



BMW Stakeholders Faculty Advisor

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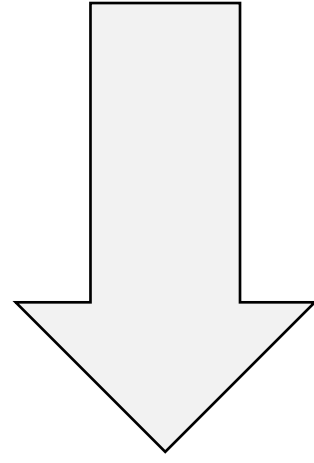


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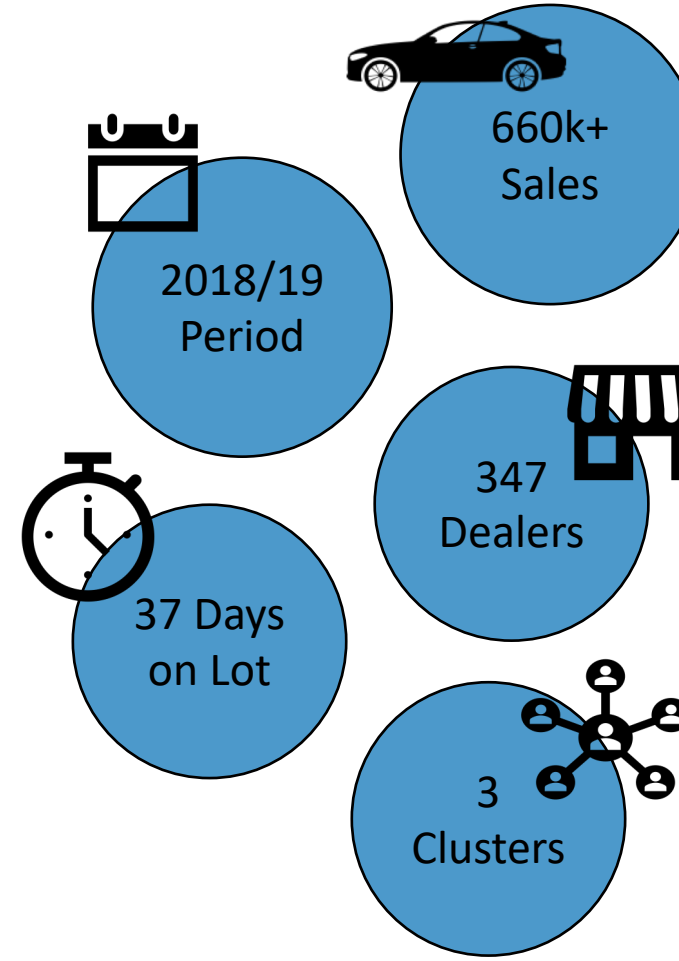
A Data-Driven Car Recommender for US Dealerships

Problem Statement

Providing **vehicles matching customer demand** is key for the business of every car manufacturer

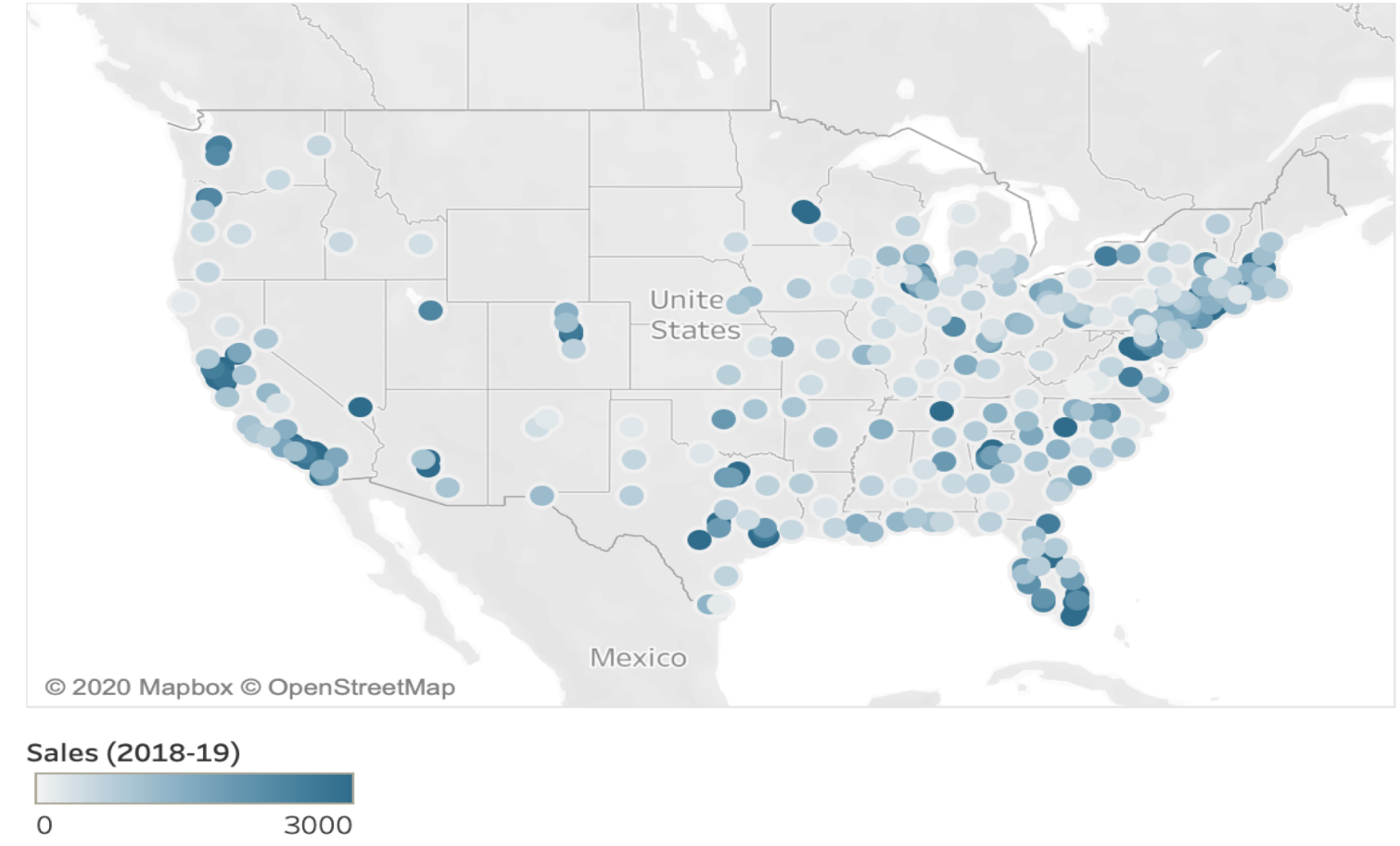


Develop a **quantitative** framework to **allocate** the most **appropriate** vehicles to **each dealership**



Data

BMW Dealerships Across U.S.



Recommendation System

Leverage **historical sales** to infer **best car configurations** at **each dealership**

	Before			After		
Dealership 1	3	?	?	3	5	0
Dealership 2	?	?	9	7	1	9
Dealership 3	21	?	?	21	15	2
...

1. Run **low-rank** matrix factorization with **side information**
2. **Estimate** how many of each car configuration would be sold at **each dealership**
3. **Compare** output with the **observed data**

Optimization Framework

Find **alternative sets** of options to keep total price **below** a threshold

$$\max \lambda_1 \sum_{i=1}^n v_i x_i + \lambda_2 \sum_{i=1}^n w_i x_i - \lambda_3 \sum_{i=1}^n x_i$$

$$s.t.$$

$$\sum_{i=1}^n w_i x_i \leq W$$

$$\sum_{i=1}^n c_i x_i = 1 \quad \sum_{i=1}^n t_i x_i = 1 \quad \sum_{i=1}^n r_i x_i = 1$$

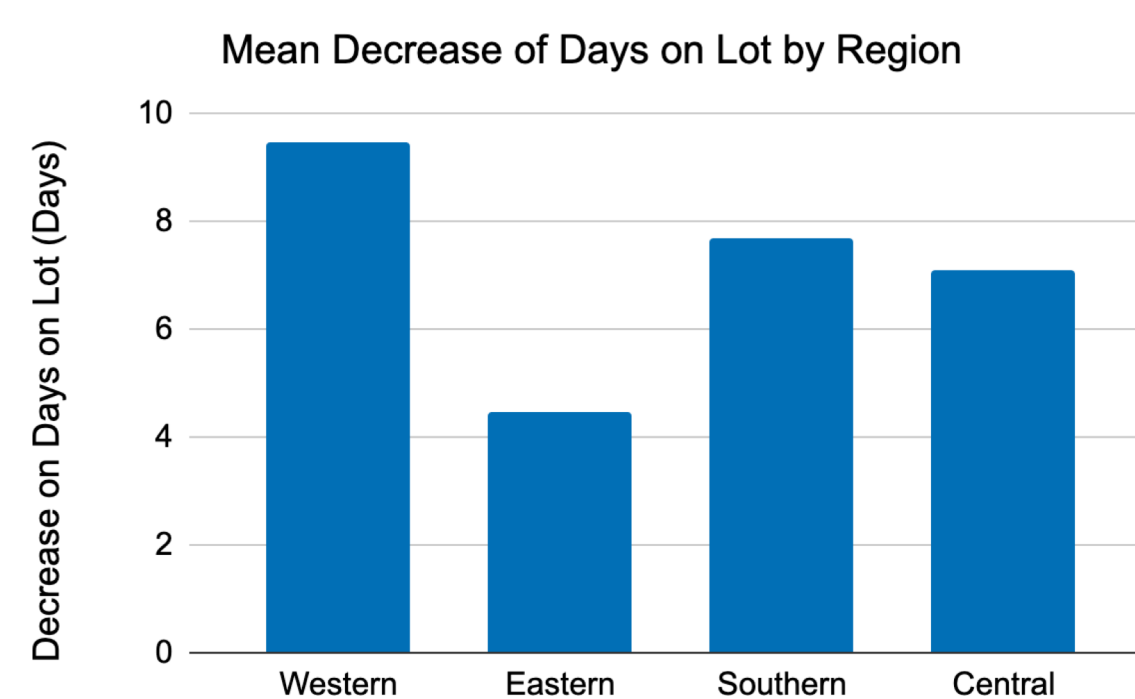
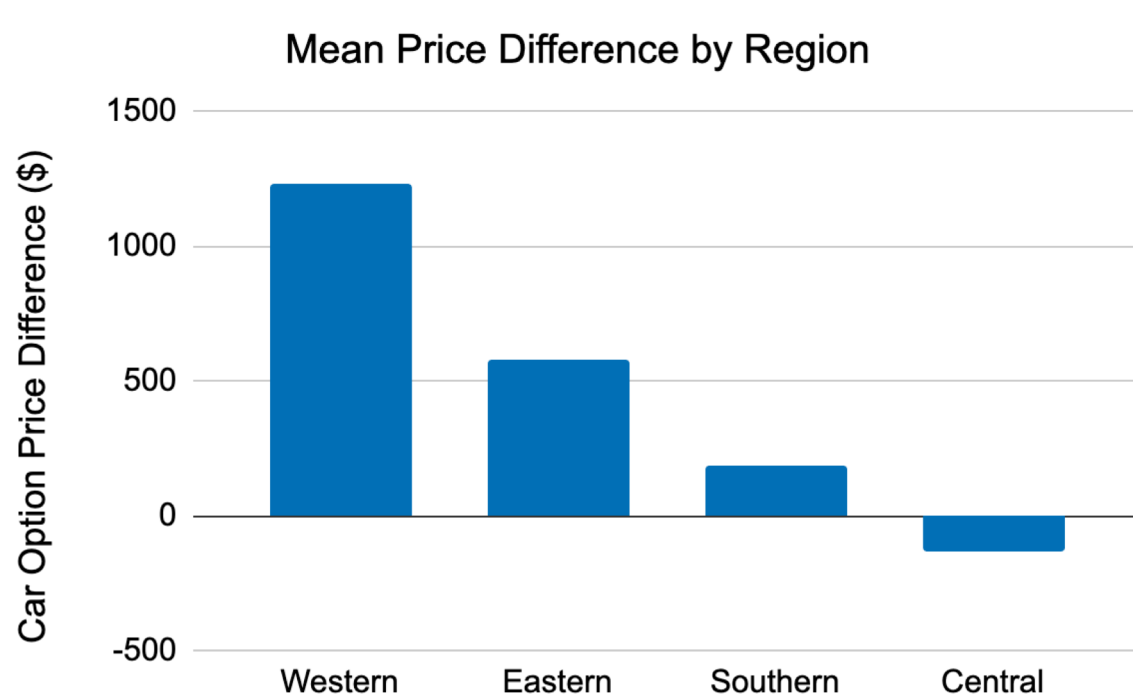
$$x_i \leq x_j \quad \forall (i, j) \in \zeta$$

$$x_i + x_j \leq 1 \quad \forall (i, j) \in \xi$$

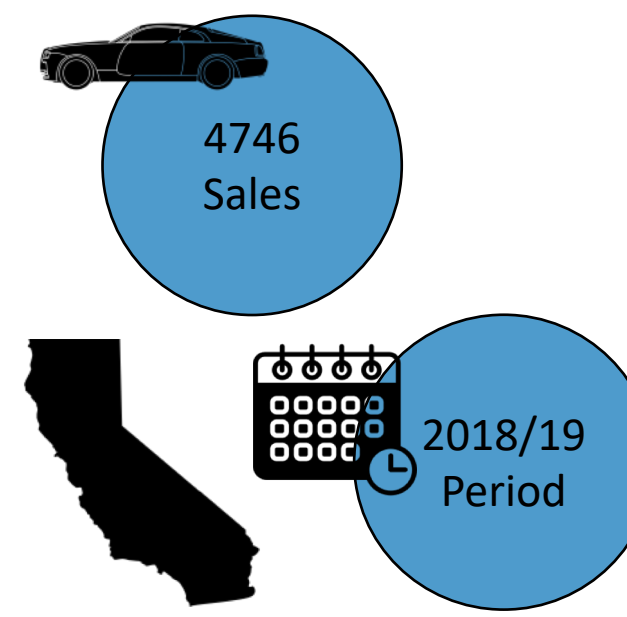
$$x_i, c_i, t_i, r_i \in \{0, 1\}$$

Results

- Revenue is **increased by 9%** and sales happen **20% faster**
- **86.5%** of the models have lower days on lot and **61.5%** of the models have higher prices



Use Case: A California Dealer



	Before	After	Difference
Revenue	\$272 Mln	\$301 Mln	+\$30 Mln
Days on Lot	36 Days	29 Days	-7 Days

- Revenue is **increased by 30 million (~11%)**
- Days on Lot **decreased by 7 days (~20%)**

Implementation in Production

- ✓ Fully working, **tuneable** Recommendation System **in Production**
- ✓ **Output integrated** with current process
- ✓ Ability to **evaluate** performance according to **business metrics**
- ✓ Extensive **handover document** to transfer ownership to BMW



Model 1	Configuration 1	Configuration 2	Configuration 3	Configuration 4
% Recommended	50	25	15	10
Days on Lot	3	6	10	12
Option Prices	1000	1300	800	1150
Option 1	x			x
Option 2		x		
Option 3		x	x	x
...

