IEOR E4650 Business Analytics

Session 22: Analytics at Zara

Spring 2018

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Outline

- Zara's value proposition
- Legacy planning process
  - Potential inefficiencies
  - Analytic opportunity
- From concept to deployment
  - Leveraging forecasting and optimization
  - Testing the value of the approach

For more information, see: F. Caro, J. Gallien, M. Diaz, J. Garcia, J. M. Corredoira, M. Montes, J. A. Ramos, and J. Correa. 2010. Zara Uses Operations Research to Reengineer its Global Distribution Process. *Interfaces*, Vol.40, No.1.
http://personal.anderson.ucla.edu/felipe.caro/papers/pdf_FC12.pdf

What is Zara's Value Proposition?

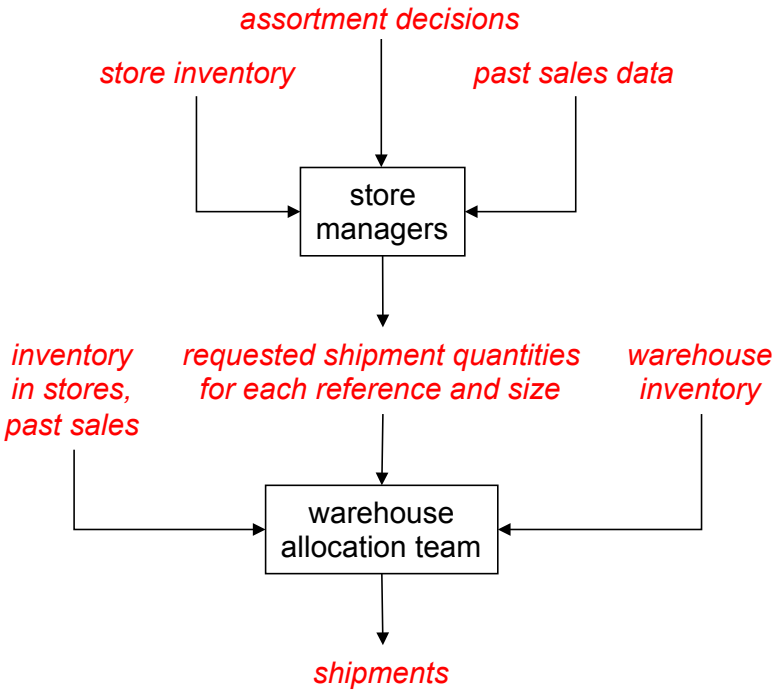
Zara's Value Proposition

- Fast fashion retailer
  - Frequent assortment rotation
  - Frequent store replenishments
  - In-season production, responsive to the market
- Local manufacturing

Today:

How does Zara make it happen?

Legacy Order and Shipment Planning Process



Main Performance Metrics

- Sales to shipment ratio (SSR)

$$\text{SSR} = \frac{\text{Cumulative sales}}{\text{Cumulative shipments}}$$

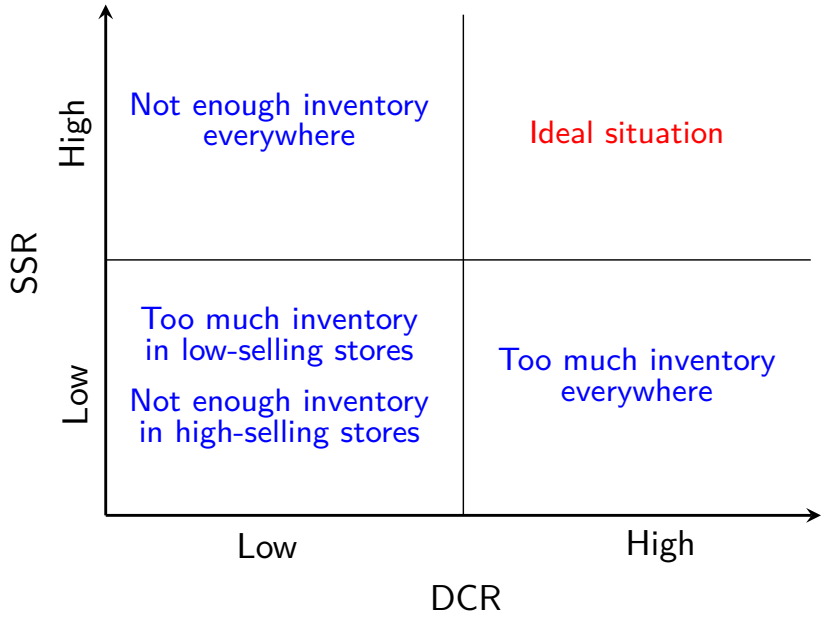
- Demand cover ratio (DCR)

$$\text{DCR} = \frac{\text{Cumulative sales}}{\text{Cumulative demand (estimated)}}$$

Two types of errors

- Ship too much: leads to items that don't sell at some stores (SSR too small)
- Ship too little: items that customers would buy aren't there (DCR too small)

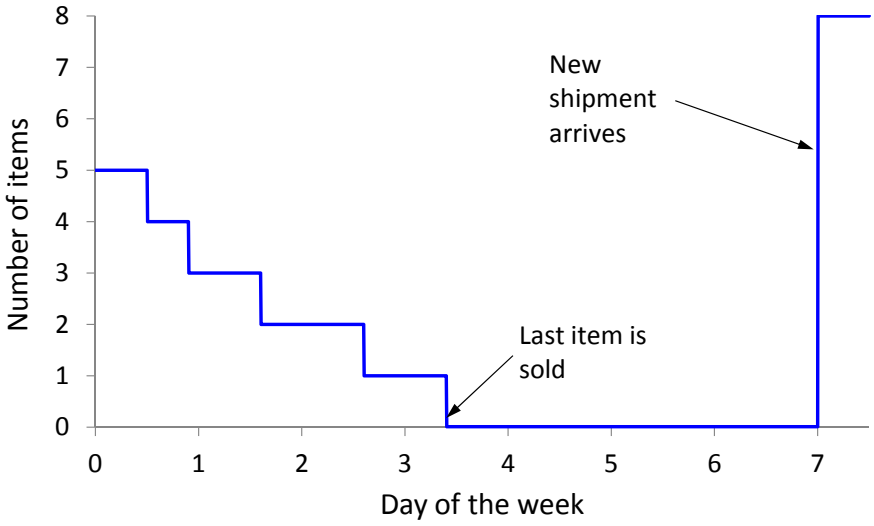
Two Goals



Sales to shipment ratio (SSR): Cumulative sales/Cumulative shipments

Demand cover ratio (DCR): Cumulative sales/Cumulative demand (estimated)

Demand Versus Sales



- Sales: the number of units actually sold
- Demand: the number of units that would have been sold if there were no stockouts
- A simple approach to estimate demand: scale up sales depending on when the last item was sold during the week
  - Further refinements: day-of-the-week effect and other factors

Exercise

Warehouse Decisions: How Much to Ship?

	Store 1	Store 2	Store 3	Store 4
Sales 3 weeks ago	10	9	7	11
Sales 2 weeks ago	12	11	10	7
Sales last week	14	16	8	10
Inventory	3	3	5	8
Order	30	30	3	1
Shipment	s_1	s_2	s_3	s_4

- Warehouse currently has 100 items in stock; 19 units are at the stores
- Orders from stores were just received (30, 30, 3, 1)
- Shipment decisions need to be made this week: $s_1, s_2, s_3,$ and s_4
- Week 1 demand will be revealed
- Process repeats for week 2 and week 3
- At the end of week 3 teams will be measured on their SSR and DCR

Warehouse Decisions: Week 1

	Store 1	Store 2	Store 3	Store 4
Inventory	3	3	5	8
Order	30	30	3	1
Shipment	30	30	3	1
Inventory	33	33	8	9
Week 1 demand	6	9	12	14
Week 1 sales	6	9	8	9
Inventory	27	24	0	0
Order	7	9	15	14
Shipment	s_1	s_2	s_3	s_4

Warehouse inventory remaining: 36

Warehouse Decisions: Week 2

	Store 1	Store 2	Store 3	Store 4
Inventory	3	3	5	8
Order	30	30	3	1
Shipment	30	30	3	1
Inventory	33	33	8	9
Week 1 demand	6	9	12	14
Week 1 sales	6	9	8	9
Inventory	27	24	0	0
Order	7	9	15	14
Shipment	7	9	15	5
Inventory	34	33	15	5
Week 2 demand	10	10	4	11
Week 2 sales	10	10	4	5
Inventory	24	23	11	0
Order	7	9	15	14
Shipment	s_1	s_2	s_3	s_4

Warehouse inventory remaining: 0

Warehouse Decisions: Week 3

Shipments must be zero (in this case): the remaining warehouse inventory is zero

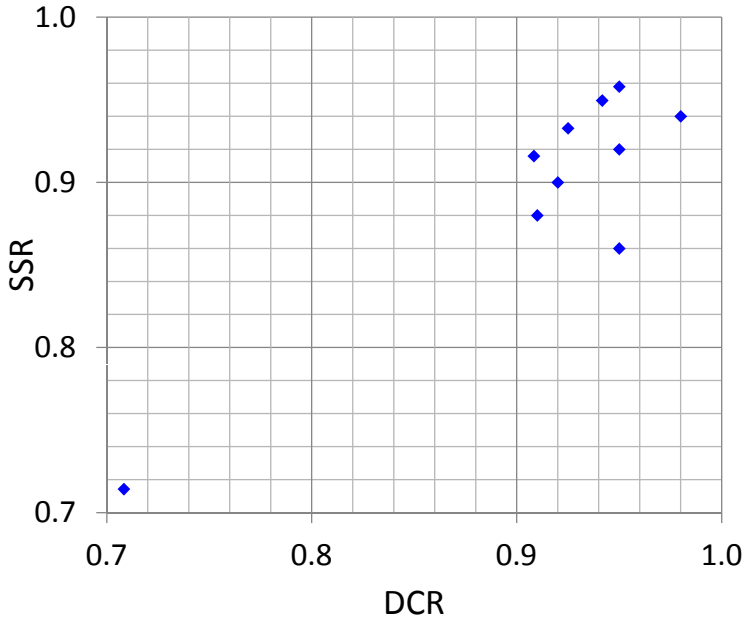
Warehouse Decisions: Week 3 After Demand

	Store 1	Store 2	Store 3	Store 4
Inventory	24	23	11	0
Order	7	9	15	14
Shipment	0	0	0	0
Week 3 demand	11	7	12	14
Week 3 sales	11	7	11	0
Inventory	13	16	0	0

- Cumulative sales: 90
- Cumulative shipments: 119
- Cumulative demand: 120

- Sales to shipment ratio (SSR): Cum. sales/Cum. shipments = $90/119 = 0.76$
- Demand cover ratio (DCR): Cum. sales/Cum. demand (estimated) = $90/120 = 0.75$

SSR Versus DCR: Possible Outcomes



Sales to shipment ratio (SSR): Cumulative sales/Cumulative shipments

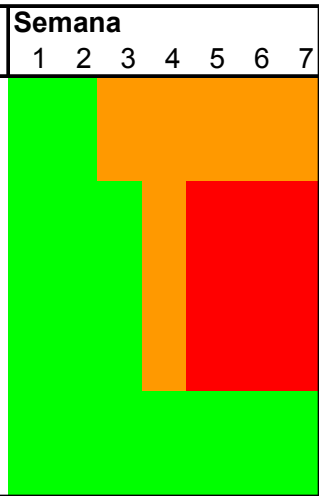
Demand cover ratio (DCR): Cumulative sales/Cumulative demand (estimated)

Diagnostic

Legacy Process: Potential Inefficiencies

Example of item: PANTALON NINA TEJANO CON PRINT ROMANTICO

Tienda	Nombre	Ventas Totales
3197	MIL-VITORIO....	238,608
3028	CC MATOSINHOS..	193,862
382	TS-TSIMISKI....	137,671
306	BRAGA.....	94,192
76	ALICANTE.....	93,960
3043	AVE-CC FORUM...	93,157
3093	ANDORRA.....	92,885
117	BARC-DIAGONAL..	56,521
1086	KC-CAD.NOVENA..	56,510
3208	T.A-REHOVOT....	10,640
3158	QUE-CC STE.FOY.	10,195
3293	MON-CHAMPLAIN..	10,012



Stock relativo
a la capacidad de venta:

- Alto o sufficiente
- Insuficiente
- No Stock

Stores that need inventory "starve"
while some stores have plenty of leftover inventory

Legacy Process: Potential Inefficiencies

Sources of inefficiencies

- Store incentives
  - Store managers rewarded on sales
  - Store level optimization versus centralized optimization
- Warehouse resources and guidelines
  - How many decisions have to be made every week?

    1,000 stores $\times$ 3,000 items $\times$ 8 sizes
    $\Rightarrow$ approximately 24 million decisions per week

Analytics Opportunity?

- Reduce biases through predictive analytics
    - Obtain an "objective" view of demand
- Process and optimize a very large number of decisions in a systematic fashion
    - Mitigate inefficiencies that may arise
    - Potential to use optimization

Zara's Approach

Predictive Analytics: Forecasting Weekly Sales

Goal: Forecast weekly sales at the model, quality, color and size level at every store

In a fast fashion retail environment, is there any useful information from past years?

Predictive Analytics: Approach to Forecasting Demand

Unit of time t: week

$$\text{Demand}_t = \alpha\,(I_t + X_t) \;+\; (1-\alpha)\,Y_t + \text{ error}$$

I_t: current inventory at the store

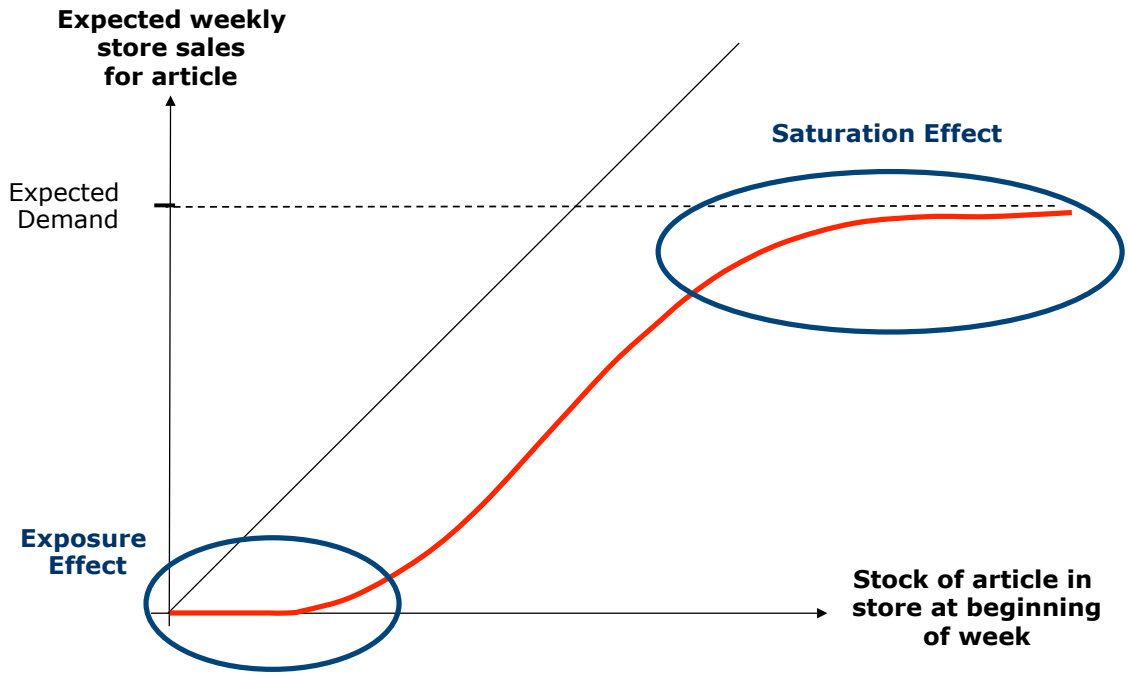
X_t: store manager's order

$I_t + X_t$: subjective forecast of demand

Y_t: data-driven forecast of demand, constructed using

- Year-on-year subfamily sales (seasonality correction)
  Examples of subfamilies: basic t-shirts, basic pants
- Last week subfamily sales (short-term trend)
- Proportion of subfamily sales attributed to target item
  ("top-down" item forecast)

Forecasting Sales as a function of Inventory and Demand



Prescriptive Analytics: Optimizing the Shipment Decisions

Decision variables

- $x_{i,j,k}$ = number of units of item i of size j to send to store k

Constraints

- Cannot ship more than what is available in the warehouse

Two objectives

- Maximize DCR: want to make sure not to miss demand
  - ship a lot initially (short term)
  - make sure to keep inventory for future demand (long term)
- Maximize SSR: want to make sure not to have unsold inventory at the stores at the end of the season
  - Limit initial shipments to keep flexibility for later allocations (long term)

Optimization Approach

Maximize Next week's forecasted dollar sales at stores

Subject to:

Leftover inventory at WH / Total initial inventory $\geq \mathbf{K}$

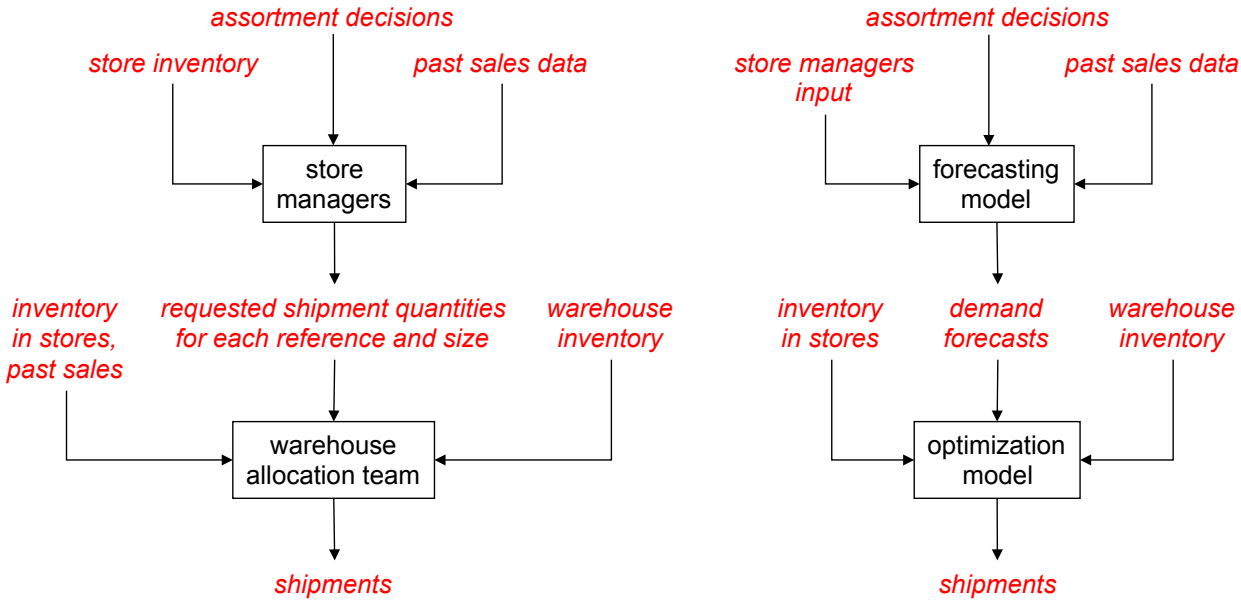
Leftover inventory at WH = Initial WH inventory − sum of all shipments

Sum of all shipments $\leq$ Initial WH inventory

$\mathbf{K}$: aggressiveness parameter

- Can be tuned by users
- High $\mathbf{K}$ is conservative: keep flexibility for later
- Low $\mathbf{K}$ is aggressive: used toward the end of an article's lifecycle

Legacy Process versus New Process



(a) Legacy Process *(b) New Process*

Pros and Cons?

- Pros
  - Introduces objectivity in the decision-making process
  - Easily scalable to more stores and items
  - Accounts for store managers' input (forward view) in addition to historical patterns of sales
- Cons
  - Future value of flexibility is captured in a heuristic fashion
  - Subjectivity in selecting tuning parameter $\mathbf{K}$

Decision Support System Snapshot

Ajuste de Pedidos — 3203 LIS-DIOGO C.C.

11/7 MARR/C | 0264/009/753 | *B-(L-2)-CTA ALG C/B CINTA M/3/4 | Uds. Lote : 2

Tnd.	S :: 718				M :: 2546				L :: 132				XL :: 36			
	718				2546				132				36			
LIS-DIOGO C.C.	28	2	9	3 5	28		17	7	24	14	6	10				35
LIS-CC V.GAMA..	16	16	18	15	20	20	28	22	18	18	15	16			3	5
BRAGA.....	12		14	5	16	12	6	8	8		16	7				18
KUW-AVENUES....	6		4		12		5	1	12		4				4	2
CAS CC SHOPPING			21	4	16	14	11	13	10	2	11	6				53
AVE-CC FORUM...	6		31	3	14	6	20	11	4		29	3			3	3 2
LOU-LOURES CC..	8	12	3	10	10	14	3	9	4	6	6	6			3	3 4
DUBAI CC.....	10		9	2	6		20	1	6		25	1			3	
SANTANDER.....	6	4	4	3	16	12	1	7		4	9	3 7				1
DUB-MALL CC....	6		22	1	8		20	1	6		20	1			4	2
CC MATOSINHOS..	8		10	5			21	10	12	2	7	3			3	3 5
COIM-FORUM CC..	4		13	2	6	4	10	3	8		20	4			2	3 4

Analytics Solution

What is the potential value of such a system for Zara? (In other words, how much should Zara be ready to pay for such a system if the alternative is doing nothing?)

(a) 0-50K

(b) 50-200K

(c) 200K-500K

(d) 500K-2M

(e) 2-10M

(f) >10M

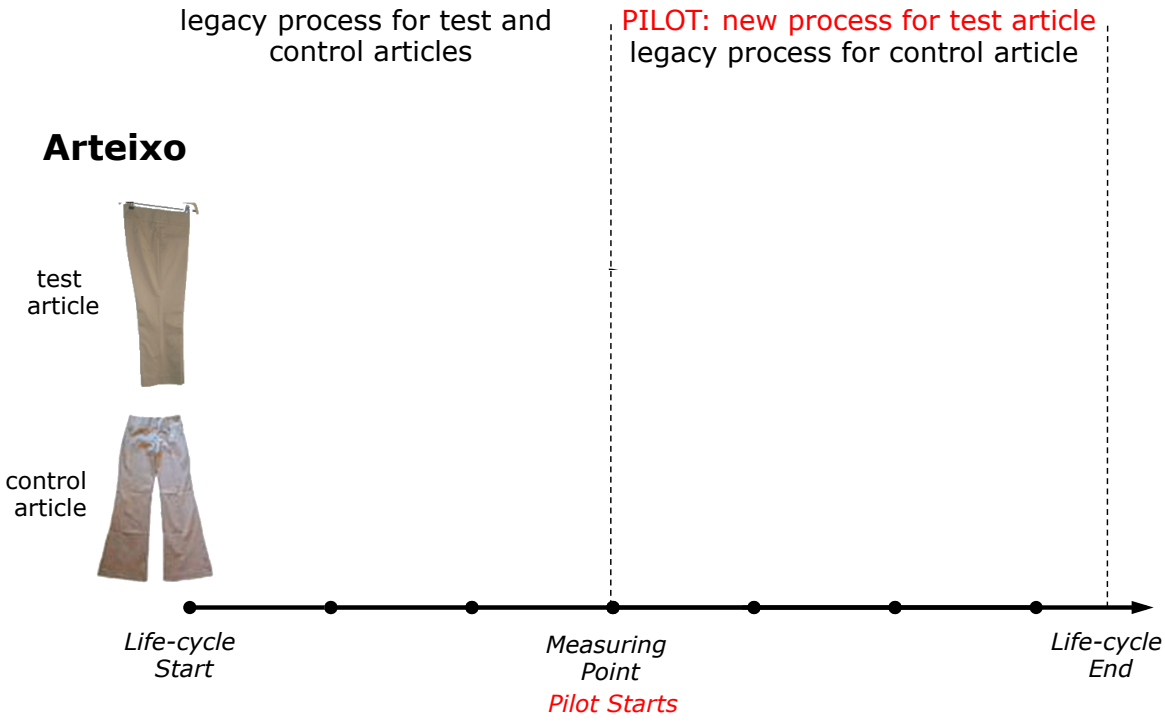
From Proposal to Validation: How?

Assessing the Value through a Pilot

- 10 test articles that represent Zara's assortment
- Each test article was matched with a control article based on
  - Type: basic versus fashion
  - Age: date of introduction differs by at most one week
  - Similarity in performance prior to start of pilot:
    sales to shipment ratio (SSR) and demand cover ratio (DCR)
- Implemented at Arteixo warehouse

Setting up the Pilot

Setting up the Pilot



Assessing the Impact: Methodology

Difference-in-Differences (DiD) approach

For each matched pair of test/control articles, and performance metric M, compute:

$$\Delta M = [M^{\text{end}}_{\text{test}} - M^{\text{start}}_{\text{test}}] - [M^{\text{end}}_{\text{control}} - M^{\text{start}}_{\text{control}}]$$

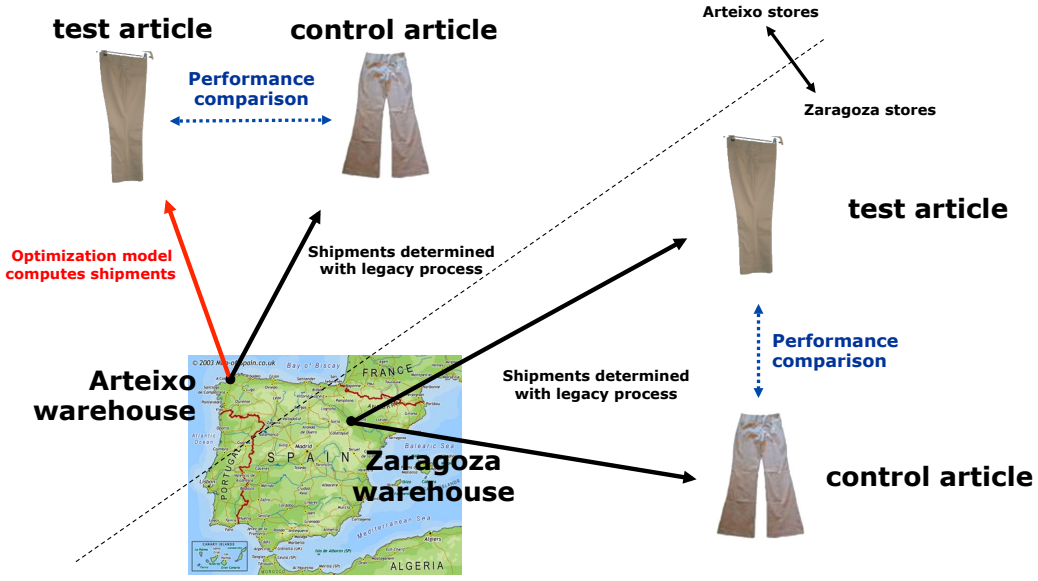
- Eliminates factors that are common to test and control articles

Assess impact on performance metrics SSR and DCR

Pilot Results

Warehouse	Articles	Δ SSR	Δ DCR
Arteixo	Basic	−2.2%	10.1%
	Fashion	6.4%	1.9%
	All	3.0%	5.2%

Secondary Control



- Pilot at Arteixo WH: measures the impact of the new process
- Control at Zaragoza WH: measures estimation error (second layer of control) using same articles

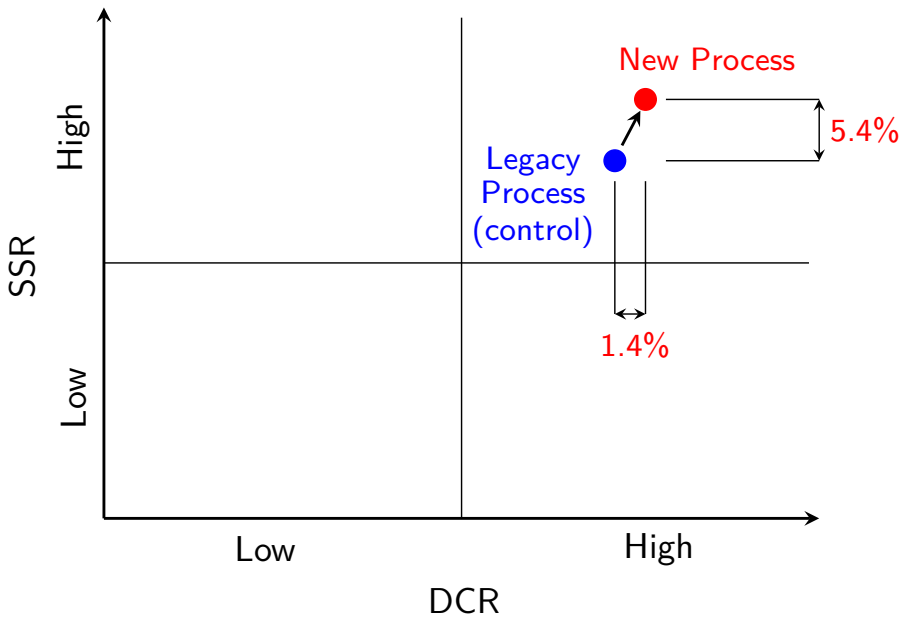
Final Results

Warehouse	Articles	Δ SSR	Δ DCR
Arteixo	Basic	−2.2%	10.1%
	Fashion	6.4%	1.9%
	All	3.0%	5.2%
Zaragoza (control)	Basic	−5.3%	2.6%
	Fashion	−0.5%	4.6%
	All	−2.4%	3.8%

(1) Interpret the results: How did the program work?

(2) Evaluate, through a back of the envelope calculation the potential value of the new system (if any)

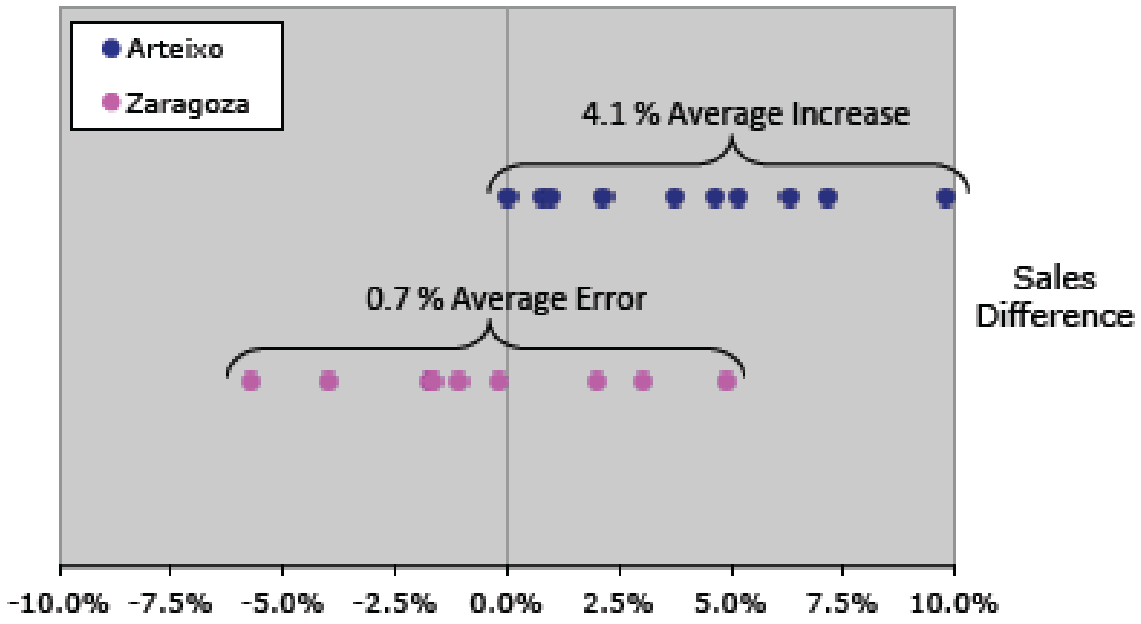
Visualizing Pilot Results



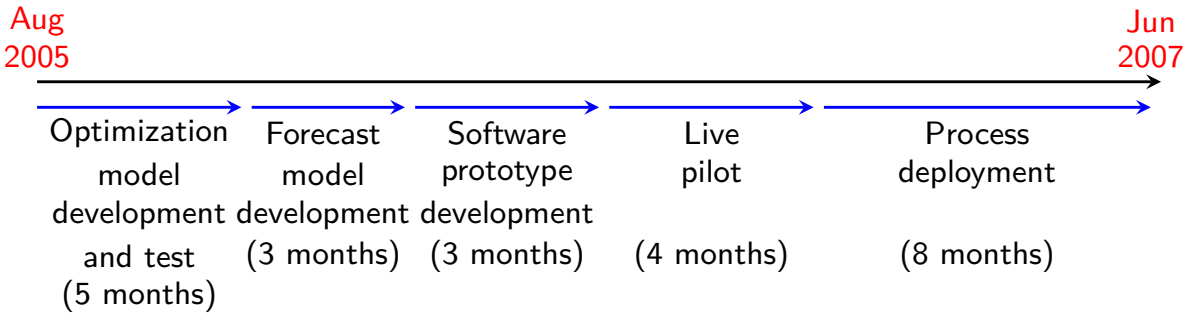
Sales to shipment ratio (SSR): Cumulative sales/Cumulative shipments

Demand cover ratio (DCR): Cumulative sales/Cumulative demand (estimated)

Pilot Results: Sales Impact



The Timeline from Concept to Deployment



Wrap Up

- From labor intensive legacy process to a new process
  - Scalable process without major capital investments
  - Systematic rules for decision-making through optimization and forecasting
- Even imperfect models can yield significant value
- Framework developed is broadly applicable: Zara has since re-optimized its markdown policies following a similar framework[1]
  - Modeling of the key drivers of the demand for items that are marked down (e.g., broken assortment effect)
  - Validation of demand forecast
  - Dynamic optimization of markdowns with forecast as input
  - Pilot in Belgium and Ireland (DiD)
- Analytics is a core value driver in many supply chains

[1] Source: Caro, F., J. Gallien. 2012. Clearance Pricing Optimization for a Fast-Fashion Retailer, *Operations Research*, Vol.60, No.6. http://personal.anderson.ucla.edu/felipe.caro/papers/pdf_FC15.pdf