Zara Uses Operations Research to Reengineer Its Global Distribution Process

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Zara’s Continuous Business Cycle

Distribution

Stores

Customer feedback and fashion trends

Global Warehouses

Suppliers

Production and delivery

Production and specifications

Design Team
Legacy Distribution Process (2006 and Before)

store managers

store inventory

past sales data

assortment decisions

requested shipment quantities for each article and size

inventory in stores, past sales

warehouse inventory

warehouse distribution team

shipments
Problems with Legacy Process

- Store incentives and local optimization
- Warehouse resources and guidelines

![Diagram showing stock levels and sales](image)
New OR-Based Distribution Process

Legacy Process

New Process
The Optimization Model

For every article:

\[
\text{Max} \quad \sum_{\text{store } j} \text{Price}(j) \times \text{Sales}(j)
\]

Subject to:

\[
\begin{align*}
\text{Expected revenue for upcoming week} + \text{Value of leftover inventory} = \\
\sum_{\text{store } j} \text{Sales}(j) &= \text{Function} \left[ \text{Store Inventory}(j,s) + \text{Shipment}(j,s) , \text{Forecast}(j,s) \right] \\
\text{Inventory-to-sales function} = \\
\sum_{\text{store } j} \text{Shipment}(j,s) = \text{Existing WH Inventory}(s) - \sum_{\text{size } s} \text{Leftover WH Inventory}(s) \\
\text{Leftover inventory calculation}
\end{align*}
\]

Subject to:

\[
\sum_{\text{store } j} \text{Shipment}(j,s) \leq \text{Existing WH Inventory}(s)
\]

Inventory availability constraint

\[
\sum_{\text{store } j} \text{Shipment}(j,s) \text{ is integer}
\]
Inventory-To-Sales Function

Expected store sales for article that week

Expected demand (Forecast)

Exposure Effect

Saturation Effect

Stock of article in store at beginning of week
Exposure Effect and Size Display Policy

Article with 4 Sizes
(Small, Medium, Large, Extra Large)

<table>
<thead>
<tr>
<th>remaining sizes</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
<td>S M L XL</td>
<td>Keep on display</td>
</tr>
<tr>
<td>M L XL</td>
<td>Keep on display</td>
</tr>
<tr>
<td>S M L</td>
<td>Keep on display</td>
</tr>
<tr>
<td>M L</td>
<td>Keep on display</td>
</tr>
<tr>
<td>S M XL</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>S L XL</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>S M</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>L XL</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>S L</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>M XL</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>S XL</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>S</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>M</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>L</td>
<td>Move to backroom</td>
</tr>
<tr>
<td>XL</td>
<td>Move to backroom</td>
</tr>
</tbody>
</table>

Entire article is removed to backroom when major size Medium or Large stocks out
Stochastic Store Display Model

- Poisson process arrival rates obtained from demand forecasts

- Customer Arrival Process
  - $\lambda_{\text{SM}}$ for SM
  - $\lambda_{\text{M}}$ for M
  - $\lambda_{\text{L}}$ for L
  - $\lambda_{\text{XL}}$ for XL

- Inventory
- Sizes

Starting inventory $x_s$ of each size $s$:
$$x_s = \text{Store}_\text{Inventory}(s) + \text{Shipment}(s)$$

- Stochastic stopping times:
  - The time when a size stocks out: $\tau_s \triangleq \inf\{ t \geq 0 : N_s(t) = x_s \}$
  - The time when the first major size stocks out: $\tau_A \triangleq \min_{s \in A} \tau_s$

- Linear approximation of expected sales function:
$$\mathbb{E} \left[ \sum_s N_s(\tau_A \wedge \tau_s \wedge 1) \right] = \lambda_A \mathbb{E}[1 \wedge \tau_A] + \sum_{s \notin A} \lambda_s \mathbb{E}[1 \wedge \tau_{A \cup \{s\}}]$$
$$= \text{Function}[ \text{Store}_\text{Inventory}(s) + \text{Shipment}(s), \text{Forecast}(s) ]$$
Mathematical Model Formulation

\[ \text{Max} \quad \sum_{j \in J} P_j z_j + C \left( \sum_{s \in S} (W_s - \sum_{j \in J} v_{sj}) \right) \]

\[ \text{Subject to:} \]

\[ z_j \leq \left( \sum_{s \in A} \lambda_{sj} \right) \tau_j + \sum_{s \notin A} \lambda_{sj} \omega_{sj} \quad \forall j \in J \]

\[ \tau_j \leq a_i (\lambda_{sj}) (Y_{sj} + v_{sj} - i) + b_i (\lambda_{sj}) \quad \forall j \in J, s \in A, i \in I \]

\[ \tau_j \leq 1 \quad \forall j \in J \]

\[ \omega_{sj} \leq a_i (\lambda_{sj}) (Y_{sj} + v_{sj} - i) + b_i (\lambda_{sj}) \quad \forall j \in J, s \notin A, i \in I \]

\[ \omega_{sj} \leq \tau_j \quad \forall j \in J, s \notin A \]

\[ \sum_{j \in J} v_{sj} \leq W_s \quad \forall s \in S \]

\[ z_j, \tau_j, \omega_{sj} \geq 0, v_{sj} \in \mathbb{N} \]
Pilot Test: Objectives

- When: 2006 Fall/Winter season

- Objectives:
  1. Prove concept feasibility through actual implementation
  2. Refine software interface and model features based on feedback from field users
  3. Estimate the model’s specific impact on inventory distribution
Pilot Test: Matching Procedure

• 10 test articles that represent Zara’s assortment

• Each test article was matched with a control article

• Matching criteria:
  - same type of article
  - same life-cycle
  - similar prior performance
Pilot Test: Experiment Design

- **test article**
- **control article**

Zaragoza stores
Arteixo stores

Optimization model computes shipments

Shipments determined with legacy process

Performance comparison

Arteixo warehouse
Zaragoza warehouse
Pilot Test: Arteixo Warehouse

- Legacy process for test and control articles
- PILOT: new process for test article
- Legacy process for control article

Arteixo

- Test article
- Control article

Life-cycle Start

Measuring Point
- Pilot Starts

Life-cycle End
Pilot Test: Zaragoza Warehouse

Zaragoza

legacy process for test and control articles

life-cycle Start

Measuring Point

Life-cycle End

test article

control article

Life-cycle End
1. Remove *anything* that happened prior to the pilot

\[
M'_{\text{Test}} - M_{\text{Test}} \quad \text{for test articles}
\]

\[
M'_{\text{Control}} - M_{\text{Control}} \quad \text{for control articles}
\]
Pilot Test: Impact Estimation Methodology

1. Remove *anything* that happened prior to the pilot

\[ M'_{\text{Test}} - M_{\text{Test}} \quad \text{for test articles} \]
\[ M'_{\text{Control}} - M_{\text{Control}} \quad \text{for control articles} \]

2. Eliminate factors that are common to test and control articles (1\textsuperscript{st} dimension of control)

\[ (M'_{\text{Test}} - M_{\text{Test}}) - (M'_{\text{Control}} - M_{\text{Control}}) \]

- Arteixo: impact of the new process
- Zaragoza: measurement of impact estimation error (2\textsuperscript{nd} dimension of control)
Pilot Test: Increase in Sales

Arteixo
Zaragoza

Sales Difference

-10.0%  -7.5%  -5.0%  -2.5%  0.0%  2.5%  5.0%  7.5%  10.0%
Pilot Test: Increase in Sales

Arteixo

Zaragoza

Sales Difference

-10.0%  -7.5%  -5.0%  -2.5%  0.0%  2.5%  5.0%  7.5%  10.0%
Pilot Test: Increase in Sales

0.7% Average Error

Arteixo

Zaragoza

Sales Difference

-10,0%  -7,5%  -5,0%  -2,5%  0,0%  2,5%  5,0%  7,5%  10,0%
Pilot Test: Increase in Sales

- Arteixo
- Zaragoza

4.1% Average Increase

0.7% Average Error

Sales Difference

-10.0% -7.5% -5.0% -2.5% 0.0% 2.5% 5.0% 7.5% 10.0%
Pilot Test: Increase in Sales

- 4.1% Average Increase

= 3 to 4% Increase in Sales

- 0.7% Average Error

Sales Difference

Arteixo
Zaragoza
Realized Financial Impact

3 to 4% Increase in Sales
Realized Financial Impact

3 to 4% Increase in Sales

2007

Additional Revenue
$233 M

Additional Net Income
$28 M
Realized Financial Impact

3 to 4% Increase in Sales

Additional Revenue

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>$233 M</td>
<td>$353 M</td>
</tr>
</tbody>
</table>

Additional Net Income

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Income</td>
<td>$28 M</td>
<td>$42 M</td>
</tr>
</tbody>
</table>
Operational Impact

- Display Cover Ratio

\[
\frac{\text{days on display per store}}{\text{days} \times \text{stores}} \quad \rightarrow \quad +3.5\%
\]

- Transshipments and Returns Ratio

\[
\rightarrow \quad -19\%
\]
Conclusion

• Technical OR achievements:
  – First application of OR to fast fashion
  – Tight MIP formulation of complex stochastic problem
  – Distributed IT implementation with many real-time users
  – Large controlled field experiment to estimate impact

• Business impact:
  – Substantial measurable increase in sales by 3-4% → $350M
  – Shelf exposure time increased by 3.5%
  – Transshipments and returns reduced by 19%
  – Scalable process without major capital investment

• Human impact: Positive transformation of sixty employees’ daily lives