

Challenges in Large Scale Article Discounting



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Pricing Platform

GOR working group Real World Optimization, 2022-10-06

zalando



Champion of style



Fashion

> 1,800,000 articles

> 6,500 brands

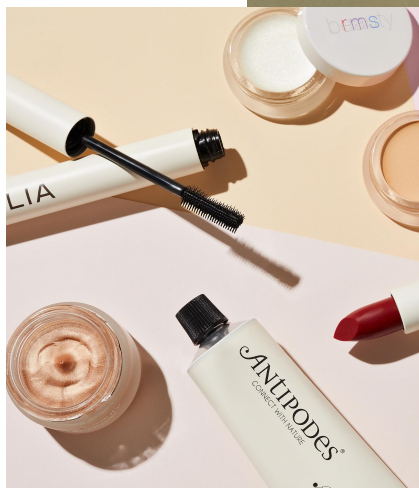
Dedicated content creation
by Zalando Content Solutions



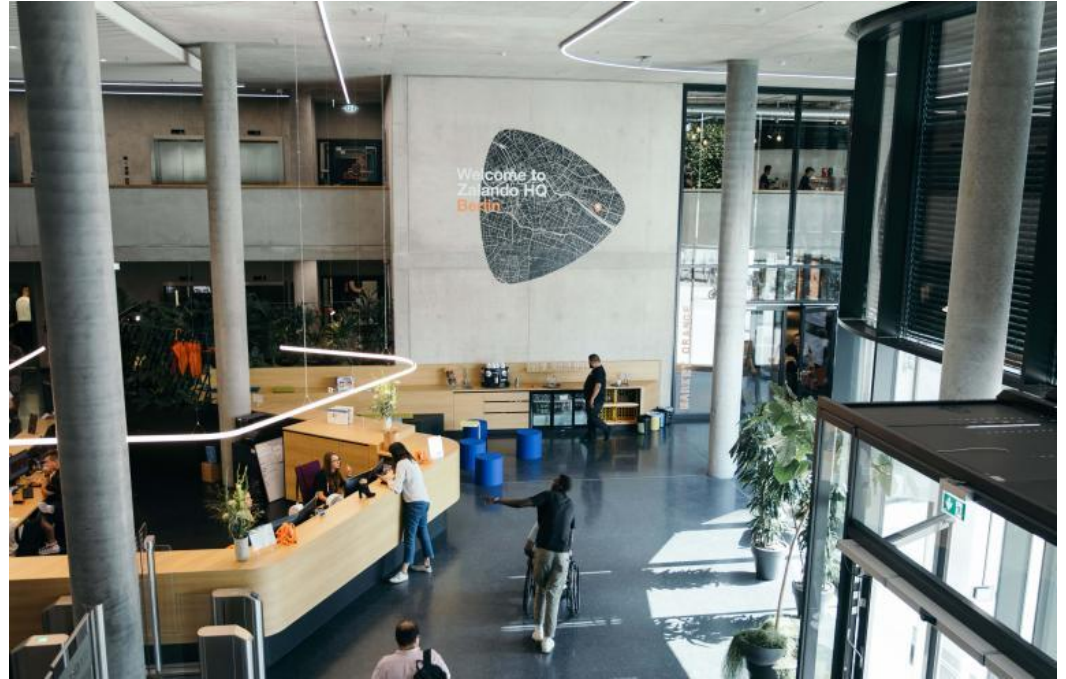
Beauty

> 35,000 products

Strategic partnership with Sephora



Large Scale Article Discounting



Pricing Goal: Provide profit optimal discounts

simplistic Pricing Idea: stock bought ahead of time → sell it for best profit

- recommend best discount schedule per article
 - for all articles in the shop
 - for all countries we are serving
 - with a certain frequency, e.g., weekly until season end
(→ couple **hundred millions of discounts**)

rationale: maximum profit for entire assortment → maximum profit per article

Issue: Business targets (et.al.) combine single article optimization
(discount rate in Italy 20%, discount rate Kids articles 10%)

→ profit maximization is a huge connected problem



Optimal Discounts with Targets


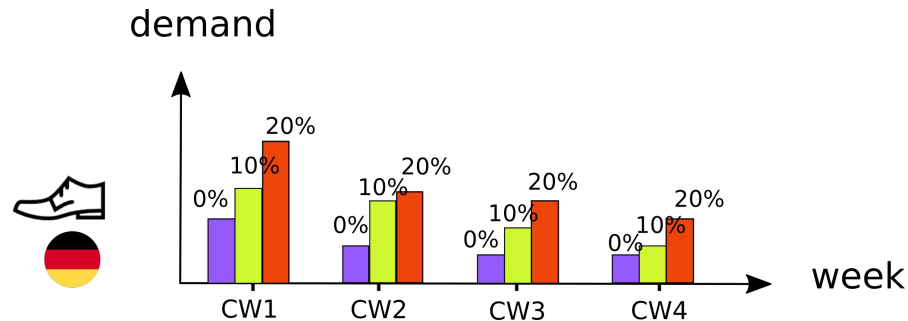
- Given some forecasts (demand, return rate, cost...), the stock flow can be modeled as




Mixed Integer Program per article

→ Optimal discount schedule computable easily per article over all countries

(few seconds)

- Targets across articles modelled via **Lagrangian Relaxation**
(decouples huge single problem in many small problems)

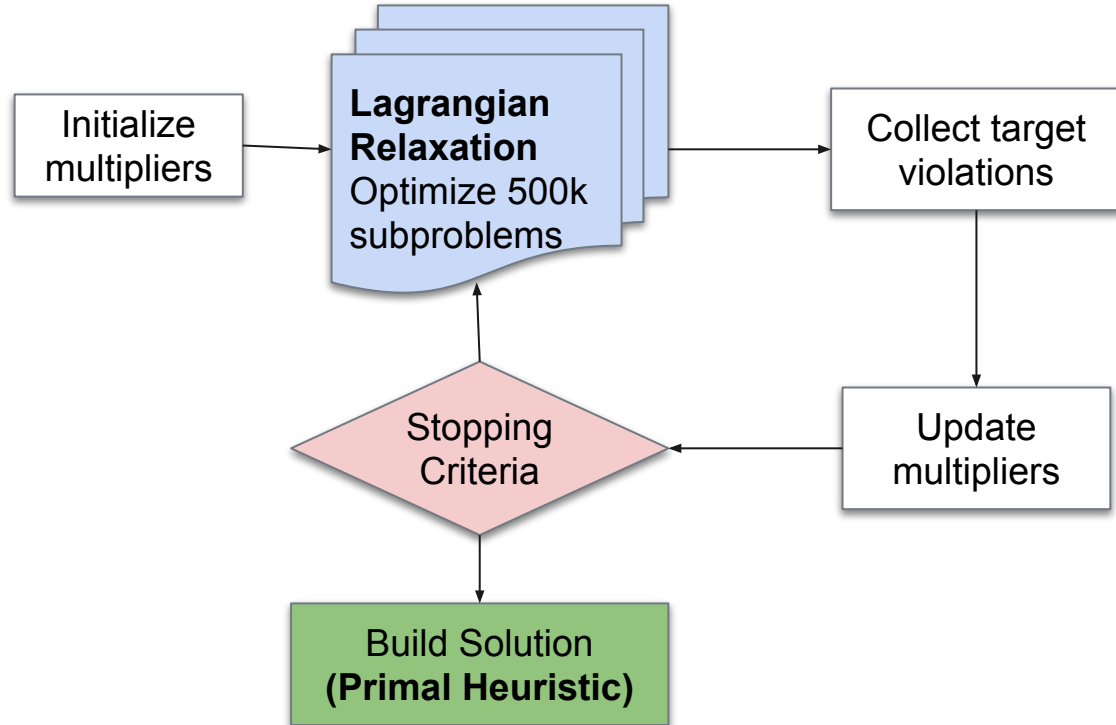


	CW1	CW2	CW3	CW4
	20%	15%	15%	0%
	15%	15%	20%	15%
	25%	15%	10%	5%

Optimal Discounts with Targets

Target Steering Optimization

- consumes article data and forecasts
- runs iterations of the lagrangian relaxation
- heuristic generates preferred solution at the end
- reaches typical targets
- generates reports to for users



Large-scale Price
Optimization for an Online
Fashion Retailer



Optimal Discounts with Targets

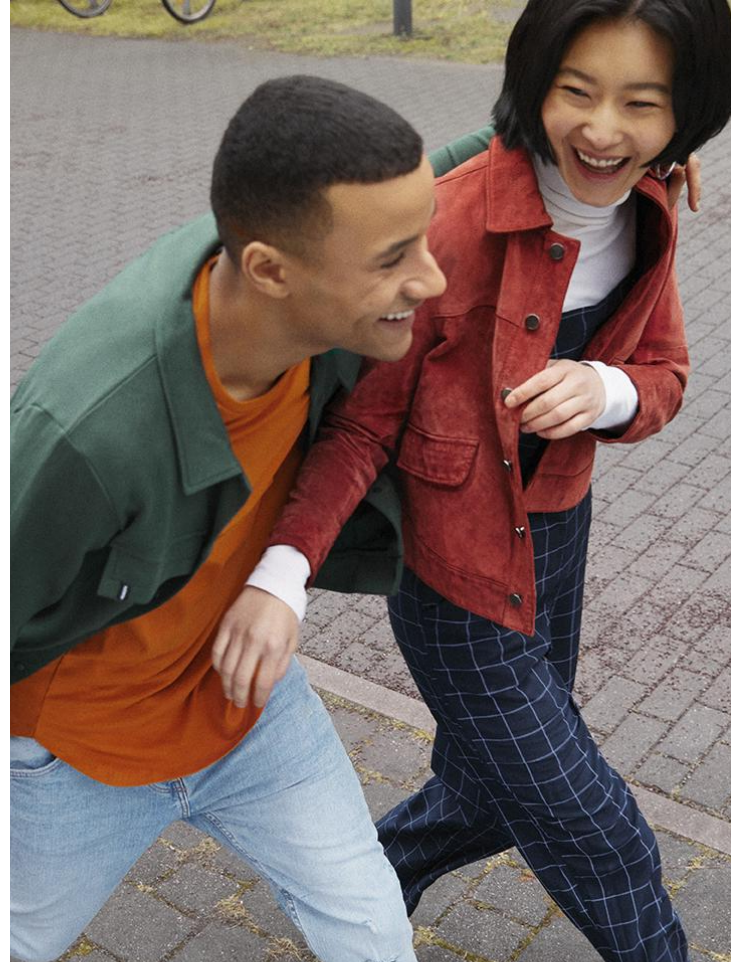
Success?: **Yes**

- **hitting targets** given by business partners
- **provable gap** and lower bound
- **predictable** and **stable** runtime and execution
- **scalable** towards an ever-growing assortment

BUT.....

Lots of hidden challenges and complications for this rather clean approach

Expectations And Requirements





“Pricing” Department

Mission: Provide Engaging Discounts to our Customers

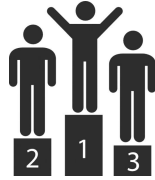
Disclaimer: This reflects my point of view mostly

Important Aspects for Optimization & Forecasting:

- black prices (original price)
 - setting original prices per country (e.g. different VAT)
- red prices (discounts)
 - risk: ensuring to sell seasonal articles until the end of the season
 - competitive and strategic: creating engaging offers
- vouchers
 - for certain customers/markets on all or part of the assortment
- specific marketing campaigns
 - e.g., special sales periods in selected countries

Resulting Requirements & Challenges

Competitive Discounting
match competitors`
discounts strategically



Sales Events
support themed events
selected countries



Legal Requirements
different rules per country,
i.e., share of articles at certain
discount if advertised



Seasonal and **Non-Seasonal** Articles
some articles available all the time

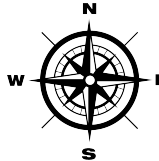


Brand Perception
careful discounting for premium brands



Guidance for Planning
forecast impact of business goals

Warehouse Capacities/**Stock** Availabilities
slow down sales for warehouse capacities



Forecasting related Challenges



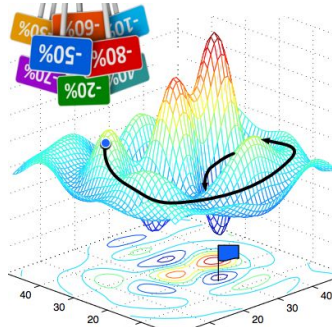
Forecasting Components - Demand or Sales

Sales Forecast

Input: discount schedule
(all countries/weeks)

Output: resulting sales

- considering stock, returns, resupply,..
- matches observable data
- fewer parameter for optimization to keep track/work

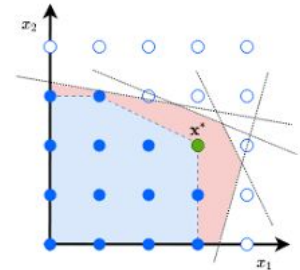


Demand Forecast

Input: single country-week discount

Output: resulting demand

- less coupling between countries
- demand only observable if below stock
- more possibilities/responsibilities for the optimization



Forecasting Components - Sales & Demand

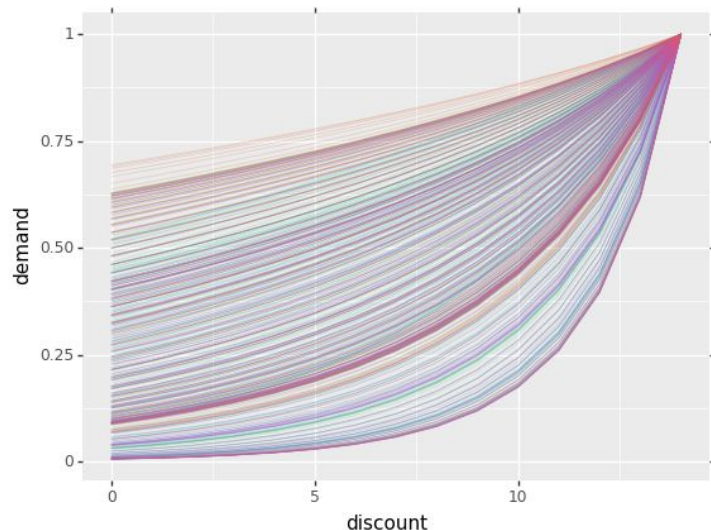
Uncertainty in Article Elasticity

How far is the future reliable to predict?

- big spontaneous impact: weather
- also consumer's willingness to spend money
- certain discounts rarely observed

Possible approaches:

- (telescopic) time aggregation
 - probabilistic forecasts
- highly coupled to optimization





Forecasting Components - Sales & Demand

Sizes and **niche** articles

Which type of article has the most sizes?

Forecasting Components - Sales & Demand

Sizes and niche articles



Choose your size

34x30

34x32

34x34

34x36

34x38

34x40

Standard delivery

Size

Some articles have lots of sizes.

(e.g., Jeans with 17 widths, each with several lengths → 100 sizes)

→ Group sizes for forecasting purposes

Niche

Big share of assortment is sold rarely
(long tail)

→ How to forecast when article is sold only every other week?

Forecasting Components - Expected Costs

- **Shipping** and Handling

- discounts are set per article, shipping is done with entire order
- mixed calculation of costs
- articles might or might not be in the same warehouse
(cost depends on customer's order and warehouse allocation)

- Return Rates and **Return Costs**

- returns are possible up to 14 weeks after purchase → observed very late
- returns are not always in re-sellable (in shop) condition (estimated share)



Mixed calculations that aren't perfect

Forecasting Components - Expected Costs

Cannibalization and Halo Effect

- demand/sales interdependent between articles
- High discount on similar article
→ less demand (e.g., similar sweater)
- High discount on a complementing article
→ higher demand (matching shorts & t-shirt)

Also: Recommendations play a big role, can work as price anchor

Residual Values

- How to deal with stock that cannot be sold? What is its value?
- Past observations might be incorrect for this seasons article



Optimization related Challenges






Optimization Problems and Components

Model Behavior & Reality

sales are modelled as variables, bound by stock & demand (depending on discount)

Balanced Sales

	demand	profit/sale
	20	30€
	15	25€
	10	28€




**What could clash with reality
if model “decides” sales?**

Optimization Problems and Components

Model Behavior & Reality

sales are modelled as variables, bound by stock & demand (depending on discount)

Balanced Sales

	demand	profit/sale
	20	30€
	15	25€
	10	28€

Model

- pushes sales to most lucrative countries
- refuse to sell if it is unprofitable

Example: stock = 25 items

→ sales: CH: 20 (100% demand), DE: 0 (0%), FR: 5 (50%)

Reality: No country preference, orders fulfilled as they occur

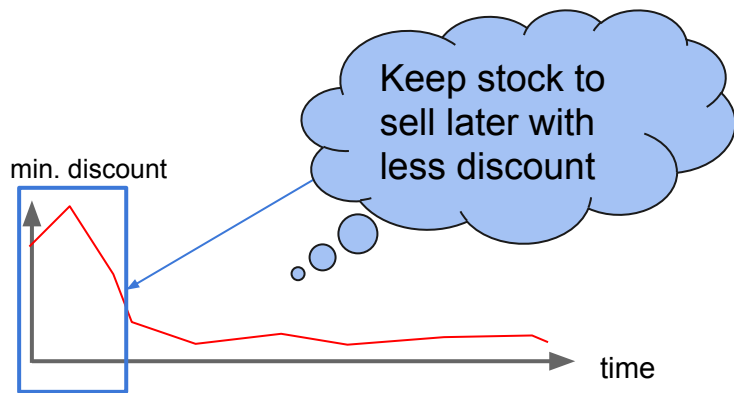
Simple **Constraint:** Same ratio of demand fulfilled per time

Optimization Problems and Components

Model Behavior & Reality

sales are modelled as variables, bound by stock & demand (depending on discount)

Stock Hedging



→ optimization could choose against fulfilling demand

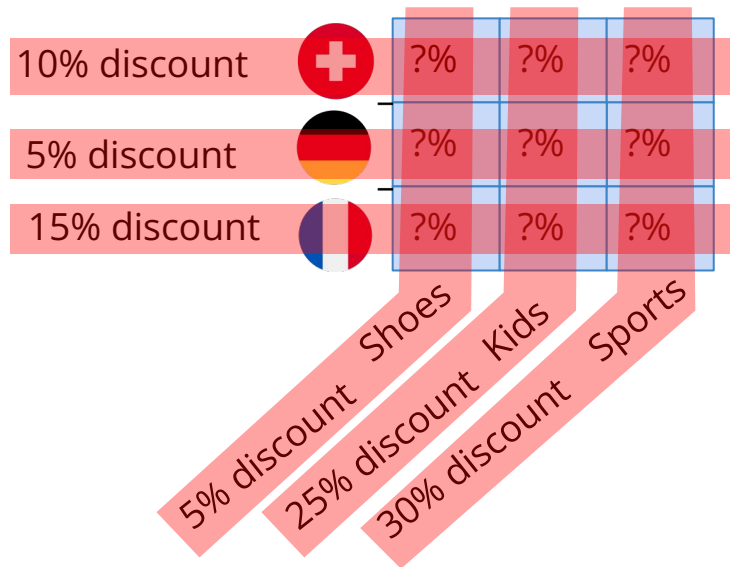
- fighting against sales periods
- potentially exploiting demand forecasts

Reality: Articles are not taken offline

Binary constraint: either **demand fulfilled** or **stock depleted**

Optimization Problems and Components

Infeasible Targets



different types of targets hard to judge
(GMV, average discount, stock levels,...)

Business Targets can be **incompatible**

Lagrangian Relaxation:

best upper bound is $-\infty$

- How to detect upfront?
- What is smallest change to make it feasible?
→ Theoretical hard questions

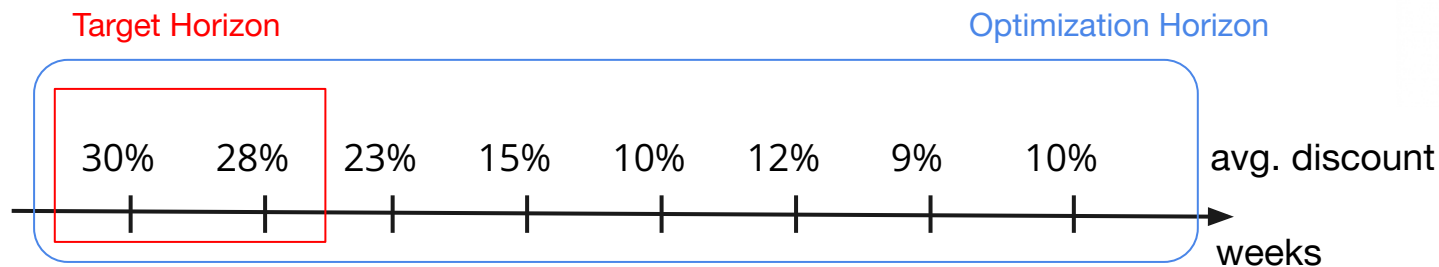
Approaches (all with lots of effort)

- provide guidance to planners
- adjusts targets automatically
- provide reasonable fallback solution

Optimization Problems and Components

Long Term Profit Optimization

Business has **quarterly, monthly, weekly**, targets
Optimization looks ahead at the end of a season



Targets affect optimization in nearest future → optimizer's believes it can be compensated later



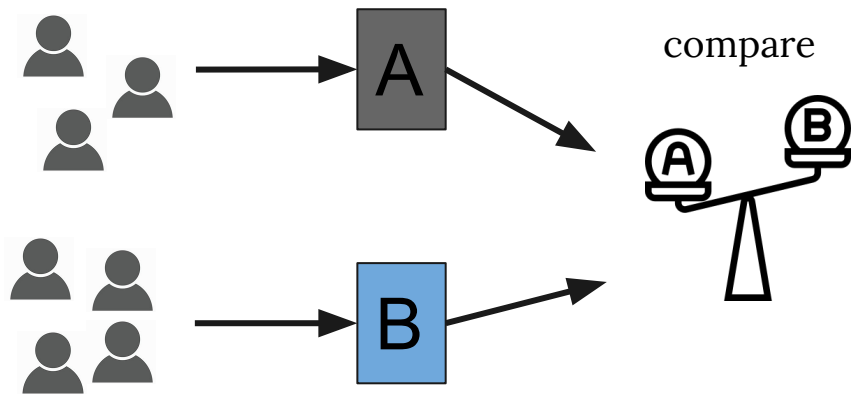
Adjusted targets can harm this plan

Approaches: **Hierarchical** model, include **long term targets** as well

Optimization Problems and Components

AB Testing

“**Easy**”: different web page layout, checkout, recommendations, sortings, ...



AB Tests possible **but** tricky to setup and analyze

Complications:

- How to setup an AB test?
 - different prices per **customer**
→ **forbidden** price discrimination
 - different prices per **country**
→ countries already show different behavior
 - different prices per **article** granting
 - same general behavior
 - robust against cross effects, e.g., cannibalization
 - keep for some time to observe long term effects
- How to measure **long term** profits of two different discount strategies?

Conclusion

Attention to Detail in Modelling

setup optimization and forecast models carefully

mathematically perfect solution pointless if missing details

Measure Real Impact

analysis can be complicated but crucial

starting point to spot issues or celebrate successes

Stay in Contact with Users

learn how and why they use or avoid your product

misusage or desired feature can lead to better products



Thank you

