


OPTIMIZE, ALLOCATE, DRIVE:
REVVING UP VOLUME ALLOCATION FOR BMW

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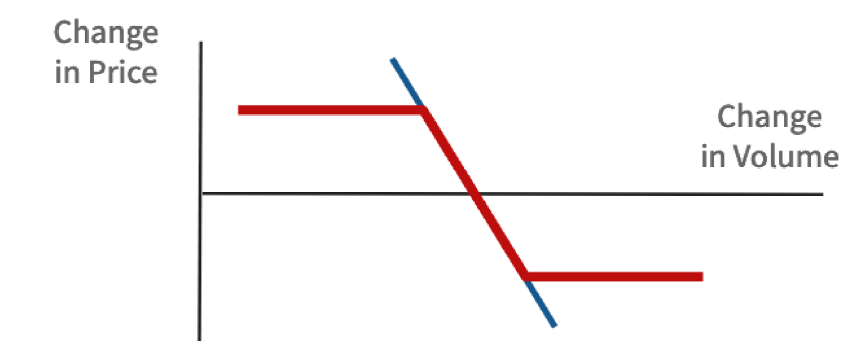
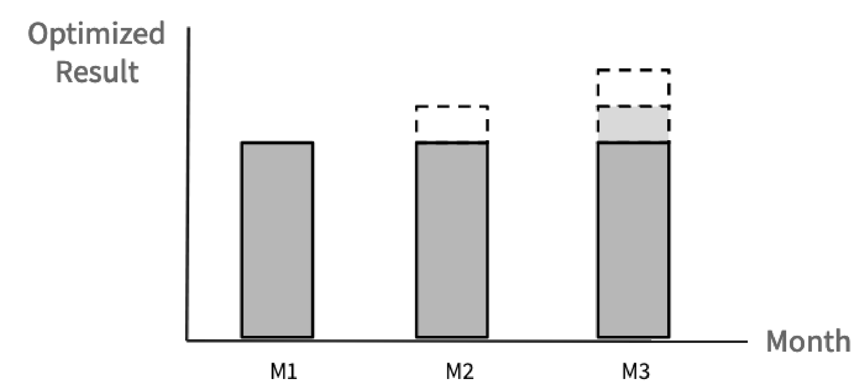
1. CONTEXT

BMW is a luxury car manufacturer that sells over **200 models** in **29 markets** across Europe and every month, BMW decides how much volume of each model to allocate to each market in Europe to maximise profit

The is an optimization model already in place to help them make that decision, but:

- It fails to capture relationship between change in price & change in volume i.e., **price elasticity**
- It builds over previous month's output, thus may lead to sales over production/sales capacity i.e., **ratchet effect**





Problem Statement:

How can we help BMW include price elasticity and reduce ratchet effect in their current optimization infrastructure to give a more accurate picture of profit?

2. CURRENT PROCESS & CHALLENGES

Every month, the volume allocation plan is created using market inputs, production capacity data, optimization output and stakeholder input

Market Request **Production Capacity** **Optimization Result**

Monthly Volume Allocation Plan

We faced several data challenges in the project:

- Limited historical data
- No price or volume data
- No demand or supply data
- Limited Elasticity data

3. OPTIMIZATION

maximise for each model-market combination:

*Volume * [Contribution Margin + (Revenue * Change in Price)]*

Does not capture price elasticity

Mathematically:

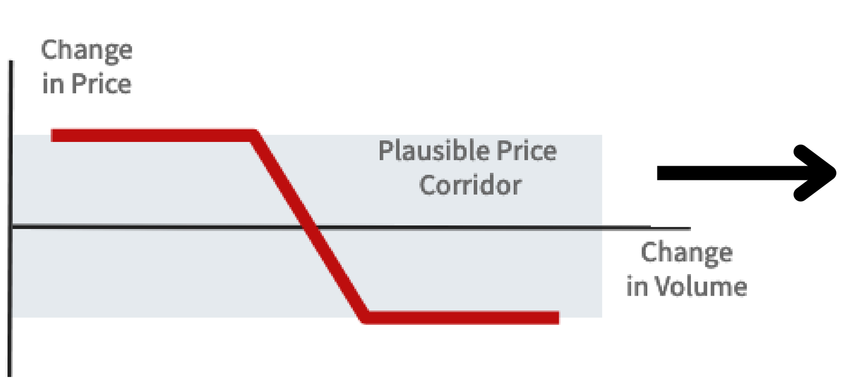
$$\max. \quad \Sigma_i \Sigma_j \; x_{ij} * [m_{ij} + (r_{ij} * p_{ij})]$$

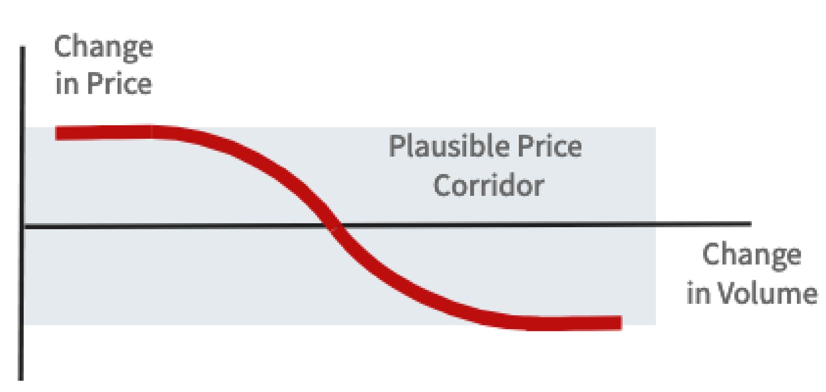
subject to:

Carbon Emission Constraints
Production Constraints
User Input Constraints
Based on previous optimization — *Causes ratchet effect*

4. SOLUTION: INCLUDING PRICE ELASTICITY

To include the non-linear nature of price elasticity into the model, we proposed a sigmoidal curve instead of the discontinuous S-shaped curve. This makes the problem **continuous** and **easier to solve**.

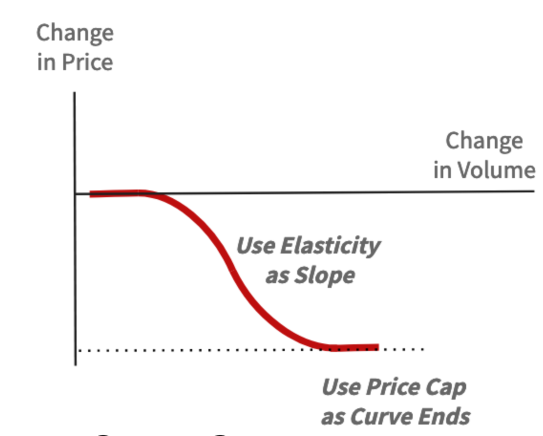




3 Step Approach to Model Price Elasticity:

Model	Market	.	.	Elasticity
XX	RV	.	.	
XY	SG	.	.	(Predict)
YZ	NL	.	.	

Model	Market	.	.	Elasticity
XX	KB	.	.	1.5
YZ	KB	.	.	2.1



$$\Sigma_i \Sigma_j \; x_{ij} * [m_{ij} + (r_{ij} * p_{ij})]$$

Step 1:
Generalize Elasticity from existing data or Predict using XGBoost

Step 2:
Create Sigmoidal Elasticity Function using Elasticity values

Step 3:
Apply Elasticity funtion to calculate Change in Price

5. SOLUTION: TACKLING RATCHET EFFECT

We tried 4 approaches to tackle the ratchet effect and picked the one which best aligned with our stakeholders priorities:

- **Rolling Averages:** Using the averages of the last 3 months to decide boundaries
- **Penalising objective**: Adding a penalty to the objective when deviations from the base are steep
- **Non-linear constraints:** Instead of using linear % changes from the base, apply quadratic constraints
- **Dynamically changing boundaries:** Propotional changes to boundaries at runtime based on historical data

3 Step Approach to Tackle Ratchet Effect:

Model	Month 1	Month 2	Month 3
XX	-10%	-10%	-10%
XY	5%	2%	3%
XZ	10%	10%	10%
VC	-4%	-6%	-2%

$$\frac{x}{y} * \text{boundary}$$

Step 1:
Using historical data, highlight models with ratchet effect

Step 2:
Apply a proportional increase/decrease to boundary

Step 3:
Instead of fixing, boundary created dynamically at runtime

6. RESULTS & IMPACT

We successfully implemented price elasticity and reduced ratchet effect in the optimization model:

★ **Reduce Perceived Profit**

★ **Prevent Overallocation**

Fetch Data From Cloud > Preprocess & Transform > Create Dynamic Boundaries > Compute Elasticity Func. > Run Optimization > Store Results

Improved volume allocation can have a positive impact on:

Financial Planning
Using historical data, highlight models with ratchet effect

Logistical Cost
Apply a proportional increase/decrease to boundary

Internal impact
Instead of fixing, boundary created dynamically at runtime