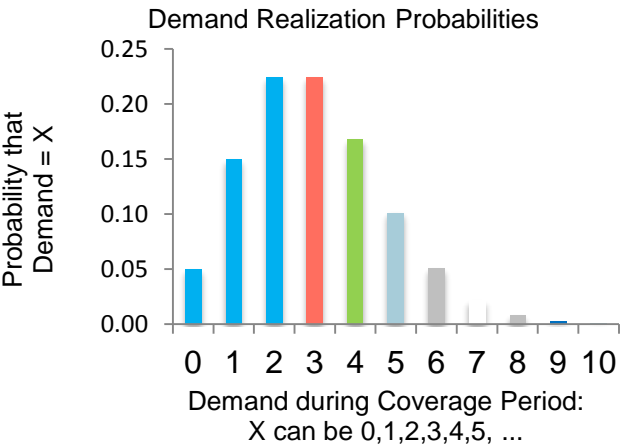


Inventory carry over: Holding Cost

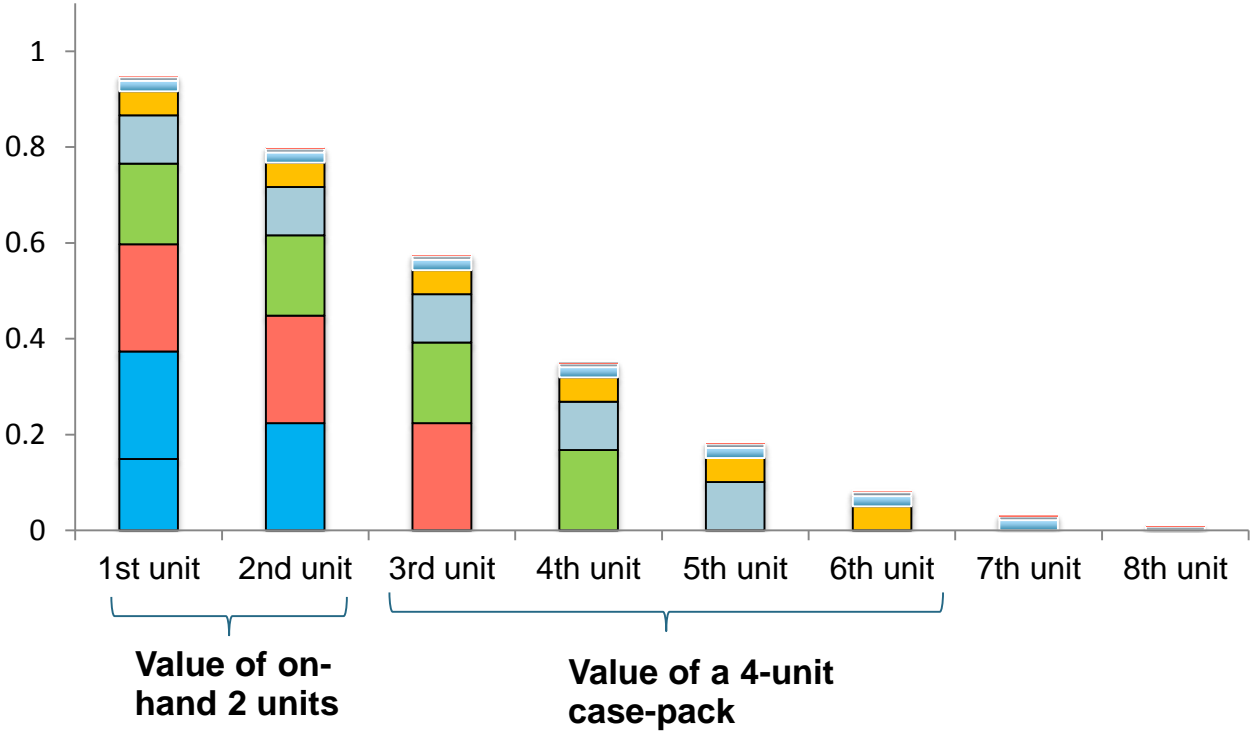
Profit maximizing inventory position optimally determined for each store-SKU

Computing the expected margin contribution of each additional unit of inventory for each Store-SKU pair

Consider a store-SKU pair with 2 units on-hand, and unit gross margin is \$1.00



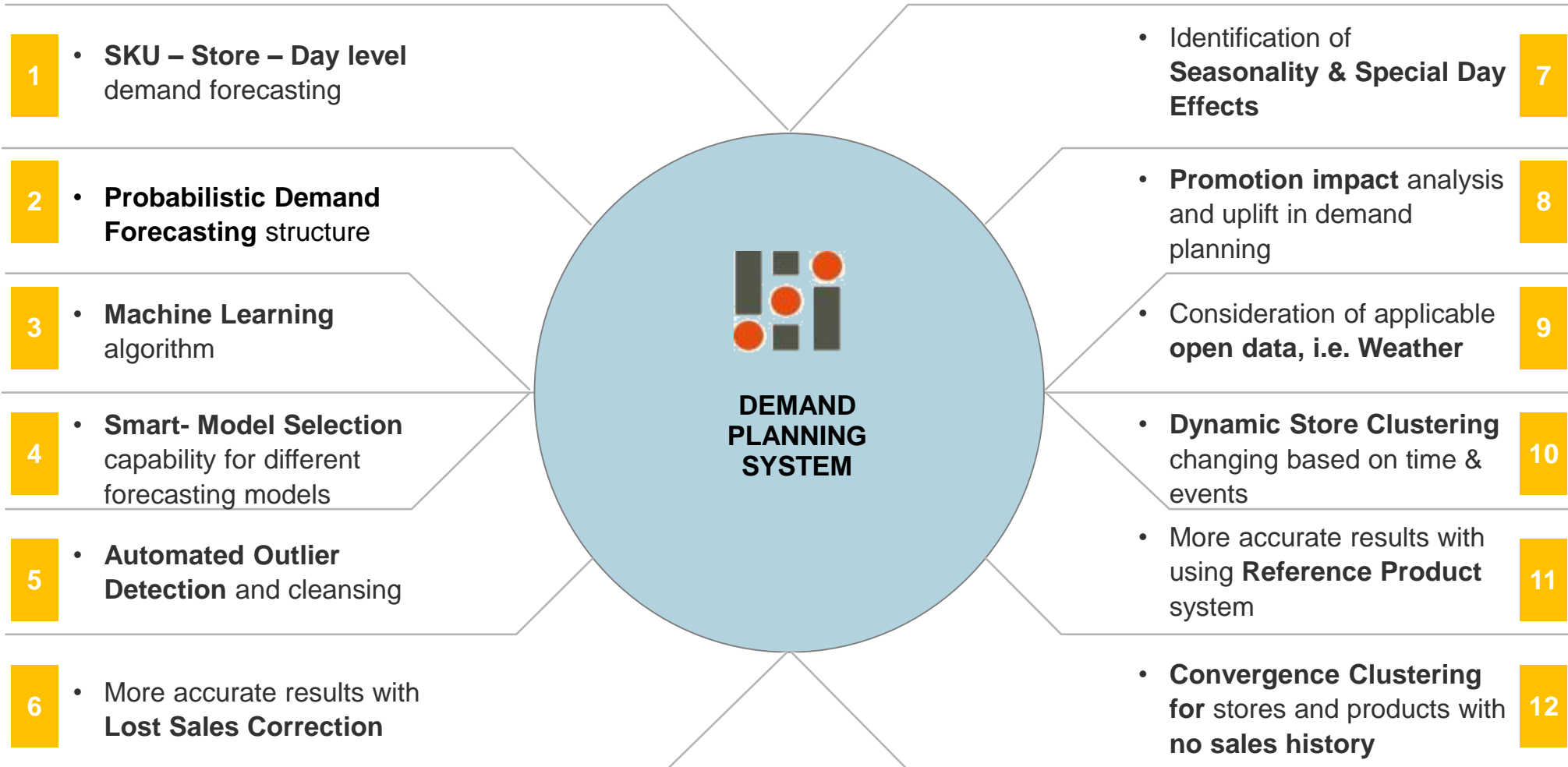
Expected Margin \$ Contribution of Each Unit



Challenges in Demand Forecasting

- **Data volume**
- **Censored demand**
- **Slow movers (zero-inflated distributions)**
- **Anomalies**
- **Promotion mix**
- **Seasonality/Day effects**
- **Products with no history (new items)**

Advanced Demand Forecasting Algorithms

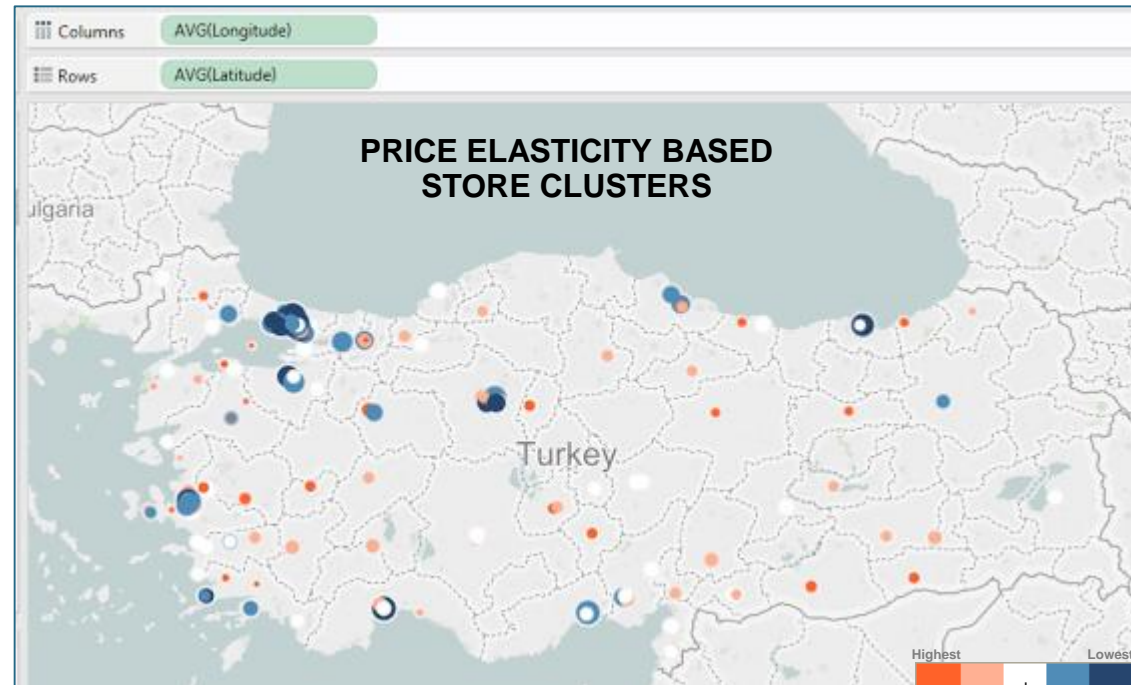


2

Dynamic Store & Product Clustering technique enables more accurate forecasting and business results

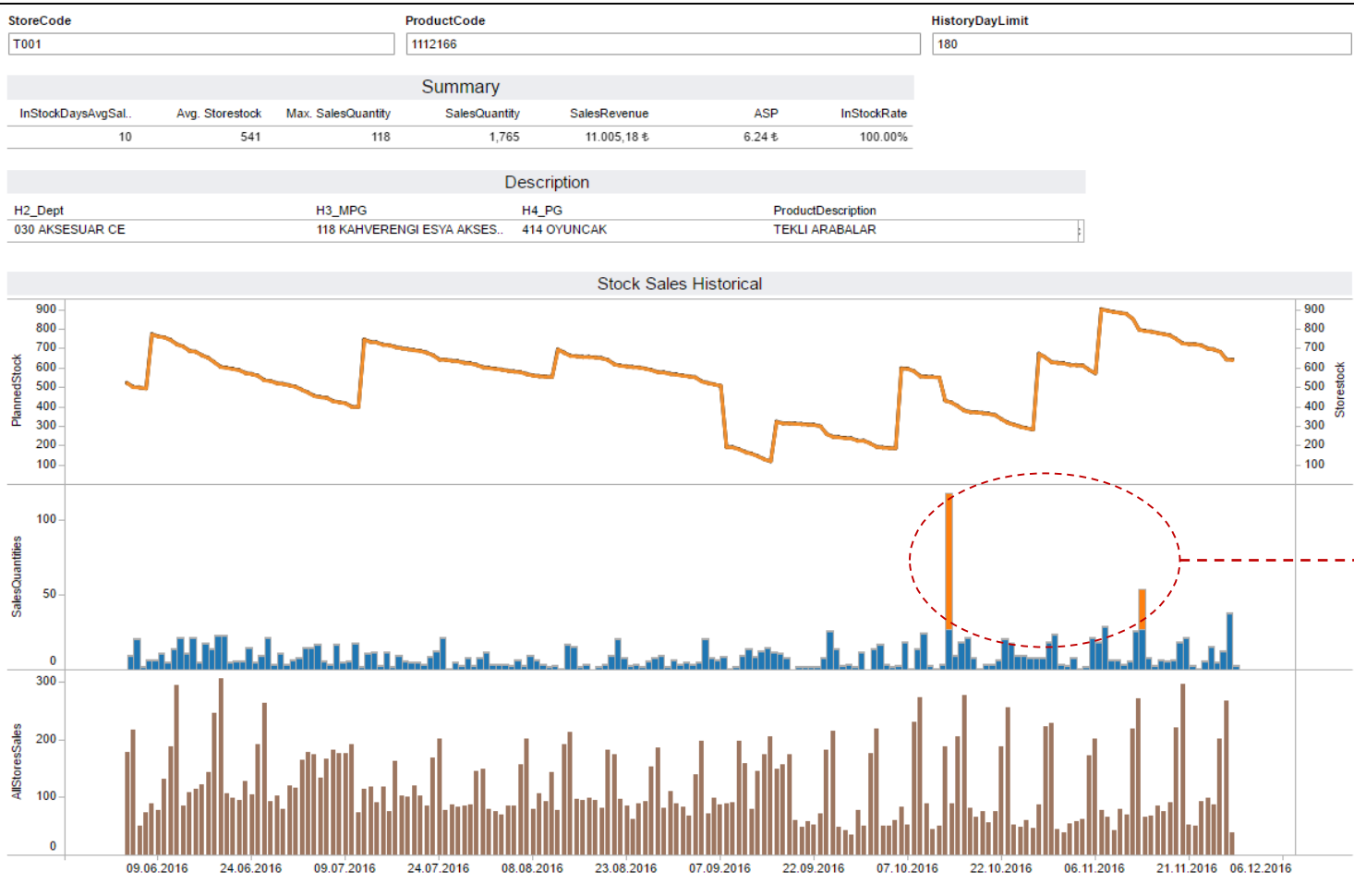
STORE & PRODUCT CLUSTERING DIMENSIONS

- **Store Clustering**
 - Product group – store performance cross groups
 - Store turnover groups
 - Seasonality groups
 - Price elasticity groups
 - Special day groups (Differentiating for each special day, i.e. Religious Bayram vs. Christmas)
- **Product Clustering**
 - Product turnover groups
 - Price level and elasticity groups
 - Promotion uplift groups
 - Special day groups



2

Outlier sales (corporate, whole sale etc.) are automatically detected and cleansed by system to provide best outcomes in future decisions



Outlier detection and correction algorithms corrects the data based on a regular trend of the product

3

In addition to national special days, also local & regional events are taken into consideration



Kurban Bayram



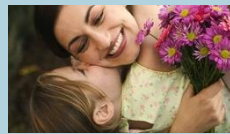
Ramazan Bayram



Christmas



Valentines Day



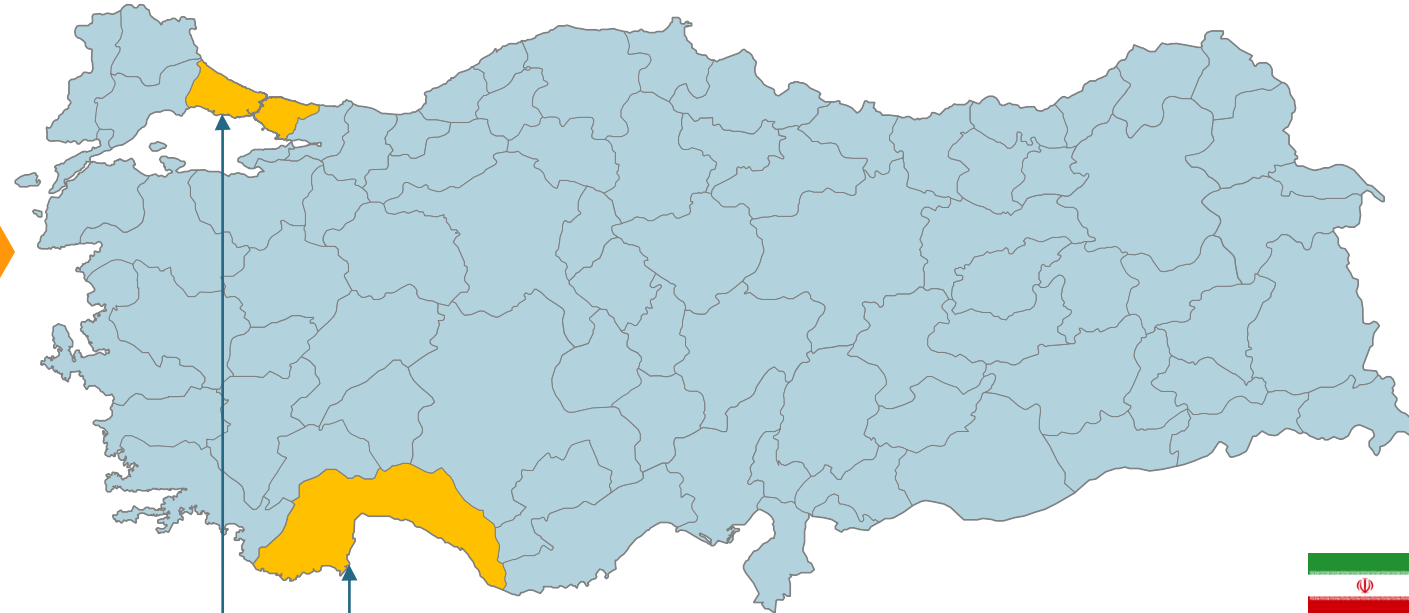
Mother's Day



Father's Day



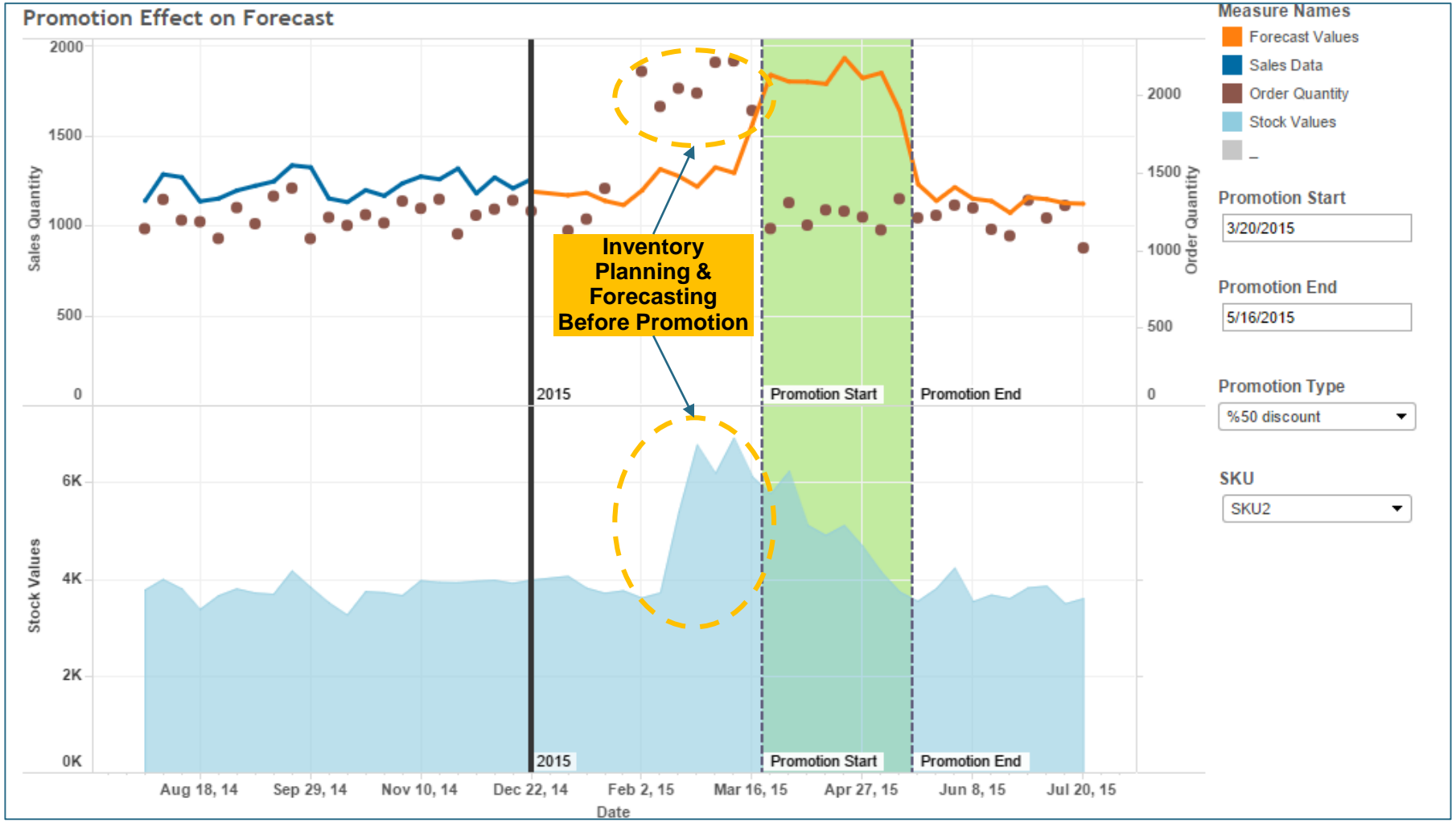
- What is the impact of Nevruz Bayram to sales and inventory planning decisions?
- At what level it impacts different stores at different cities?
- At which categories is it more impactful?



Impact of tourists coming from Iran to Turkey during Nevruz should be taken into consideration while preparing the demand and inventory plan for Istanbul and Antalya cities

3

Elasticity of demand is critical for promotions and markdown events in both price and inventory planning problems



Key Performance Indicators



DAILY AND WEEKLY

IN-STOCK RATES

LOST SALES

**INVENTORY TURNS
(STOCK COVER)**

Pilot Test: Difference in Differences

		Products		
		<u>Grup 1</u> (140)	<u>Grup 2</u> (140)	Others
Stores	<u>Grup A</u> (22)		mavi	mavi
	<u>Grup B</u> (22)	mavi		mavi
	Others	mavi	mavi	mavi

Stores:

Paired Matching Algorithm identifies pairs of stores based on sales and demographics

Products:

Product pairs were selected based on sales/inventory/price/hierarch information

KPI:

Pre-post test

Delta(revenues, profit, inventory turns) and statistical significance

Advantages:

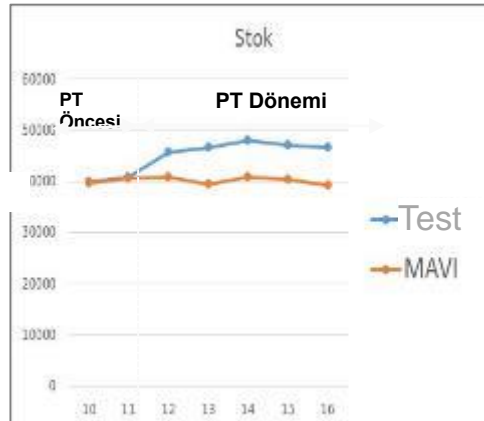
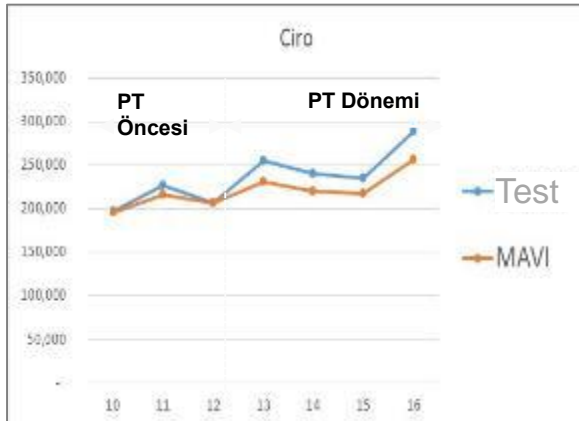
Difference in Differences approach accounts for both store and product differences

Directly measurable from POS sales data

Replenishment optimization solution developed for MAVİ provided 4 points improvement in Lost Sales during a controlled A/B test

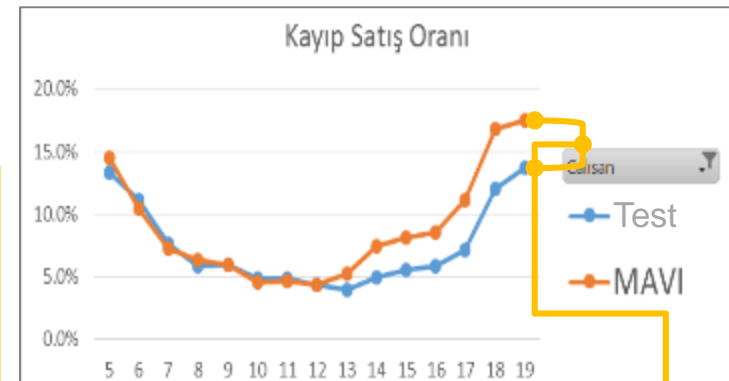


Replenishment Optimization



Dönem	Week	INVENT	MAVI	Diff
PT Öncesi	10	196,949	195,829	100.6%
PT Öncesi	11	226,518	216,310	104.7%
PT Öncesi	12	205,991	206,299	99.9%
PT Sonrası	13	254,390	230,621	110.3%
PT Sonrası	14	240,780	220,363	109.3%
PT Sonrası	15	235,441	216,751	108.6%
PT Sonrası	16	288,375	256,493	112.4%

Dönem	Week	INVENT	MAVI	Diff
PT Öncesi	10	39934	39657	101%
PT Öncesi	11	40726	40559	100%
PT Öncesi	12	45635	40742	112%
PT Sonrası	13	46500	39383	118%
PT Sonrası	14	47889	40749	118%
PT Sonrası	15	47122	40323	117%
PT Sonrası	16	46627	39241	119%



9.6% Increase in Turnover

1% Increase in Inventory Turns

4 Points Difference in Lost Sales

Concluding remarks

- **There is no free lunch**
 - **Smart combination of different approaches outperforms individual models**
- **Learning from mistakes/errors**
 - **Boosting algorithms**
- **Keeping models up-to-date (online algorithms)**
- **Transfer learning (i.e. joint feature learning)**
- **Publicly available information**
 - **Google Trends**

THANKS

Questions?